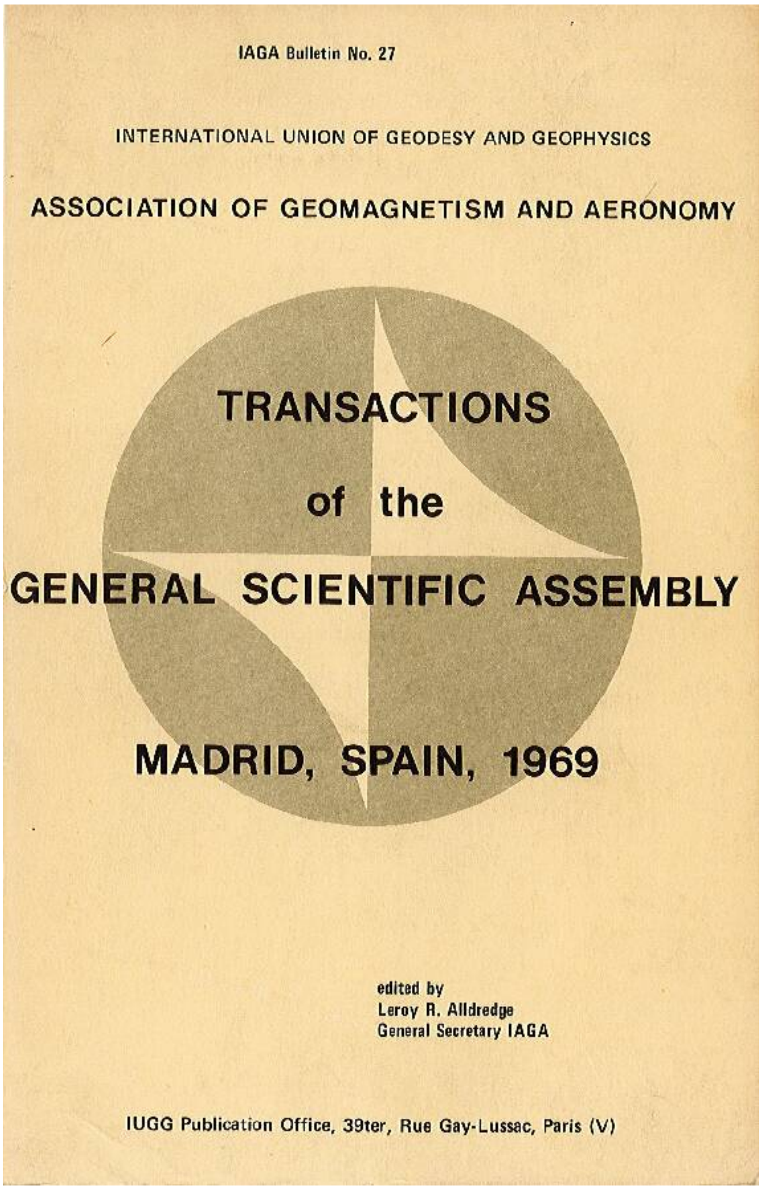


How to cite:

IAGA (1969). ***IAGA Bulletin No. 27, Transactions of the General Scientific Assembly Madrid, Spain, 1969.*** **IUGG Publications Office. https://doi.org/10.25577/rvas-0p60**

IAGA Bulletin No. 27

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

ASSOCIATION OF GEOMAGNETISM AND AERONOMY

TRANSACTIONS of the GENERAL SCIENTIFIC ASSEMBLY

MADRID, SPAIN, 1969

edited by
Leroy R. Alldredge
General Secretary IAGA

IUGG Publication Office, 39ter, Rue Gay-Lussac, Paris (V)

IAGA Bulletin No. 27

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

ASSOCIATION OF GEOMAGNETISM AND AERONOMY

TRANSACTIONS

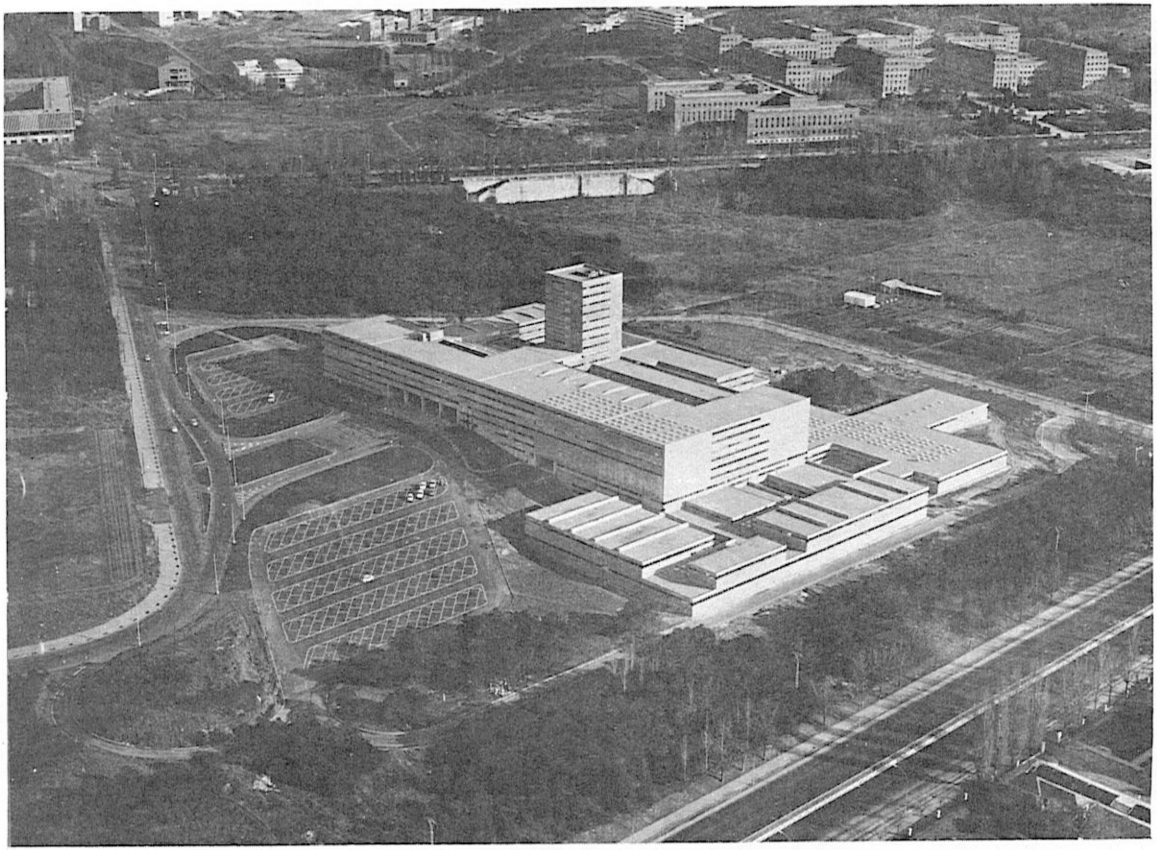
of the

GENERAL SCIENTIFIC ASSEMBLY

MADRID, SPAIN, 1969

edited by
Leroy R. Alldredge
General Secretary IAGA

IUGG Publication Office, 39ter, Rue Gay-Lussac, Paris (V)



Escuela Tecnica Superior de Ingenieros de Caminos Site of IAGA General Scientific Assembly Madrid, Spain 1969

CONTENTS

INTRODUCTION

The IAGA held a General Scientific Assembly in Madrid, Spain on 1-12 September 1969. On this occasion, both IAGA and IASPEI were guests of their Spanish hosts lead by the following Local Organizing Committee:

President:	Rev. Fr. A. Romaña, S. J.
Secretary:	Dr. Ing. J. M. Munuera
Vice Secretary:	Dr. Ing. L. de Miguel
Treasurer:	Prof. J. M. Gamboa
Members:	Rev. Fr. J. O. Cardus, S. J.
	Dr. Ing. J. M. Bonelli
	Prof. J. M. Torroja

During the first week, each Association held independent sessions with its own scientific reports and symposia. In the second week, there were joint meetings with symposia on subjects of interest to both Associations as well as additional separate meetings by each Association.

All the sessions were held in the Escuela Superior de Ingenieros de Caminos, Canales y Puertos, located in the University City of Madrid (see frontispiece). The sessions lasted from 9:00 to 12:00 in the morning and from 16:00 to 19:00 in the afternoon. Business meetings of the working groups of IAGA were held from 12:00 to 13:30 during week days.

Appreciation is given to Father Romaña and his committee which made all the delegates and their guests feel very welcome in Madrid. IAGA is also very grateful for the secretarial services and facilities provided by the local committee.

Four hundred and sixty scientists registered in Madrid for the IAGA assembly. The program for the assembly, which is available from the IUGG Publications Office, 39ter, Rue Gay Lussac 75, Paris (V), France, as IAGA Bulletin No. 26, shows there were 483 papers submitted for presentation by 625 authors. These figures include the 57 papers presented in the three Symposia which were jointly sponsored by IAGA and IASPEI (the UMC also co-sponsored two of these Symposia).

Appreciation is given here to the following scientists who gave freely of their time during the Scientific Assembly in Madrid in helping with the preparation of the Resolutions: Rev. J. O. Cardus, S. J., chairman; Dr. E. Selzer and Mr. K. L. Svendsen.

Thanks also go to all of the Commission Chairmen and Working Group Reporters. An extremely good response was received from these IAGA Officials. Almost all of them submitted written reports of their work during the Assembly before they left Madrid, so that this Transaction could be prepared without delay.

During the Scientific Assembly, only a minimum number of organizational and administrative items were handled. Chiefly among these were discussions regarding a French proposal to reorganize several of the Unions within ICSU to decrease the overlap of Unions working the aeronomy, space and solar-terrestrial fields.

There was, of course, a considerable amount of scientific business transacted. This business, along with resolutions and scientific highlights, are reported in this bulletin. This bulletin together with Bulletin No. 26, Program and Abstracts of the Assembly, constitute a complete report of the Assembly.

PLENARY SESSIONS

OPENING IAGA – IASPEI PLENARY SESSION

The joint IAGA – IASPEI General Scientific Assembly was opened at 11:00 a.m. on 1 September 1969 in the large auditorium Aula Magna, by Rev. Fr. A. Romaña, S. J., who was president of the Local Organizing Committee. Four speakers followed Father Romaña. At the end of the opening greetings, the host committee provided a wonderful reception during which a great variety of finger foods and refreshing drinks were served to all delegates and their guests. The speakers comments are reproduced below (translations were provided in Spanish, French and English by most speakers. The talks may have been delivered in a different language than the one presented below).

REV. FR. A. ROMAÑA S. J.,
President of Local Organizing Committee:

On October 1, 1924, at ten o'clock in the morning, the inaugural session of the Madrid Assembly of the International Union of Geodesy and Geophysics, presided by H. M. King Alfonso XIII, took place. It was the first time that the seven Associations, which today still form part of the Union, met together in a General Assembly. What took place at Rome in the year 1922 had been the actual establishment of the Union, which had been founded at the end of the war in 1919 by the then existing International Council of Scientific Research, predecessor of today's ICSU. Besides, not all of the Associations had been able to meet at Rome: the Association of Scientific Hydrology, founded in Madrid in 1924, was, for one, missing. The Union was then made up of 27 countries of which only 23 were present in Madrid; but since another 8 countries, who aspired for membership, assisted, the total number of those present was 31: 17 from Europe, 8 from America, 3 from Asia, 2 from Africa and one from Oceania. As we can see, the Union was being faithful from the start to its name of International.

Spain was highly honored in that occasion by the selection of its capitol as meeting place for the Assembly and took great pains to assure its success. And in fact in the closing speech, the then President of the Union, Prof. Charles Lallemand (who, by the way, had delivered his opening speech in excellent Spanish and had shown an extraordinary familiarity with the history of Geodesy and Geophysics in our country) stated that "the organization of the Assembly at Madrid will always serve as a model to be imitated by the organization of future Assemblies."

You may, therefore, imagine the great pleasure we feel with this new selection of Spain as meeting place when, again for the first time, the new method approved in the last General Assembly of the Union at Switzerland is going to be put into practice: the holding of the General Scientific Assemblies of the Associations in groups of two or three in the years between two General Assemblies, which, from now on, will have an emminently administrative character. But at the same time, we are aware of our great responsibility in following the steps of our predecessors of half a century ago and in living up to their achievements.

It is true that today only 2 Associations are meeting; but the fact that the number of attendants of the Associations at the Assembly of 1924 was not even one-fourth of the number meeting here today, is evident proof of the Union's growth. And if we turn to the number of countries which today make up the Union, we find that the 27 members of those days have become 69: 27 from Europe, 15 from Asia, 10 from Africa, 13 from America and 4 from Oceania, an obvious proof that our Union is today not just International, but worldwide.

It is also evident that, even though you represent only two Associations, your Assembly constitutes the most genuine representation of the Union as a whole, since you are part of its worthiest and most notable members, and more than anything else, because of your numerous and encompassing undertakings. I do not think there is anyone who can doubt that the former IATME, predecessor of our IAGA, was the father and organizer of the II Polar Year 1932-33 and I believe I can honestly say that the IAGA has been, if not the father, at least the soul and eminent inspirer of the extraordinary activity of the International Geophysics Year and of the International Years of the Quiet Sun, undertakings of such fruitfulness and transcendental results that it is not surprising that as a consequence of them, the study of the relations between Solar Physics and Earth Physics has acquired such a great importance that plans are being made for the creation of a new International Union exclusively dedicated to this object.

And, as for IASPEI, it will suffice to note the extraordinary work carried out all over the world for the Upper Mantle project and the advantageous application of Antiseismic Engineering in all those countries which suffer the calamities of earthquakes. It is, therefore, natural that other scientific organizations should have wished to meet here with you on the occasion of your Assembly. Among these organizations are the Upper Mantle Committee, the European Engineering and the Inter-Union Committee for the study of the relations between Solar Physics and Earth Physics, and, honouring all with its presence, the Executive Committee of the Union itself.

We heartfully welcome each and every one of you and wish you the best success in your work. It is well known of old that the Assemblies of the Union Associations are meetings which undertake highly intensive work, at times perhaps excessive, unlike that famous Congress at the beginning of the last century which caused to be said that "the Congress is having fun". It is clear by your crowded schedule of sessions and by the 4 volumes of the Abstracts, that, as we said before, an enormous amount of work awaits you. And if there is anyone who still doubts it, I would ask him to note that your Assemblies are not simply a Congress attended by those who are interested in exchanging opinions and personal progress concerning a branch of human knowledge; your Assemblies are not just made up of those of you who are present: behind many, and I would even say behind the majority of those who are here today, stand those great Scientific Institutions you belong to and represent, being in many cases their heads and directors, and which await your return in order to receive your guidance and organize with greater productivity their work in years to come. I am tempted to compare this Assembly to a joint meeting of the Boards of Directors of several important international firms that had decided to unite their efforts so as to find out the needs of the world in a specific field and to organize their future work in order to meet them as best as possible.

It is certain that through this noble struggle to possess the Truth and reach a perfect knowledge of those branches of the Science of the Earth which you deal with, and through your discussions, you will reach agreements whose transcendance will only be fully realized in years to come. Would the feat of Apollo XI and of Mariners and Venera have been possible without that meeting held in Rome in October 1954, when several of you here today agreed that the Government of the United States should be asked to decide to build the first artificial satellite, and without the sessions held in Barcelona in 1956 when the head of the Soviet Delegation announced that the USSR, at first skeptical, was at last interested in that task?

You have returned to Madrid after 45 years. In 1924 a considerable number of delegates visited, at the end of the Assembly, the Ebro Observatory, which, along with the one in San Francisco, were the only magnetic observatories then existing in Spain. At that time the Director of the Geographic Institute and President of the National Commission of Geodesy and Geophysics, Mr. Luis Cubillo, pointed out the efforts that were then being made in our country in the field of Geophysics and cited the seismic observatories at Cartuja, Ebro, Fabra and San Fernando and mentioned those which the Seismological Service was installing or had just installed in Toledo, Almeria, Malaga and Alicante. This half century has not passed in vain. The net of magnetic observatories has increased considerably: besides the two peripheric observatories mentioned before there exist today the central one in Toledo and those in Almeria, Logroño and, outside the Peninsula, in Tenerife (Canary Islands) and Moca (Fernando Poo), the latter being of great importance due to its location near the Equator, since it seems that it is much more difficult to install observatories in torrid zones than in Polar ones. As for the seismological observatories, besides the great improvement of the equipment, we have to add the growth of the peninsular network with the installment of the observatory at Lograño and its extension into the torrid zone, as well as the observatory at Moca, which Ecuatorial Guinea has today inherited, although the Geographical Institute still looks after it. The consequence are quite clear: if to the Spanish observatories, we add those in Portugal, it will be seen that the Iberian Peninsula is one of the regions of the world best covered seismically and magnetically; even if we compare it with Europe, that part of the world with more observatories, its lead is obvious: whereas in all of Europe the proportion is around 180.000 Km^2 for each magnetic observatory, in our Peninsula it only reaches 100.000 Km^2 and as for the seismical, the same proportions for each observatory are 90.000 and 50.000 Km^2 respectively. It must be said nevertheless, that the amount of research work published in Spain does not correspond to this density of observatories and in several aspects, it must be improved; but the reason is clear: the little dedication that the official scientific studies give to geophysical subjects makes impossible to count with that select group of young graduates which in other countries attend the geophysical observatories and laboratories and contribute to specialized journals with their Masters and Doctorate theses; and as for the personnel of the observatories themselves, the scarce number that make up their staff as well as the occasional lack of economic funds, has forced it to dedicate itself to observation work, necessary nevertheless, for any sort of serious research to be undertaken in these subjects. And yet, improvement in this field is also taking place: a Department of Earth and Cosmic Physics has been created in the Science Faculties to remedy the small number of scholars; although, little by little, the contributions of original publications has not ceased growing; and the desire to cooperate and contribute as far as possible to the progress of Universal Science is seen not only in the quantity and and quality of the data furnished to researchers all over the world, but also in the Service of Fast Magnetic Variations, which fifteen years ago was installed in Tortosa and whose activity is testified to by the growing volume of quarterly Bulletins with their Annual Supplements and Bulletins No. 12, 2 of IAGA, a result of the work done in filing, analyzing and discussing the enormous quantity of data sent monthly by nearly a hundred observatories from all over the world. If to that we add the considerable number of Spaniards who have actively collaborated since the founding of your Associations in its special Committees or have held directive posts in them, there won't be any doubt left of our sincere wish to cooperate as far as means allow.

All that remains is to wish you a happy stay in Spain. We hope that the weather will be sufficiently pleasant so that you may carry out your work without having to bear the discomforts of a late Madrid summer. And, also, that in your free time you may enjoy the artistic and natural splendors of our country. Various tours taken in your leisure days or immediately after the assembly, will allow you to visit diverse places in the Peninsula or its adjacent islands; the Committee also invites all of you to join in a visit to Toledo, besides the receptions and folklore shows mentioned in your program. Toledo is a city in which many see the synthesis of our past due to its history and art; but it also look forward towards the future, as the installment of the Central Geophysic Observatory outside this city testifies: because of this, we feel that a visit to this city carries with it a symbolic significance. In the struggle for the attainment of scientific truth, we find a stimulus in the forseeable achievements, which we hope will become more spectacular each day; but another source of encouragement is the memory of those efforts made by the pioneers ("Los Adelantados" as they were called in the Imperial Toledo) who in spite of their want of material needs, opened the way for the future. If today we are closer to our goal, it is thanks to those who have gone through each stage of scientific research with faith and enthusiasm in their hearts and devotion and sacrifice in their work. Gentlemen, this example is daily given by many of you and is for all of us an ideal to follow.

In the name of the Spanish Committee, I once again thank you for having met here to fulfill this task. Again, we welcome you and wish you success in the work which you will be carrying out during this Assembly.

PROFESSOR J. P. ROTHE,
General Secretary of IASPEI

President, Ladies and Gentlemen, Dear Colleagues,

I am addressing you in the name of the International Association of Seismology and Physics of the Earth's Interior, and I wish to apologize to you on behalf of Prof. Wadati for his not being able to attend this meeting due to his University duties; and on behalf of Prof. Magnitsky, whose arrival has had to be delayed.

This is the second time that Madrid serves as meeting place for geophysicians; and I would like to express a personal testimony. My father was fortunate enough to attend the 1924 meeting, which brilliantly marked the renewal of the International Scientific collaboration after World War I and my mother, who accompanied him, spoke to me only a few days ago of the wonderful memories she holds, even after 45 years of the 1924's meeting, which were of such a great significance.

This interval of 45 years has shown a considerable development for the science of seismology, quite a number of new stations have been established; the number of laboratories has increased, their equipment improved, and the number of seismologist researchers grows daily. The numerous scientific exchanges delivered in this Assembly are a testimony to this.

The great hypotheses have turned into certitudes; and now suddenly, our field of studies has enlarged even more with the analysis of earthquakes that we now so frequently detect on earth, and to which we can add those analyses registered on the moon. The installment of a seismograph in our satellite is a scientific success that we view with great admiration and we give our most sincere congratulations to the cosmonauts of the Apollo XI and to all the collaborators who have made this magnificent event possible.

As the complexity of geophysical problems grows, it becomes impossible for these problems to be studied by a single group of specialists gathered in only one association.

This is the reason why this meeting at Madrid in 1969, of these two IUGG Associations, points to a closer collaboration between specialists of similar disciplines for a common study of the great problems related with the structure of the interior of the earth and of the methods that perhaps one day, will reach a definite solution which will allow us to forecast earthquakes.

Therefore, a great deal of work is still to be accomplished and we are grateful to the Organizing Committee, for all they have done with the help of their Government, to help us to exchange ideas and carry out discussions in this peaceful and lovely University campus. Once again, we want to thank all our Spanish friends.

PROFESSOR T. NAGATA,
President of IAGA:

His Excellency, Ladies and Gentlemen,

In this opportunity to open the First General Scientific Assembly of the International Association of Geomagnetism and Aeronomy here in Madrid, Spain, I would like to express, on behalf of all members of our Association, our sincere gratitude to the scientists, to the Council of Scientific Research, to National Commission of Geodesy and Geophysics and to the Government of this host country, for their cordial invitation extended to us together here today, and for their magnificent arrangements for our Assembly, which we shall enjoy for a couple of weeks from today.

I would like to thank particularly the Vice-President of the Government and the Ministries of Education and Science and of Information and Tourism, and their honorable representatives, and the chairman of the Spanish Organization Committee, Rev. Father Romaña, for their warm welcome, which we have just received.

Spain is one of the oldest civilized countries in the World. We know for instance, regarding our scientific speciality, that the magnetogram recordings have been continuously maintained in this country since the time of very beginning of the geomagnetic registration. It may be, needless to say, that Christopher Columbus and his crews discovered the regional difference of the geomagnetic declination in as early as 1492.

In this historic capital of Spain, we are now going to discuss modern highlights of geomagnetism and aeronomy, sincerely and happily.

I must say a few words about our fellow Association of Seismology and Physics of the Earth's Interior, which also is opening its General Assembly here today with us. We, the two Associations, have long been in the same Union, namely International Union of Geodesy and Geophysics. It is the first time for us however, that the two Associations gathered in the same place at the same time to have a number of joint symposia on the topics of our common interest. I do hope that this Assembly is fully successful for IASPEI as well as for ourselves in IAGA.

Thank You

PROFESSOR EINER ANDERSON,
Treasurer of IUGG:

Ladies and Gentlemen,

It has been requested that the President of the IUGG speak after the Presidents of the Associations celebrating here a joint symposium to mark the importance of this event in the life of the Union.

Regretting his absence, Prof. Coulomb has requested me to take his place in the name of our Great Union.

I've been charged for this task, as I am a member of the IUGG's bureau, since 1960 of which I am also treasurer and therefore I am well informed. I hope that you will not be deceived.

Mentioning the Bureau, I feel with sorrow for the great loss that the IUGG has suffered on the recent death, following a long sickness of our Vice-President Prof. Hisashi Kuno from Japan.

Prof. Kuno was born in Tokyo on Jan. 7, 1910. Once he finished his studies, he first became assistant from 1933 to 1939, and from 1939 to 1955 assistant professor, and finally professor since 1955 in the University of Tokyo. He received his doctorate in 1948 and was given the award of the Academy of Japan in 1954. He was appointed honorary member of the Geological Society of America, President of the Vulcanology Association from 1963-67. He married in 1940 and had two children: Takashi and Shuzuko. Let us honour his memory!

In the name of Prof. Coulomb, I will inform you of the following: I recall that the General Assemblies of the Union were celebrated up to the present every three years, and at the same time the General Assemblies of the Associations were taking place. This General Assembly of the Union will not be held but every four years, from now on, and its scientific tasks will deal on subjects referring to various disciplines at the same time. The Associations are able to celebrate their own Assemblies in the intervals.

We have realized as well, that two of our Associations will also devote their intermediate Assemblies to a program of common interest. We are pleased with your effort in avoiding an excess of specialization: a considerable progress in many important matters may result from the multiple points of view. But it is also necessary to thank our Spanish colleagues for all the troubles they have undergone in organizing these important confrontations.

I will profit by this occasion, which has been given to me, to celebrate with you a double anniversary. First: it is the fiftieth anniversary of the IUGG. On the occasion of the Interallied Conference of Scientific Academies, which took place in Brussels in July 1919, this Union was definitely constituted, at the same time as the International Council of Scientific Research, precursor of the International Council of Scientific Unions.

Truly speaking, the 1919 meeting was preceded and followed by other two of equal importance: the ratification of the statutes of the Union took place in Rome in 1922, on the occasion of the International Council of Research Assembly, and the creation of the Union had been prepared by the Second Interallied Conference in Pairs, in Nov. 1918. This task was not as simple as we could presently suppose. I would like to expose briefly, the surprising discussions to which this matter gave place.

Geophysicists do not lack experience in the question of international collaboration. If we limit ourselves to consider the cooperation manifestations in the both sciences represented here, the Magnetism Association has, as its predecessor, the Magnetische Verein, constituted in 1836 under the inspiration of Gauss & Humboldt; the study of earthquakes had been recognized since 1903, in the 9th Geological

Congress held in Vienna, as one of the branches of investigation in which an international agreement would be most fruitful. But the most organized subject was Geodesy, since an intergovernmental convention in 1886 created the Internationale Erdmessung or International Geodesic Association.

In the Paris Meeting, the French Academy of Science proposed the creation of an "International Geophysical Union", divided into various sections, one of them would follow the tasks assured by the Association of Geodesy before the war; Seismology and Terrestrial Magnetism should unite with the other section known as Metereology. All geodists did not agree with this proposal, and it should be said, that the new orientation, though it had allowed an extraordinary scientific development of Geodesy, had not turned out properly, financially speaking, because the Geodesy Association's means which represented, at the beginning, half of the Union's budget, do not surpass the fifth part presently. The Union's promotors expected to subvene generously, as the Association Geodesic had done, more ambitious jobs than those which could be undertaken by the different countries members. The international scientific meetings that had formed later a great part in our activity, had hardly then been mentioned.

The discussion had been largely confusing. Lacroix and Ricco obtained the integration of Vulcanology in the second section. Picard proposed the Union of Geodesy and Seismology, while Schuster, who mistrusted the Meteorology, wanted Geodesy to be united to Terrestrial Magnetism. It had also been intended to unite Geodesy and Geophysics to the Astronomical Union. And even under the false excuse that marriages were easier than divorces, they were on the verge of creating various independent associations.

It was Hale, the great American astrophysicist, who valued the hopes that could exist in the systematic approach to the matters which are really related, obtaining the vote of the initial project.

At last the Geodesical and Geophysical Union arose in 1919 with six sections: Geodesy, Meteorology, Terrestrial Magnetism, Seismology, Vulcanology, and Oceanography, which with the ratification of 1922, would be changed into Associations, to which Scientific Hydrology would then be added.

To the jubilee, which I have just evoked, another anniversary could be added. Fifteen years ago, in the Assembly of Rome, the Association of Magnetism and Terrestrial Electricity took its actual name of Geomagnetism and Aeronomy, while some time later, other Associations would change their names: mainly the Association of Seismology would add to itself the Physics of the Earth's Interior.

The aim of these changes were to recognize the characteristic evolution of the international scientific organizations: these are frequently created to take the most advantage of a new technique; in its origin, the Association of Magnetism consecrated itself mainly to obtain good measurements in the field, and accurate registers in the observatories; the Association of Seismology studied the best procedures for the exploitation of the seismographs (after trying without result to make the macroseismic scales comparable).

But when the methods seem precise enough and assured, young scientists appear rejecting in some ways all the efforts made, and only interested in results, or even in pure theories.

Giving up Terrestrial Electricity, which had not responded to the faith placed in it, the reform of 1954, conserved the valuable experience acquired in classic Magnetism, but accepted the renewal of points of view symbolized by the new word, *Aeronomy* (forged by Sydney Chapman precisely to avoid classic subdivisions). This word was badly accepted by meteorologists who required a more precise definition, and who should have been satisfied with the promise of not interfering with the layer of ozone. The word Aeronomy does not strike anyone actually.

The Radio – Scientific International Union, gathered primarily around the radio-electric techniques, has suffered an evolution similar to that of the Association of Magnetism. Presently there are other organizations also interested in Aeronomy. A study of the ways of obtaining a better structure on this field, is necessary.

But this is another problem. For today, I only want to place this meeting on the perspective of those preceding it; and tell you all: It is clear that both Associations have a powerful life, since they try a new formula and, if convenient, we shall not stop the evolution in the future.

We are immersed in the tasks of the present and are aware of their magnitude, but nevertheless, we take great pride in those achievements of our past which had universal dimensions or which constituted indelible milestones in our scientific evolution. The study of Astronomy and Geophysics in our country dates back to Seneca. They acquired special importance in the schools of Cordoba and Toledo and in the scientific center which Alfonso X, the Wise, established there, gathering nearly fifty of the best astronomers and mathematicians, native as well as from the Near East, in order to elaborate the famous "Tablas Alfonsinas". Later on, the discovery of America, the great feat of the Catholic Kings, and the travels through the Oceans, posed new problems which had to be faced by the royal cosmographer Jaime Ferran. Meanwhile, in 1530, Alonso de Santa Cruz, astronomer and geophysicist, completed for the first time, a graphic table of magnetic declinations and thus became, along with Burroughs, a precursor of Halley.

EXCELLENCY SENOR MANUEL LORA-TAMAYO,
Presidente del Consejo
Superior de Investigaciones Cientificas:

It is a great satisfaction for me to have been entrusted with the pleasant task of greeting you in the name of the Vice-President of the Spanish Government, Honorary President of these Assemblies, who to his great regret, has been unable to preside over today's meeting, pressed as he is with the obligations of his high post. My satisfaction is twofold: in addition to acting as representative, my position as actual President of the Consejo Superior de Investigaciones Cientificas allows me to join in its satisfaction at having been honored with your selection of Spain as the meeting place for this distinguished scientific congress in which the International Associations of Seismology and Physics of the Earth's Interior (AISPEI) and Geomagnetism and Aeronomy (IAGA) are united.

Forty-five years ago, as Father Romaña reminded us, our country had the opportunity to welcome the second General Assembly of the International Union of Geodesy and Geophysics which along with the Assembly of Astronomy, a closely related science, was a foundling of the newly established International Council of Scientific Research. I believe that on that occasion, as on the present one, you were paying homage to an old tradition as well as to an evident desire of collaboration that inspires the specialists of today and for which we all feel extremely grateful. The Spanish Consejo de Investigaciones Cientificas is made up of the most diverse branches of Science and each and every one of us feels a mutual interest in one another's work, filled as we are with a common desire for scientific progress and with the wish to contribute to it through the product of our own undertakings.

We might also note the fact that the University of Salamanca was the first to include in its programs, the heliocentric doctrine and that the first legislation concerning the construction of earthquake-proof buildings was carried out by the Council of Indies in the reign of Philip II. Apart from these two interesting facts, the names of the sailor Jorge Juan and of Ulloa, who in the XVIII century took part in the measuring of the meridian arc of Peru and the installment of the Cadiz Observatory, which would later on belong to the San Fernando Marine, constitute landmarks in the development of the Sciences of the Earth in our country. The installment of the Madrid Observatory in 1854 and the founding in 1869 of the Instituto Geografico, where the Servicios Nacionales de Sismologia y Geomagnetismo were located, added further to this development.

In the Assembly of 1924 due tribute was paid to the memory of one of our most renown figures in the second half of the last century: General Ibanez ñde Ibero, who established the Instituto Geografico mentioned earlier and was one of the most eminent founders of the International Association of Geodesy of which he was president, until his death, in the service of universal science.

In speaking of this vast aspect of international cooperation which is today a basic point in the scientific policy of nations, allow me to deal briefly with those considerations which influence the actions of the Consejo Superior de Investigaciones Cientificas.

In the first place, our Institutes, as such and because of the personal relation between its members, participate even in the most intimate and selective international colloquies and symposia, which often result in later coordinated actions. We are up to date in important scientific sectors and aspire to participate in those others which still remain beyond our formative means, through personal contacts and meetings, whether on a Council level or not, as indispensible contributions towards a total and efficient incorporation on our part to common tasks. Further proofs of our constant wish to cooperate in the most arduous tasks, with a generous spirit of team work where our collaboration in the work carried out by the International Geophysical Year and the International Years of Quiet Sun, the organization of expeditions to the Gulf of Guinea, Sweden and the Sahara to collaborate in the geodesic as well as astronomic goals of observing the total sun eclipses of 1952, 1954, 1959, the permanent dedication of the Ebro Observatory to the Service of Rapid Magnetic and Telluric Variations, our cooperation in the International Hidrologic decade, our contributions made in the study of the hibernal anomaly of ionospheric propagations over the Iberian Peninsula, and the contributions which will probably soon be made in the Canary Islands and the Sahara.

After its foundation in 1940, the Spanish Consejo Superior de Investigaciones Cientificas established the Instituto Geofisico, especially dedicated to seismical and geoelectric prospection and later on, in 1946, brought into existence the Union Nacional de Astronomia y Ciencias Afines (UNACA), which oversees as far as it is able, the observatories at Ebro, Cartuja and Santiago de Compostela, as well as the Seminary of Astronomy and Geodesy at the University of Madrid.

The work carried out by the Ebro Observatory in the field of Terrestrial Magnetism and Telluric Currents and in the study of the Ionosphere, as well as that of the Cartuja Observatory in the field of Seismology, is familiar to all of you. As for the Seminary of Astronomy and Geodesy at the University of Madrid, it constitutes a sure guarantee for the necessary advancement of future specialists. Apart from this, the Seminary has already become an important post in the investigation of zodiacal light and the air glow, thanks to its close connection with the observatory which is being installed in the slopes of Teide, at an altitude of 2400 meters, in the Island of Tenerife, very valuable because of the incomparable purity of its skies. And everything also seems to point to its importance, in a short time, in the study of the nature and of the physical activity of the sun, an indispensible requirement for our greater knowledge of the relation between Heliophysics and Earth Physics.

We are convinced that today's scientific investigations will daily expand towards supranational fields of work. This condition, which is always convenient, becomes indispensable when referred to what has been termed as "macroscience" which call for economic resources that are beyond the means of national budgets due to their magnitude. It is necessary to establish tentative bilateral agreements on certain occasions; more ample regional coordinations at other times; and as a final resource, vast international unions to aid the common good which the universality of scientific knowledge represents.

But there are other reasons for this expansion of international cooperation besides the economical one: the indispensable standardization of methods and the accumulation of data whose total usefulness will only be reached when it is made up of results proceeding from the most diverse geographical latitudes and distant points of observation. The sciences which you deal with will progress all the more and will better aid in the progress of those great feats of today in investigation of the earth and the space that surrounds it, if both observations and methods are planned and coordinated in an intercontinental scale with a strong sense of team work, wherein lies the success of your undertakings. Evidence of this spirit of team work which moves you is the great number of attendants at these Assemblies, the eminence of its members and the tight schedule of work that awaits you.

Spain, honored today at being your place of reunion, aspires to be always present in these common tasks and is increasing its resources and experimental systems as far as its means allow. Your presence here is a stimulus for the tasks that lie ahead and a catalyst in their achievement. We welcome you and hope that your stay among us will be pleasant and fruitful as we sincerely wish it to be and that you will go back with the image of a growing country, of scientific institutions that participate intensively in the quest for new fields of investigation, and of the men at their service who seek a closer understanding between all nations and peoples.

FIRST IAGA PLENARY SESSION

The first IAGA Plenary session was called to order at 4:00 p.m. on Monday, 1 September, in room 27, by President T. Nagata. He announced the appointment of the Resolutions Committee as follows:

Rev. J. O. Cardus, S. J., Chairman
Dr. E. Selzer
Mr. K. L. Svendsen

President Nagata explained that since this was a scientific assembly there would be very little administrative work done. Elections and the appointment or reappointment of Commission Chairmen and Working Group Reporters will be done during the XV IUGG General Assembly to be held in Moscow in 1971.

Three scientific lectures were then presented as follows:

N. Ness – Highlights of the Magnetospheric Physics Symposium in Washington, D. C.
J. Cain – The International Geomagnetic Reference Field
T. Nagata – Tectonomagnetism (Presidential Address)

PRESIDENTIAL ADDRESS

TECTONOMAGNETISM

Professor Takesi Nagata – President, IAGA

ABSTRACT

A possible effect of mechanical stresses within the earth's crust on the geomagnetic field in the neighbourhood of an epicenter of a great earthquake has long been considered since the early time of beginnings of seismology and magnetostriction study, as historically sketched in Section 1. Owing to recent progresses in the precision of absolute magnetometers and researches of rock magnetism, this problem has recently revived as "tectonomagnetism".

Three typical and reliable examples of marked land deformations associated with great earthquakes and accompanied by local anomalous geomagnetic variations are described in Section 2. These examples are the great NANKAIDO earthquake in 1946, the great NIIGATA earthquake in 1964, and creeps of SAN ANDREAS fault.

Examples of a high correlation between an unusually large geomagnetic secular variation in a certain area and an occurrence of a large earthquake in its neighbourhood are given in Section 3. The examples are concerned mostly with recent Japanese data including the results of special studies on the MATSUSHIRO earthquake swarms. These anomalous geomagnetic changes seem to be recovered after the corresponding earthquakes. However, an example of irreversible geomagnetic variations caused by artificial seismic shocks, demonstrated in USSR, also is described.

Experimental data and theoretical discussions regarding magnetic properties of natural rocks under mechanical stresses are summarized in Section 4. There are two categories of the effect of stress on the rock magnetization. One is the reversible effect with respect to stress: the magnetic susceptibility and the hard remanent magnetization reversibly decrease along the axis of a uniaxial compression and reversibly increase, with a rate of a half of the longitudinal increase, into the direction perpendicular to the compression axis. This effect is principally due to a rotation of the spontaneous magnetization caused by the stress.

The other is the irreversible effect. The soft remanent magnetization irreversibly decreases with a uniaxial compression in no or weaker magnetic fields, regardless of the direction of the compression. In a reversed way, the soft remanent magnetization is produced by a uniaxial compression in any direction in the presence of stronger magnetic fields. This effect is due to the irreversible movements of the 90° domain walls. All the results are listed in Table II.

Local geomagnetic variations can be calculated from the change in the magnetization of the crustal rocks introduced by mechanical stresses by referring to the established relation between magnetization and stress. Two examples of such calculations are summarized in Section 5. Stacey's model of the stress distribution is based on a transcurrent fault and the associated shear stress, while Yukutake-Tachikawa's model is based on a hydrostatic pressure within an infinitely long cylinder embedded within the earth's crust. Assuming that the maximum elastic strain on the earth's surface is 10^{-4} c.g.s., the maximum variation of the geomagnetic field observable on the earth's surface amounts to 6-7 gammas in both cases.

1. INTRODUCTION

It has long been hopefully expected that tectonic deformations or movements of the earth's crust may be accompanied by a certain change of its magnetization, thus resulting in a local anomalous change in the geomagnetic field in the neighborhood of the tectonically active area. Paricularly in Japan, where the tectonic activity of the earth's crust is conspicuous and where Professors Milne and Ewing initiated studies on both seismology and ferromagnetism of materials about ninety years ago, the problem of a possible casuality between a great earthquake and a geomagnetic variation was seriously considered even in the early days (e.g. Milne 1890, Tanakadate and Nagaoka 1893). Even if the magnetic properties of crustal rocks themselves were very little known in those days, the magnetostriction and its reverse phenomenon of ferromagnetics had been reasonably well understood on the basis of classical thermodynamics. It seems that their knowledge of the magnetostriction phenomena led them to consider a possiblility of the magnetic effect of mechanical stresses upon the crustal rocks. Efforts to correlate earthquakes with local anomalous variation of the geomagnetic field in the neighborhood of their epicenters have been continued by S. Nakamura and his successor Y. Kato. (e.g. Kato 1939). Rothé (1950) also considered, based on European data, a possibility of appearance of local geomagnetic changes caused by seismic activity. As Kalashnikov (1954) stated and Rikitake (1968a, b) has recently confirmed, it seems most likely that those old reported data of appreciably large geomagnetic changes associated with earthquakes are due to mechanical vibration of magnetographs (in the case of magnetogram records) and to uncertainty in reoccupying the survey points and insufficient accuracy of the magnetometer in the case of repeated magnetic surveys. Indeed, precise observations of the geomagnetic field over a long period of time have been extremely difficult until recent years. At the present time, the proton precession magnetometer as well as the optical pumping one, can enable us to make reliable measurements of the geomagnetic secular variations of small magnitude, say one gamma or less, in its absolute intensity. Thus, the problem whether the geomagnetic field is locally distorted by the magnetostriction effect of the earth's crust has come back to life again in this modern age. Now, we have laboratory data, with reasonable theoretical supports, about how much change in the magnetization of the crustal rocks can be caused by mechanical stresses. Hence, the pattern and magnitude of a possible distortion of the geomagnetic field can be predicted by considering the distribution of mechanical stresses within the earth's crust in tectonically active areas.

Results of the prediction of this kind (e.g. Stacey 1964, Yukutake and Tachikawa 1967) have given the figure of several gammas (or several tens of gamma at most) as the observable geomagnetic variation on the earth's surface corresponding to the maximum considered strength of stress, namely, 100 kg/cm^2.

Careful observations of the geomagnetic field variations in association with tectonic movement such as an earthquake or creep of an active fault have been and are carried out by use of either reliable magnetographs or magnetometers. The largest difficulty which still exists in the modern procedure of the precise measurement of the geomagnetic variations is due to natural geomagnetic noises which are produced by the ionospheric and magnetospheric electric currents and their electromagnetic induction within the heterogeneous interior of the earth. Various techniques to eliminate these noises have been proposed and implemented, though they are not yet fully satisfactory. It may be said, however, that we can now reduce the effect of these noises to be less than one gamma even in a long-run record of the geomagnetic variations.

Several noticeable results of geomagnetic measurements to indicate their very probable relationship with local tectonic activities will be discussed in this review report. All the results have indicated that the detected local geomagnetic changes are of the order of magnitude of several gammas and less than 20 gammas at most. It seems thus that a study of local geomagnetic variations in association with tectonic activities through magnetic behaviours of stressed rocks, namely, *tectonomagnetism,* is beginning to qualify as a member of modern geomagnetism which should require a reliable self-consistent basis of physics.

There is another possible effect of a tectonic deformation of the earth's crust directly upon its magnetization and indirectly upon the geomagnetic field. That is an irreversible change in the direction and intensity of the remanent magnetization of rocks caused by their plastic deformations. This magnetic change is principally caused by a geometrical re-configuration of magnetized mineral particles in accordance with a plastic deformation of the non-magnetic matrix body of rocks. A number of actual cases of this kind of change have been reported particularly in regard to sedimentary rocks.

Table I gives a brief summary of possible types of changes of the magnetization of rocks caused by the crustal deformations: The crustal deformations may be classified into the elastic and plastic ones. The elastic deformation of rocks can be accompanied by both reversible and irreversible changes of their magnetization, as will be discussed in a later section, whereas the plastic deformation does not cause a reversible magnetic change.

2. LAND DEFORMATIONS AND LOCAL GEOMAGNETIC VARIATIONS

Remarkable land deformations which are closely related to great earthquakes have been actually observed in a number of cases. Fig. 1 shows tilting changes of Muroto promontory before and after the great earthquake (M=8.1) in southwestern Japan on December 21, 1946 (Nagata 1950, Okada and Nagata 1953). The promontory had been continuously tilting towards the direction of S10°E with average speed of 0.035"/year during, at least, 40 years before the earthquake; that is to say, the southernmost point of this promontory had been continuously subsiding. Simultaneously with the occurrence of the great earthquake, this point upheaved suddenly by about 110cm, resulting in a sudden reverse tilting of the promontory by about 7" in angle towards the direction of N10°W, as shown in Fig. 1. After the earthquake, the promontory has been tilting again towards S10°W, a little rapidly in the beginning and with almost constant speed of 0.035"/year later. According to the old records, Muroto's point was slowly subsiding before the great earthquakes in 1707 and 1854 in this district and both earthquakes were associated with abrupt upheavals of the point of more than one meter. These facts may lead us to conclude that the earth's crust in this area has continued to periodic deformation with a period of 100 to 150 years in such a manner as shown in the bottom of Fig. 1. Results of geomorphological studies on the inclination of the old beach lines on the marine terrace along the sea coast of this promontory also seem to support this conclusion, and they suggest further that the periodic deformation has continued during about 10^4 years in the past. Then, one may assume that the long-term general tendency of the tectonic motion of this area is a tilting towards N10°W, but the tectonic motion of Muroto promontory is resisted by some force, resulting in a reversed tilting towards S10°E, until a certain break-down of the continuous deformation of the reversed direction takes place. If it is so, the continuous slow tilting towards S10°E may represent an elastic deformation of the crust in this area, while an abrupt tilting towards the reverse direction associated with a great earthquake may indicate a release of the elastic stress by a break-down of the crust. In other words, this may be a typical example of the elastic rebound of the earth's crust in tectonically active regions.

Table I. Possible Types of Magnetization Change of Rocks Caused by the Crustal Deformations

Deformation \ Magnetic Change	Reversible	Irreversible
Elastic	Yes: $\begin{pmatrix} K \\ J_{HR} \end{pmatrix}$	Yes (J_{SR})
Plastic	No	Yes (J_R)

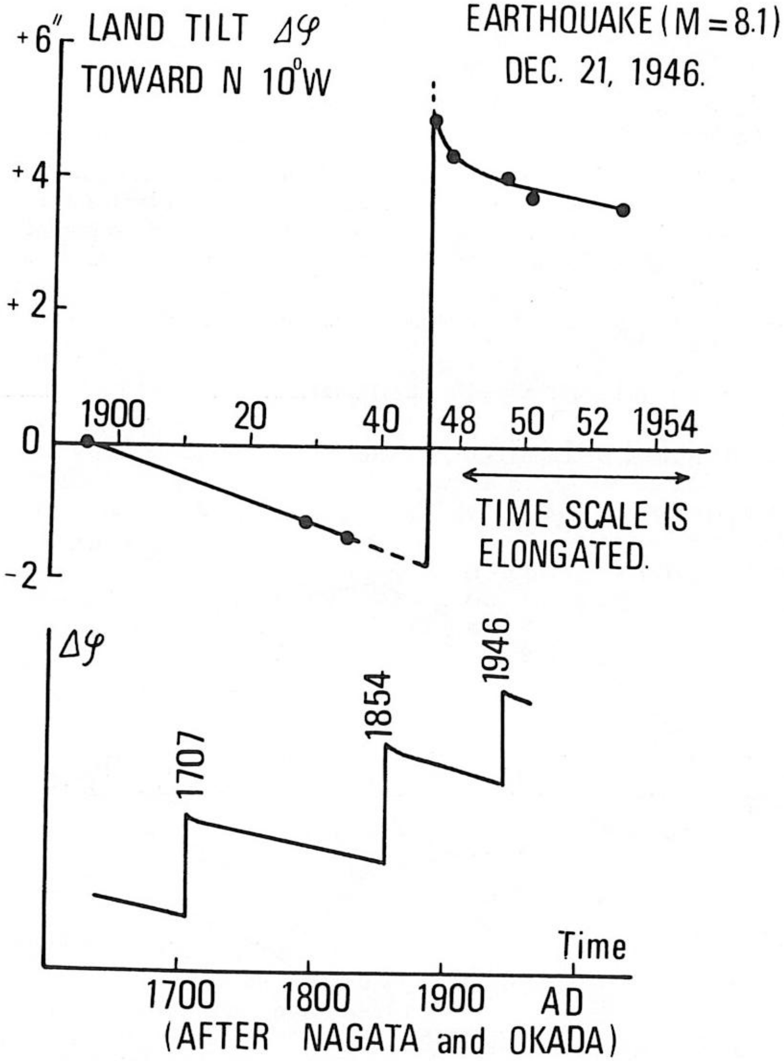


Figure 1. Land deformation of Muroto Promontory accompanying the great earthquake in 1946, and its preceding land deformations related also to great earthquakes.

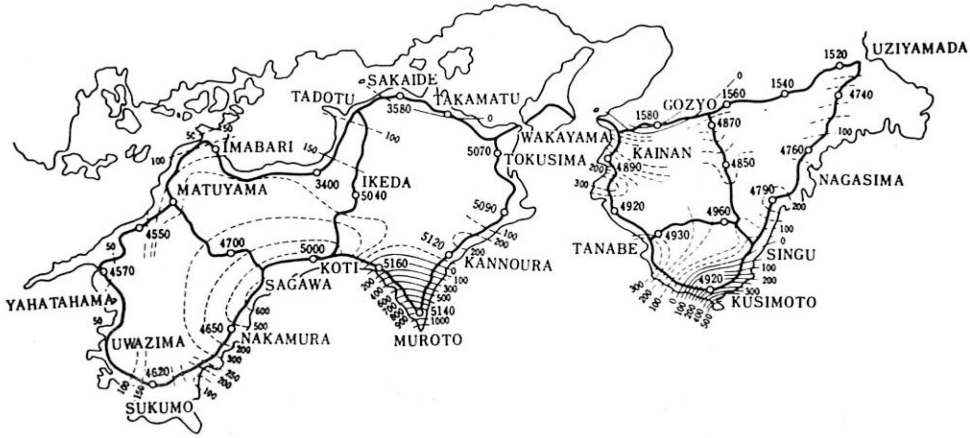


Figure 2. Earthquake time acute deformation. Full line: upheaval.
(After N. Miyabe) Broken line: subsidence in units of mm.

As shown in Fig. 2, the southernmost point of Kii Peninsula also upheaved abruptly by about 50 cm at the time of the earthquake (Miyabe 1955), and as shown in Fig. 3, this peninsula had been tilting southwards until the abrupt northward tilting took place (Okada 1960). The epicenter of the great earthquake is located between Muroto promontory and Kii Peninsula. It seems very likely, therefore, that Kii Peninsula also has repeated a periodic land deformation similar to that of Muroto Promontory.

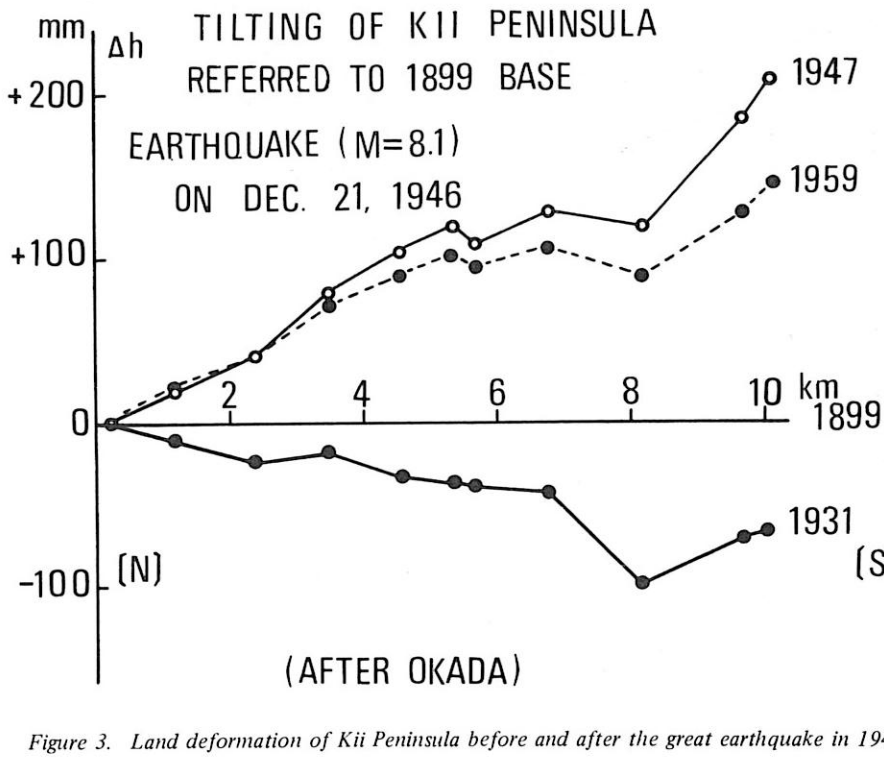


Figure 3. Land deformation of Kii Peninsula before and after the great earthquake in 1946.

In a hydrographic observatory very close to the southernmost point of the peninsula, absolute values of the geomagnetic declination were measured every 5 days on a routine base. Fig 4 shows an abrupt change in the observed declination at the time of the great earthquake. It is no doubt that the geomagnetic declination changed by about 4 minutes in angle in association with the great earthquake. Kato and Utashiro (1949), who found this discontinuous change, are further inclined to point out that a slight increase before the earthquake would be a certain kind of precursor of the earthquake.

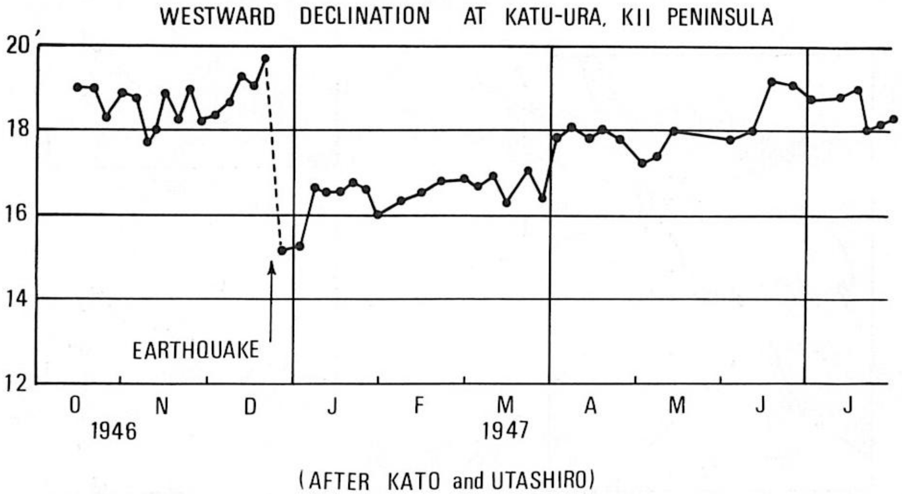


Figure 4. Anomalous variation of the geomagnetic declination observed at Katu-ura, Kii Peninsula during the period from before to after the great earthquake in 1946.

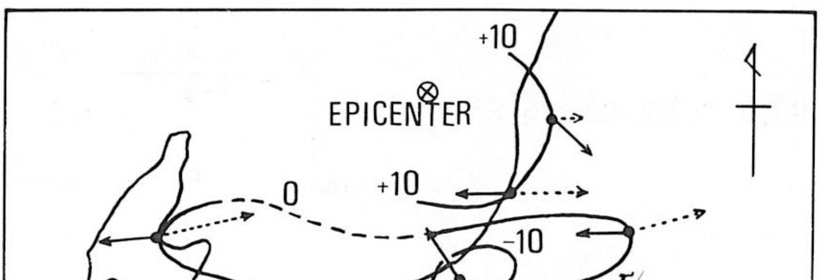


Figure 6. (Compiled based on data observed by Fujita)
Anomalous geomagnetic secular variations during 10 years before the earthquake in Niigata Prefecture (full arrows for the horizontal variation vectors and contours for the vertical variation in unit of gamma per year) and recovering anomalous secular variation during one year after the earthquake (dotted arrow for the horizontal variation vectors.)

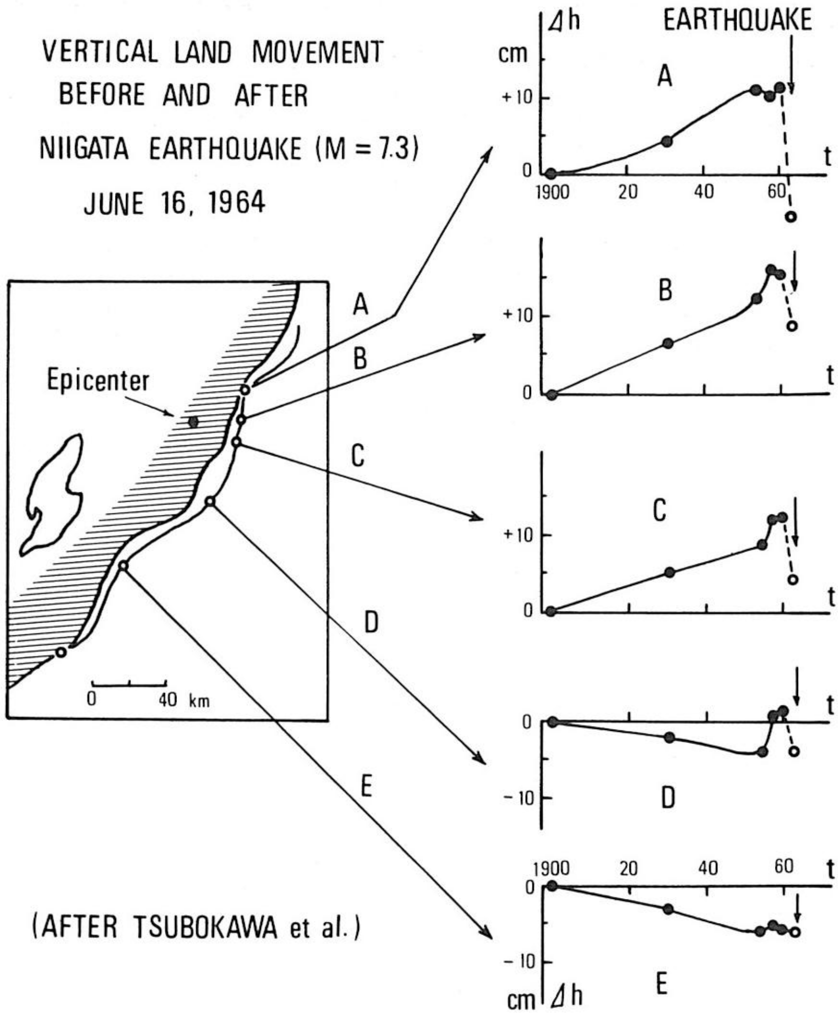


Figure 5. Land deformation before and after the Niigata earthquake in 1964.

Fig. 5 illustrates another example of markedly anomalous land deformation before a great earthquake (Tsubokawa et al. 1964). Along the levelling route shown in the figure, bench marks (A)-(E) began to upheave anomalously about ten years in advance of the great Niigata earthquake (M=7.3) on June 16, 1964. After the earthquake, all bench marks subsided as indicated by hollow circles in the figure. The land deformation was larger at a bench mark closer to the epicenter. (Remarks: Bench marks, D and E, are located on a thick layer of Quaternary deposits which has long been continuing to contract). In this area, the secular variation rate of the geomagnetic declination was anomalously larger (by about 2' during 10 years in advance of the earthquake) compared within the neighboring areas, as shown in Fig. 6 (Fujita 1965). The anomalous geomagnetic change recovered to the ordinary normal value during about one year after the earthquake.

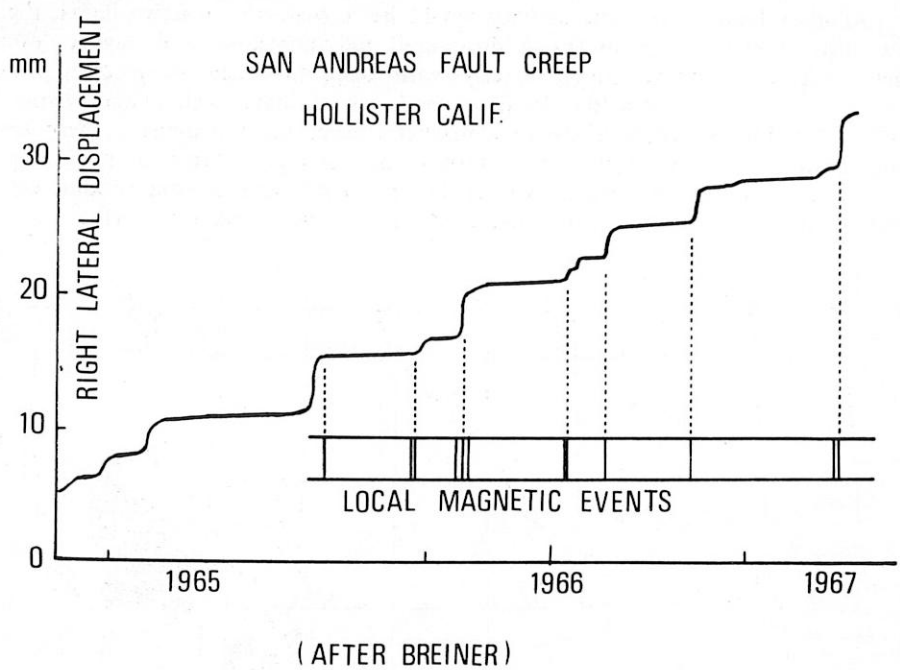


Figure 7. Discontinuous creeps of San Andreas Fault, association with local geomagnetic events.

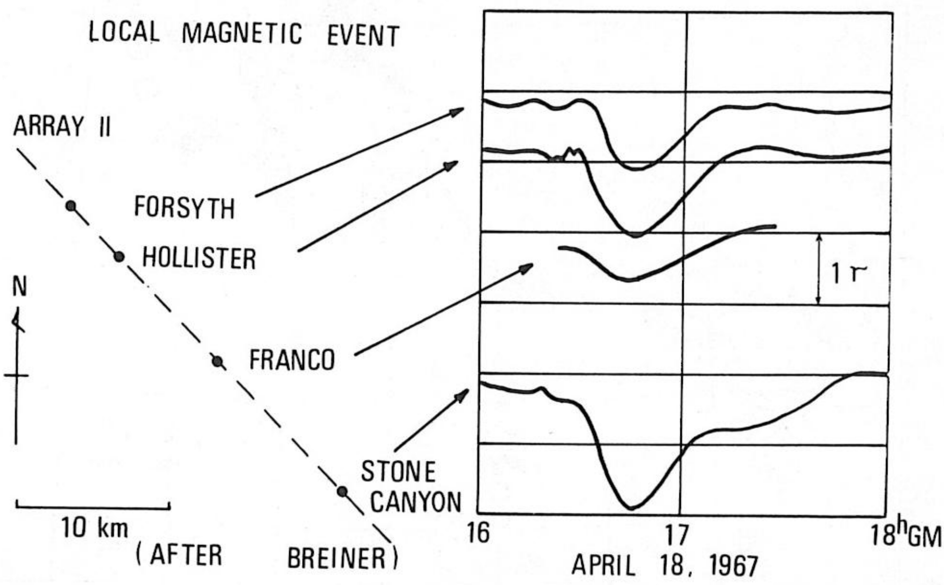


Figure 8. Example of the local geomagnetic event.

Another kind of tectonic activity would be movements of active faults. Fig. 7 shows discontinuous creeps of San Andreas fault and anomalous local magnetic events which took place almost simultaneously with discontinuously sharp creep events (Breiner 1967). The anomalous local magnetic events have such characteristics as illustrated in Fig. 8, where is shown a magnetic event accompanying a sharp creep event on April 18, 1967 given in the rightmost part of Fig. 7. Attention must be paid to a fact that the magnetic change is reversible, recovering to the ordinary value within about one hour, whereas the corresponding creep is an irreversible movement.

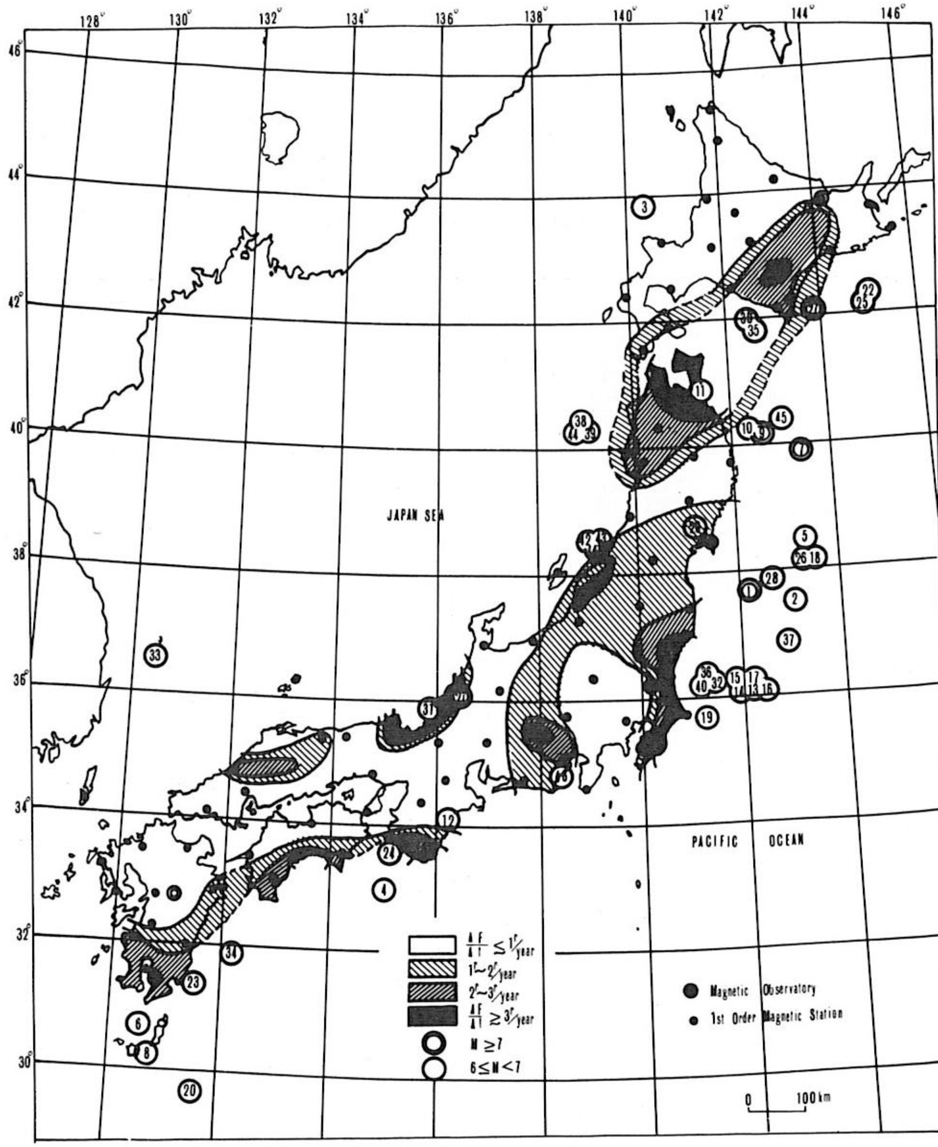


Figure 9. Distribution of anomalous secular variation at geomagnetic total force for 1955-60. (After Tazina)

3. EARTHQUAKES AND LOCAL GEOMAGNETIC VARIATIONS

Examples of sharp land deformations associated with anomalous geomagnetic variations, given in Fig. 1 – Fig. 6, have already suggested a possible relationship between a large earthquake and an anomalous geomagnetic variation in the epicentral area. Partly for the purpose of detecting abnormal areas of the geomagnetic secular variation rate, precise magnetic surveys have been repeated over Japanese Islands since 1955. Fig. 9 shows the distribution of the anomalous secular variation rate of the geomagnetic total force (F) observed during 1955-60, together with epicenters of earthquakes of M⩾6 which took place during 1959-1965 (Tazima 1966). The areas where the annual rate of change in F is larger than 2γ/year compared with the standard rate are closely related with nearby major earthquakes with only one exception of an anomalous area between 34°N and 36°N in latitude and between 132°E and 134°E in longitude.

The anomalous secular variations usually proceed in a way shown in Fig. 10, (Tazima 1966), which is the case of an anomalous area near 34°N in latitude and 136°E in longitude in Fig. 9. At magnetic bench mark A, which is located 36 km away from the epicenter of an earthquake of M=6.4, the rate of secular variation in F amounted to about 7γ/year during 1950-1960, whereas the ordinary rate of the secular variation in this region was 2 – 3 γ/year as indicated by the observed values at magnetic bench marks B and C. After two large earthquakes occurred, the anomalous increase in F at bench mark A has been coming back to the ordinary value. It seems thus an anomalous area of the geomagnetic secular variation rate is correlated, in some way, with an accumulation of stress energy and its release within the area.

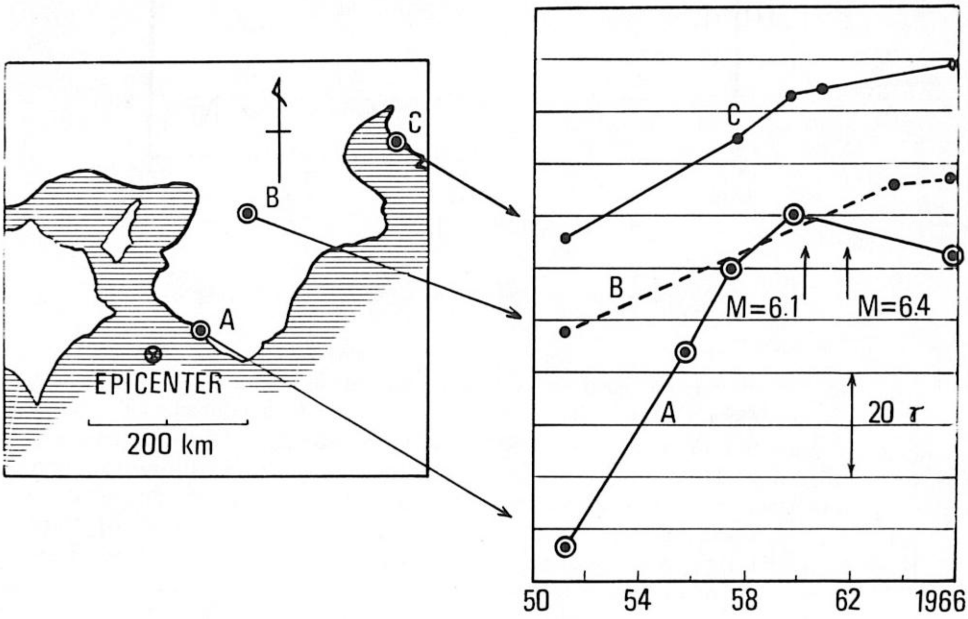


Figure 10. Example of anomalous secular 1 variation in the geomagnetic field total force and correlated earthquakes. (After Tazina)

Fig. 11 illustrates, then, a correlation between the radius (r) of an area of anomalous secular variation rate defined by $\Delta F/\Delta t \geqslant 2\gamma$/year and the magnitude (M) of the nearest earthquake to the anomalous area, (Rikitake 1969). Between r and M, there holds an approximate correlation equation expressed by $\log r^3 = 11.4 + 1.1\ M$.

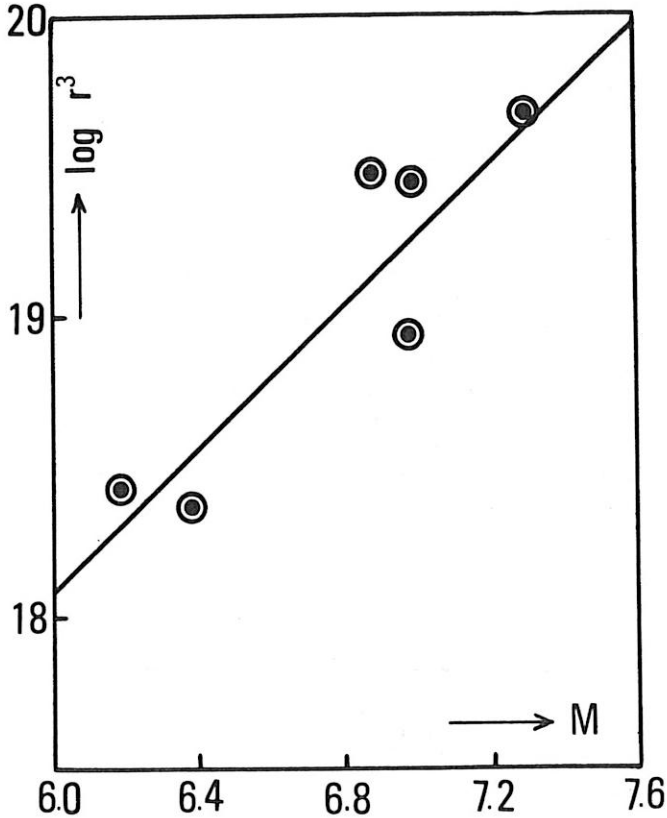


Figure 11. Magnetically anomalous area and magnitude of neighbouring quake. (After Rikitake)

On the other hand, earthquake swarms also seem to have some correlation with local geomagnetic variations. The earthquake swarms which continued during 1964-66 in Matsushiro area in Japan gave a good opportunity to Japanese geophysicists to make an extensive study on this problem by using an array of six proton precession magnetometers. Fig. 12 shows the changes of the total geomagnetic force at Matsushiro (ΔF_M) and at another station (ΔF_H) about 6 km north of Matsushiro. Here ΔF_M and ΔF_H are obtained relative to a standard magnetic observatory about 200 km apart from the seismic area. In accordance with the seismic activity towards August, 1966, an increase of about 5γ in ΔF_M and a decrease of the same order in ΔF_H can be observed in the figure. The anomalous changes recovered to the ordinary level when the particular seismically active period was over. The workers of this research program (Rikitake et al. 1966 a, b, c, 1967a, b) have pointed out that M and H stations are located on sites of positive and negative areas respectively of the local geomagnetic anomaly which is interpreted to be due to a subterranean magnetized

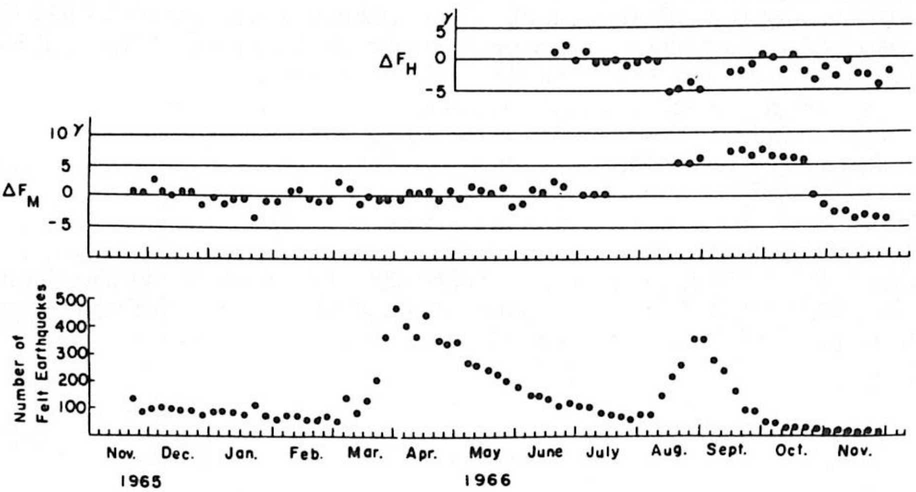


Figure 12.
Five-day means of the local anomalous changes in the total geomagnetic intensity values at two stations in the seismic area of the Matsushiro earthquake swarm. The bottom curve indicates the number of felt earthquakes.

body of igneous rocks. If we can assume that the magnetization of the subterranean body increases by one per cent or so during the seismically active period, the observed anomalous variation can be explained. Those workers have presumed that the compression of 100 kg/cm^2 or less in strength of this area along the east-west direction might cause an intensification of the northward magnetization of the subterranean body. Actually, the distribution of 'pulls' and 'pushes' of the initial motion of swarm earthquakes during this period suggests that the principal axis of compression of this area was oriented approximately along the east-west direction.

In summarizing these data, one may conclude that some great tectonic movements associated with earthquakes are often accompanied by anomalous local variations in the geomagnetic field over the tectonically active area, and that the anomalous geomagnetic changes generally come back to the ordinary state a certain period after the tectonic event. However, we still have some uncertainty. For instance in Fig. 12, no definite answer has yet been given to a question, "Why the seismic activity during March-May, 1966 was not accompanied by an anomalous geomagnetic variation at the existing station, M?"

A completely different aspect of the effects of mechanical stress on the geomagnetic field has been reported by Undzendov and Shapiro (1967). They observed irreversible changes in the geomagnetic field caused by artificial seismic shocks. In their studies, a three-component magnetograph was set up at a site (Station II) where a large local geomagnetic anomaly caused by a magnetite ore has its maximum value (about 15,000γ in the vertical force anomaly) and another one at a control station (Station I) which is 415 m away from Station II and the geomagnetic field is almost normal. Artificial explosions using gunpowder were operated five times nearby these stations to give the seismic shocks to the subterranean magnetized body. Fig. 13 shows examples of their results, where two different types of magnetic variations associated with the seismic shocks can be observed. The first type is a magnetic spike which takes place simultaneously with a seismic shock. The second one is represented by irreversible changes of several gammas which were observed only at Station II. It seems that the first type variation is largely due to mechanical vibrations of the magnetographs, whereas the second type irreversible variations are considered to be genuine magnetic changes introduced by the effect of the seismic stresses on the magnetized body. According to those investigators' estimate, the dynamic stress induced by the seismic waves is in the order of magnitude of $1 \sim 2$ kg/cm^2. It may be concluded that the dynamic stress has caused an irreversible change in the magnetization of the strongly magnetized body of about 2 parts in 10,000. Because the observed magnetic effects are irreversible, the investigators have attributed the effects to the irreversible dynamic magnetization effect (Shapiro and Ivanov 1967), which is basically the same effect as the piezo-remanent magnetization as will be discussed in the later section.

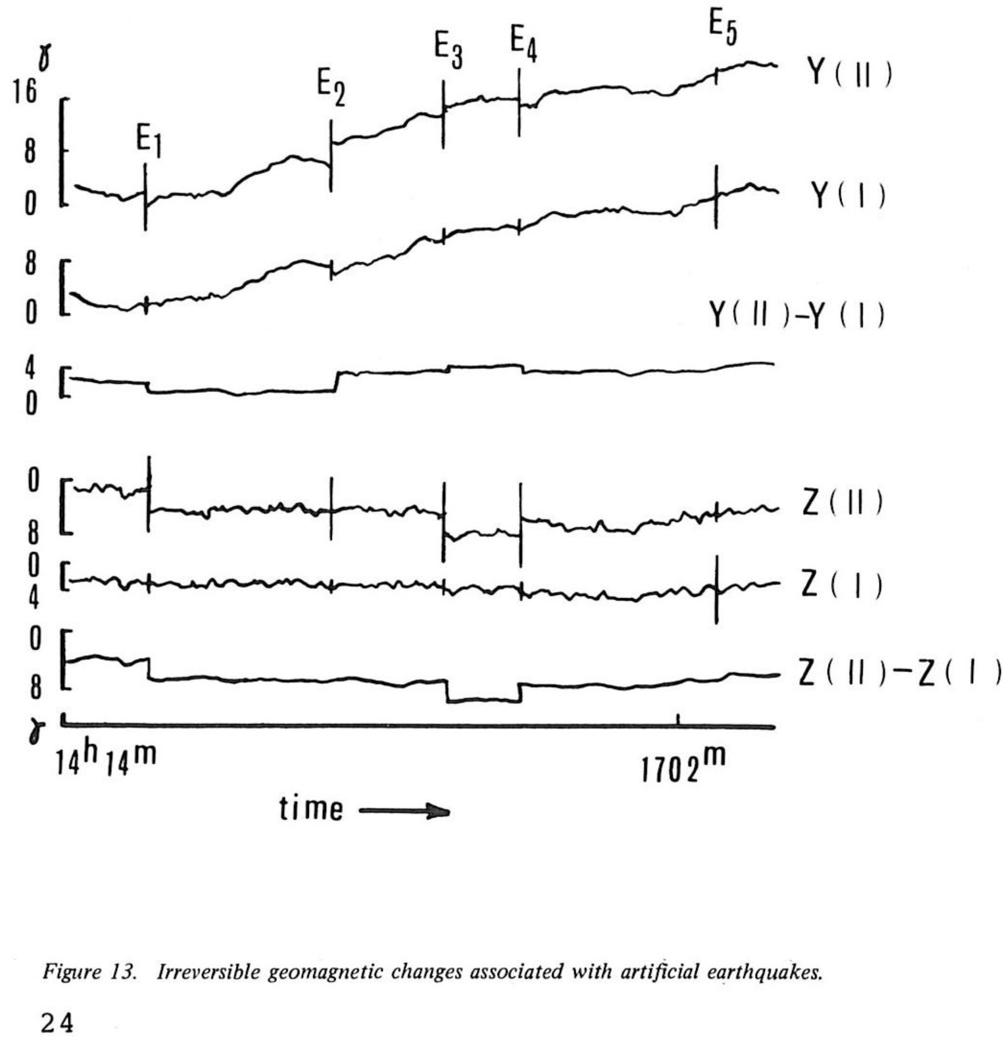


Figure 13. Irreversible geomagnetic changes associated with artificial earthquakes.

4. MAGNETIC CHANGES OF ROCKS CAUSED BY MECHANICAL STRESSES

Various magnetic properties of the crustal rocks under the effects of mechanical stresses have been experimentally and theoretically studied mostly in the last fifteen years. In most cases, these experiments and theories deal with the effects of uniaxial compressions on various kinds of magnetization of rocks either when the compression axis is parallel to the direction of magnetization (the longitudinal effect) or when the former is perpendicular to the latter (the transverse effect). Although the examinations of only the longitudinal and transverse effects are not fully sufficient to describe the anisotropic behaviours of rock magnetization under complicated mechanical stresses in general, the results of those studies are very useful for interpreting the magnetic behaviours of stressed rocks in nature, because the strain of rocks under the maximum considered stress in the earth's crust (i.e. about 100 kg/cm^2 or less) is very small, being 10^{-4} or less.

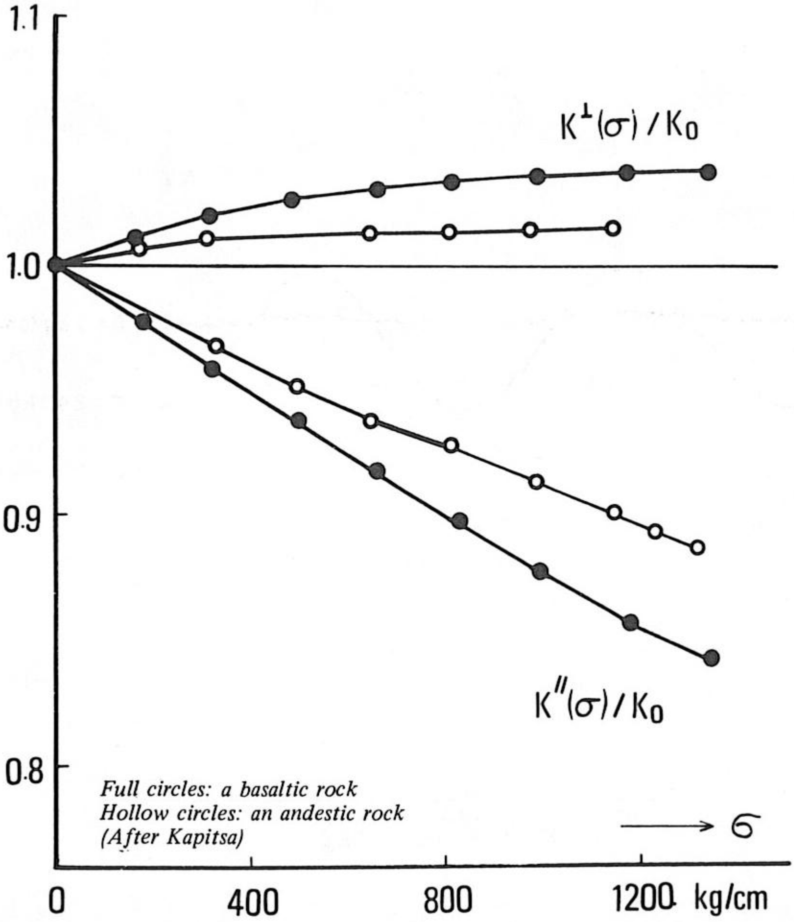


Figure 14.

Two examples of longitudinal ($K/\!/\ (\sigma)$) and transverse ($K^{\perp}(\sigma)$) effects of uniaxial compression on the magnetic susceptibility of natural rocks.

Among various parameters of rock magnetism, some parameters change reversibly with a uniaxial compression (σ), but they come back to their initial states when the compression is taken away. These parameters are the initial magnetic susceptibility (K) and the hard remanent magnetization (J_{HR}), such as the thermoremanent magnetization (TRM), and the chemical remanent magnetization (CRM) of igneous and thermal metamorphic rocks. Some others change irreversibly with a compression, their change remaining after the compression is taken out. These irreversible changes take place for the soft remanent magnetization (J_{SR}), such as the isothermal remanent magnetization (IRM), and the piezo-remanent magnetization (PRM) acquired at the atmospheric temperature and in a weak magnetic field such as the geomagnetic field.

Fig. 4 shows two examples of the reversible change of the magnetic susceptibility caused by the longitudinal and transverse compressions, (Kapitsa 1955). Fig. 15

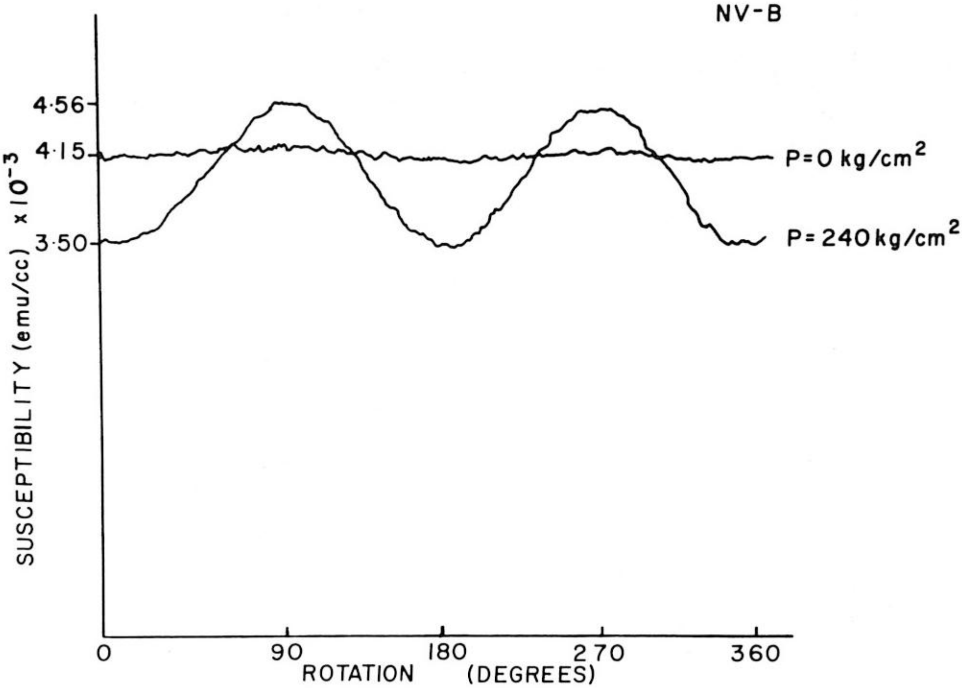


Figure 15. Anisotropic magnetic susceptibility of a rock introduced by a uniaxial compression. The axis of compression coincides with the direction of $0^\circ - 180^\circ$ in this figure. (After Kean)

shows an example of the anisotropic magnetic susceptibility of uniaxially compressed rock. As shown in these examples, the longitudinal magnetic susceptibility, $K^{\|}(\sigma)$, decreases with an increase of uniaxial compression σ, whereas the transverse susceptibility, $K^{\perp}(\sigma)$, increases with σ. The simplest possible empirical expressions to satisfy both relations between $K^{\|}(\sigma)$ and σ and between $K^{\perp}(\sigma)$ and σ may be given by

$$\frac{K^{\|}(\sigma)}{Ko} = \frac{1 + \alpha\beta\sigma}{1 + \beta\sigma} , \tag{1}$$

$$\frac{K^{\perp}(\sigma)}{Ko} = \frac{1 - \alpha F(\sigma)}{1 - F(\sigma)} , \tag{2}$$

$$F(\sigma) \equiv (\epsilon + \tfrac{1}{2}\beta\sigma) - \sqrt{\{\epsilon^2 + \tfrac{1}{4}(\beta\sigma)^2\}} , \tag{3}$$

where Ko denotes the original isotropic susceptibility without a compression effect and α (<1), β and ϵ (<1) are constant parameters. When $\sigma \to \infty$ in these expressions

$$\lim_{\sigma \to \infty} K^{\|}(\sigma) = \alpha Ko < Ko , \tag{4}$$

$$\lim_{\sigma \to \infty} K^{\perp}(\sigma) = \frac{1 - \alpha\epsilon}{1 - \epsilon} Ko > Ko . \tag{5}$$

When $\beta\sigma \ll 1$ on the other hand,

$$K^{\|} (\beta\sigma \ll 1) \simeq Ko \quad \{1 + (1 - \alpha)\beta\sigma\}^{-1} , \tag{6}$$

$$K^{\perp} (\beta\sigma \ll 1) \simeq Ko \quad \left\{1 + \frac{(1 - \alpha)}{2} \beta\sigma\right\} , \tag{7}$$

whence

$$-\frac{\partial}{\partial\sigma} K^{\|} (\sigma) \Big/ \frac{\partial}{\partial\sigma} K^{\perp} (\sigma) = 2 \quad \text{for } \beta\sigma \ll 1 . \tag{8}$$

Equations (4) through (8) are the necessary conditions required from the experimental data for empirical expressions (1) through (3).

Results of experimental measurements have shown that $(1 - \alpha)\beta$ is of the order of magnitude 10^{-4} cm^2/kg. Therefore, (6) and (7) can safely hold for $\sigma < 10^3$ kg/cm^2 which is much beyond the maximum breaking strength of the earth's crust. More simply, (6) and (7) can be re-written as

$$K^{\|} (\sigma) \simeq Ko(1 - \beta'\sigma) , \tag{6'}$$

$$K^{\perp} (\sigma) \simeq Ko(1 + \tfrac{1}{2}\beta'\sigma) \tag{7'}$$

Then, the observed values of β' (Kalashnikov and Kapitsa 1952, Kapitsa 1955, Nagata 1959a) ranges from 0.5×10^{-4} to 5×10^{-4} cm^2/kg for igneous rocks.

An example of the reversible longitudinal effect of uniaxial compressions on TRM of a basaltic rock is shown in Fig. 16 (Ohnaka and Kinoshita 1968). For the range of $\sigma \lesssim 10^3$ kg/cm^2, the reversible longitudinal effect can be approximately expressed by

$$J_{HR}^{\|} (\sigma) \simeq J_{HR}^{0} (1 - \beta''\sigma) , \tag{9}$$

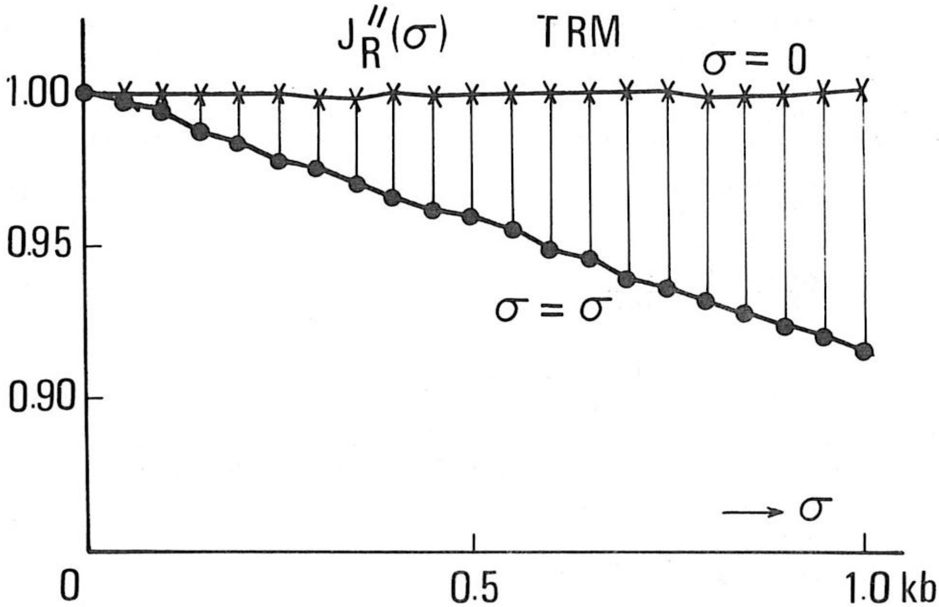


Figure 16.
An example of the reversible longitudinal effect of uniaxial compression on the thermo-remanent magnetization of a basaltic rock. Full circles represent the relative intensity under compression (σ) and the crosses represent the relative intensity after removal of σ which is represented by the abscissa value. Vertical lines represent the relative amount of the reversible change with respect to σ. (After Ohnaka and Konoshita)

where β'' ranges from 0.3×10^{-4} to 1.2×10^{-4} cm^2/kg for igneous rocks. Fig. 17 illustrates an example of the transverse effect of uniaxial compressions on the natural remanent magnitization (NRM) of a basalt (Ohnaka and Kinoshita 1968). NRM of this sample consists of the hard component of TRM as the major portion and the soft component of IRM as the minor portion. The hard component changes reversibly with σ whereas the soft component decreases irreversibly with σ, as will be discussed later. Regarding only the reversible change of the hard component, the transverse effect of uniaxial compression on the hard remanent magnetization may be expressed for $\sigma \lesssim 10^3$ Kg/cm^2 as

$$J_{HR}^{\perp}(\sigma) \cong J_{HR}^{o}(1 + \gamma\sigma) , \tag{10}$$

where γ also is of the order of magnitude of 10^{-4} cm^2/kg or less.

In the case of IRM acquired in a weak magnetic field, both the longitudinal and transverse uniaxial compressions result in an irreversible decrease of the magnetization, as shown, for example, in Fig. 18 (Nagata and Carleton 1969a). In this figure, the normalized rate of decrease of IRM (as a relative value compared with the uncompressed initial magnetization) is given as a function of σ/H, where H represents the intensity of a magnetic field which has produced the concerned IRM. In other words, IRM acquired in a weaker magnetic field can be demagnetized with the same rate by a weaker compression. As seen in the figure, the transverse effect is always a little smaller (by 10~25%) than the longitudinal one, though both effects cause the demagnetization of IRM. The irreversible decrease of NRM with the transverse compression, which is observed in the plots of $\sigma = 0$ in Fig. 17, can be attributed to this demagnetizing effect on the soft remanent magnetization.

When σ/H is not large, say $\sigma/H \leq 5$ kg/cm^2 Oe, the demagnetization effects are approximately expressed by

$$J_{SR}^{\parallel}(\sigma) \cong J_{SR}^{o}(1 - \alpha'\sigma^*/H) \quad , \tag{11}$$

$$J_{SR}^{\perp}(\sigma) \cong J_{SR}^{o}(1 - \alpha''\sigma^*/H) \quad , \tag{12}$$

where $\alpha'' < \alpha'$ and σ^* represents an irreversible effect of σ. Experimental results have indicated that $\alpha' = 0.02 \sim 0.12$ Oe cm^2/kg for igneous rocks and $\alpha'' = (0.75 \sim 0.90)\alpha'$.

The piezo-remanent magnetization (PRM) also belongs to the category of the soft remanent magnetization. When a uniaxial compression is released from a rock sample in the presence of a magnetic field, the remanent magnetization thus acquired becomes appreciably larger than the ordinary IRM acquired in the same magnetic field, as shown by an example in Fig. 19 (Nagata and Carleton 1968, 1969a). This particular remanent magnetization has been named the piezo-remanent magnetization (PRM). As shown in Fig. 20, both the longitudinal and transverse compressions can produce PRM along the direction of an applied magnetic field, though the transverse PRM is a little smaller than the longitudinal PRM. Roughly speaking, both the longitudinal and transverse PRM's of rocks increase almost linearly with H and σ, provided that H is small, say H < 10Oe, and σ is of a moderately small value, say 20 kg/cm^2 < σ < 200 kg/cm^2. In such a case, we may express the experimental results by

$$J_{PRM}^{\parallel} \cong CH\sigma^* \quad , \tag{13}$$

$$J_{PRM}^{\perp} \cong C'H\sigma^* \quad , \tag{14}$$

where C' < C. For igneous rocks, C = (0.3 ~ 13.0) x 10^{-6} emu/Oe kg/cm^2 and C' = (0.75 ~ 0.90) C.

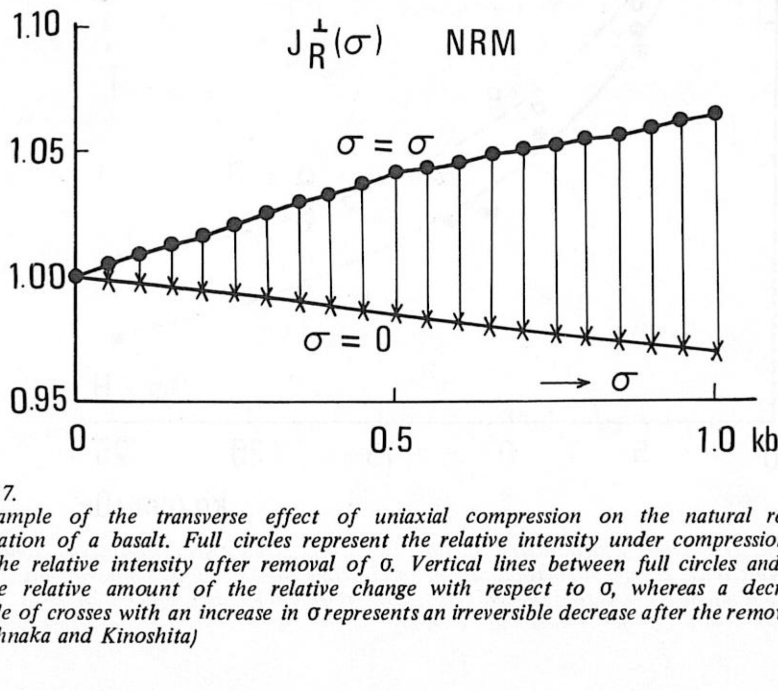


Figure 17.
An example of the transverse effect of uniaxial compression on the natural remanent magnetization of a basalt. Full circles represent the relative intensity under compression σ and crosses the relative intensity after removal of σ. Vertical lines between full circles and crosses show the relative amount of the relative change with respect to σ, whereas a decrease of magnitude of crosses with an increase in σ represents an irreversible decrease after the removal of σ. (After Ohnaka and Kinoshita)

Similar irreversible effects of mechanical stresses on the magnetization of rocks have been found in a somewhat different way. Following Petrova's initial work (Petrova 1961), Shapiro and Ivanov (1967) demonstrated that PRM is produced in magnetic minerals and rocks by giving mechanical shocks repeatedly on the samples in the presence of the geomagnetic field, and they named the remanent magnetization thus acquired the dynamic magnetization. In their experiments also, the dynamic magnetization coincides in direction with the magnetic field and is independent of the direction of shocks. According to their experimental results, the dynamic remanent magnetization, (Dynamic RM), J_{DR}, increases with an increase of number of shocks, n., in such a manner as shown by

$$J_{DR} = J_{DRS} \left[1 - \exp(-bn)\right] , \tag{15}$$

where J_{DRS} means the saturated value of Dynamic RM in a given field and for the constant strength of the shocks. They also have experimentally demonstrated that the soft remanent magnetization is demagnetized by giving mechanical shocks repeatedly in the non-magnetic space, and they have named this procedure the shock demagnetization. This phenomenon may correspond to the demagnetization effect of a static uniaxial compression expressed by (11) and (12).

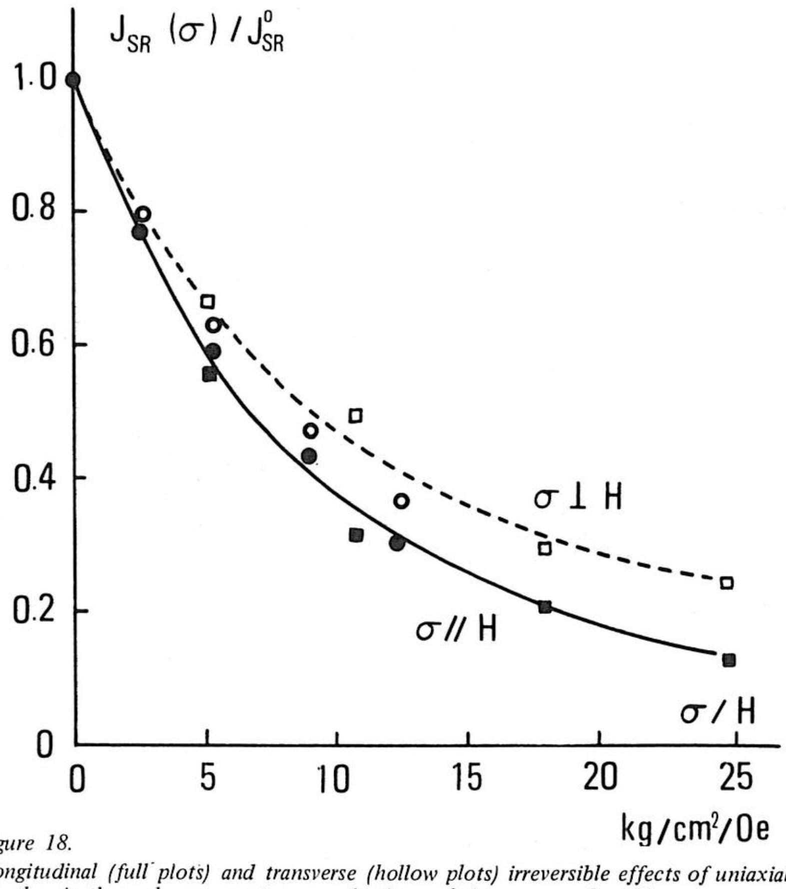


Figure 18.
Longitudinal (full plots) and transverse (hollow plots) irreversible effects of uniaxial compression on the isothermal remanent magnetization of igneous rocks. Plots represent the residual magnetization after removal of uniaxial compression σ. Circles and squares of plots indicate different values of σ. (After Nagata and Carleton).

Characteristics of the two different categories (i.e. reversible and irreversible) of the effects of uniaxial compressions on the rock magnetization can be theoretically explained with satisfactory agreement with the experimental data. In general, any change of magnetization of ferromagnetics such as magnetic minerals in rocks is due to three different kinds of processes: i.e., (a) movements of the 180° domain walls, (b) movements of the 90° domain walls and (c) rotations of the spontaneous magnetization within individual domains. However, a uniaxial compression cannot contribute to a movement of the 180° domain wall, because a change of the domain-driving pressure caused by a uniaxial compression should be the same in both sides of a 180° domain wall. On the contrary, movements of the 90° walls are sensitively subjected to a uniaxial compression, as demonstrated in Fig. 21, where appreciable changes of the domain patterns take place in a magnetite by loading a moderately small uniaxial compression, 30 ~ 120 kg/cm² in strength.

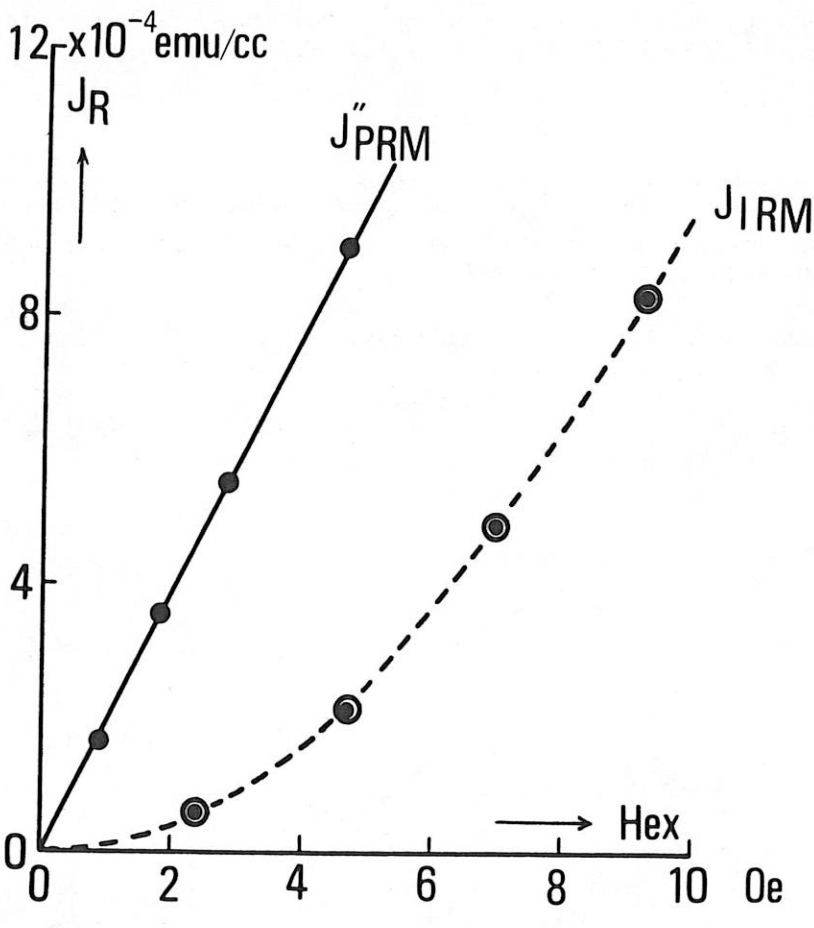


Figure 19.

An example of acquisition of piezo-remanent magnetization ($J/\!/PRM$) by a magnetic field (Hex) and a longitudinal uniaxial compression σ = 118 kg/cm^2, in comparison with the ordinary isothermal remanent magnetization (J_{IRM}) of the same sample.
(After Nagata and Carleton)

Results of theoretical studies (Nagata and Carleton 1969a, b) have shown that the irreversible effects of a uniaxial compression on the rock magnetization are due to the effect of the compression on the irreversible movements of the 90° walls. According to the theoretical results, $J^{\parallel}_{SR}(\sigma)$ and $J^{\perp}_{SR}(\sigma)$ which are empirically expressed by (11) and (12) are theoretically represented by

$$J^{\parallel}_{SR}(\sigma) = J^{o}_{SR}\left(1 - \frac{16}{15\pi}\,hc\,\sigma^*/H\right) \qquad \text{for } \sigma^*/H \leqslant 1/hc\,, \tag{16}$$

$$J^{\perp}_{SR}(\sigma) = J^{o}_{SR}\left(1 - \frac{4}{5\pi}\,hc\,\sigma^*/H\right) \qquad \text{for } \sigma^*/H \leqslant 1/hc\,, \tag{17}$$

and

$$hc = \frac{3\,\lambda_S}{\sqrt{2}\,J_S}\,, \tag{18}$$

where λ_S and J_S denote respectively the isotropic magnetostriction coefficient and the spontaneous magnetization. Comparing (11) and (12) with (16) and (17), we get

$$\alpha' = \frac{16}{15\pi}\,hc\,, \qquad \alpha'' = \frac{3}{4}\,\alpha'\,. \tag{19}$$

The theoretical representations of $J^{\parallel}_{SR}(\sigma)$ and $J^{\perp}_{SR}(\sigma)$ have been obtained for larger values of σ, namely for the range of $\sigma^*/H > 1/hc$. The full and dotted curves in Fig. 18 are the theoretical curves thus obtained.

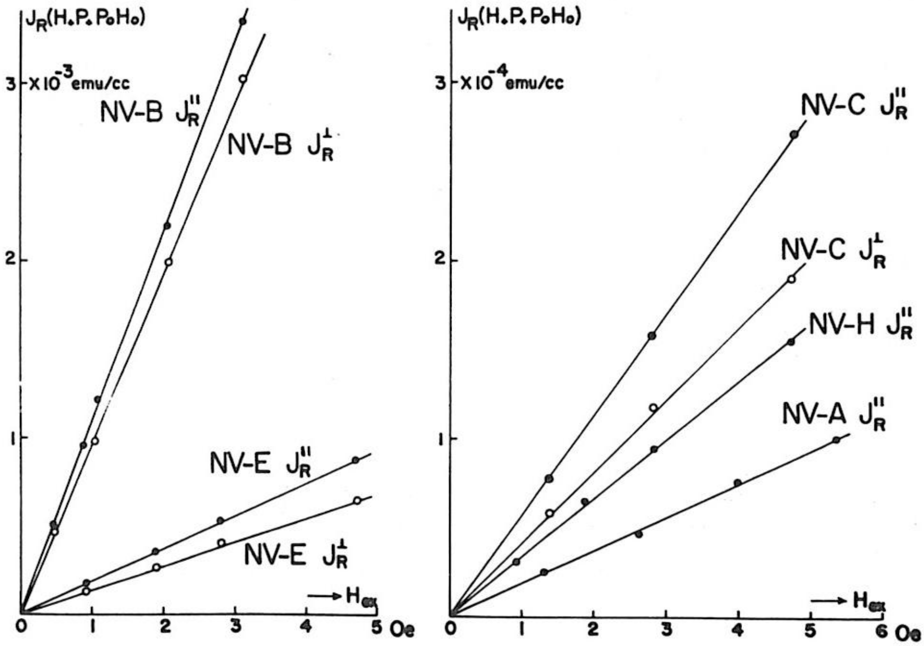


Figure 20.
Linear dependence of $J^{\parallel}_{PRM}$ (= $J^{\parallel}_{R(H+P+PoHo)}$) and $J^{\perp}_{PRM}$(= $J^{\perp}_{(H+P+PoHo)}$) on magnetic fields H, under a constant strength of uniaxial compression $P = \sigma$, where Uniaxial compression $\sigma = P = 118\ kg/cm^2$. (After Nagata and Carleton)

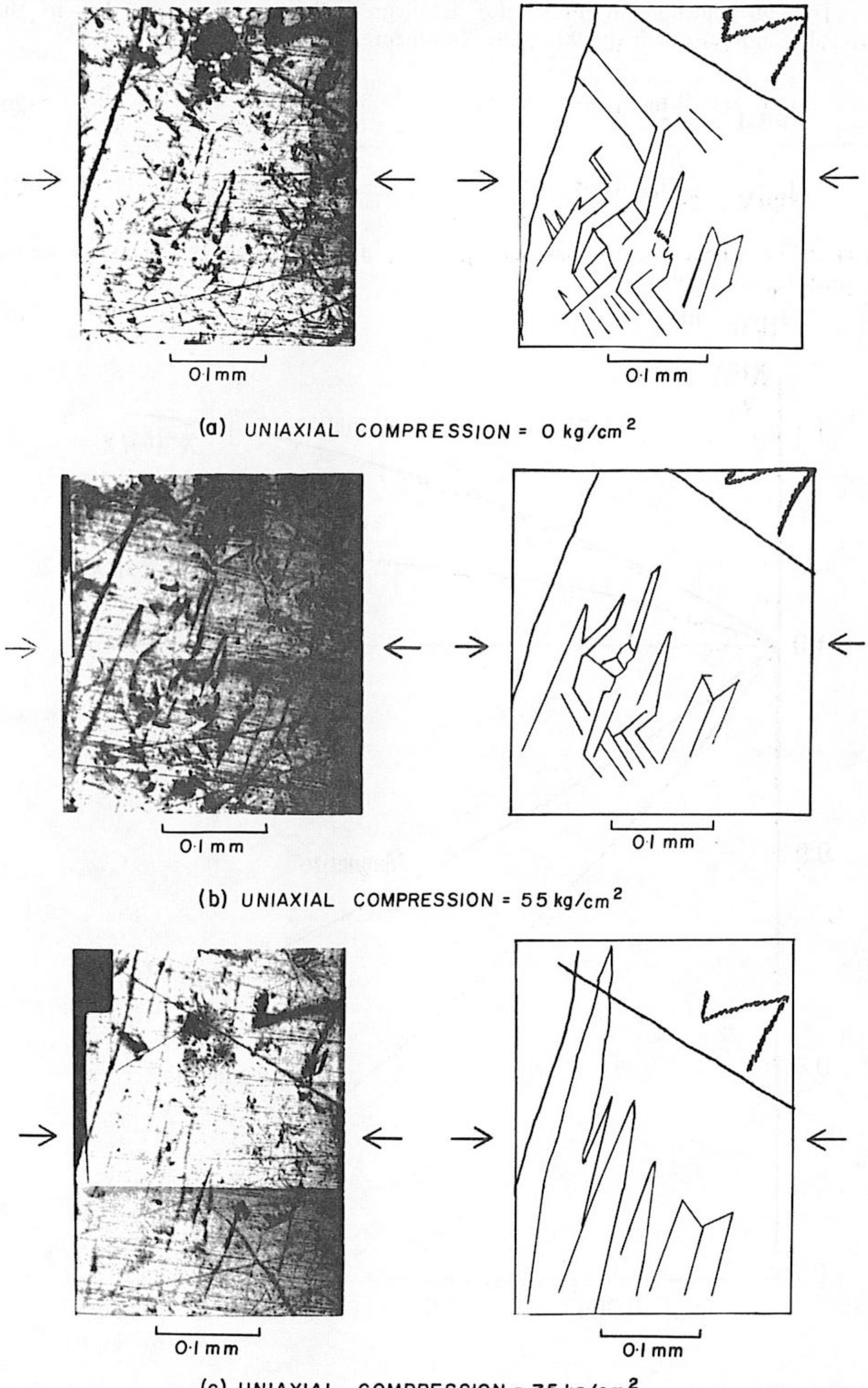


Figure 21. Changes of domain patterns of magnetite caused by uniaxial compressions. (After Kean)

The phenomenon of PRM also is theoretically proved to be due to the irreversible movements of the 90° walls. The theoretical results have given that

$$J_{PRM}^{\parallel} \cong \frac{16}{5\pi} Bhc\ H\ \sigma^* \ , \tag{20}$$

$$J_{PRM}^{\perp} \cong \frac{12}{5\pi} Bhc\ H\ \sigma^* \ , \tag{21}$$

for H << hc, where B is the coefficient for the ordinary IRM which can be represented for small values of H by

$$J_{IRM} = BH^2 \tag{22}$$

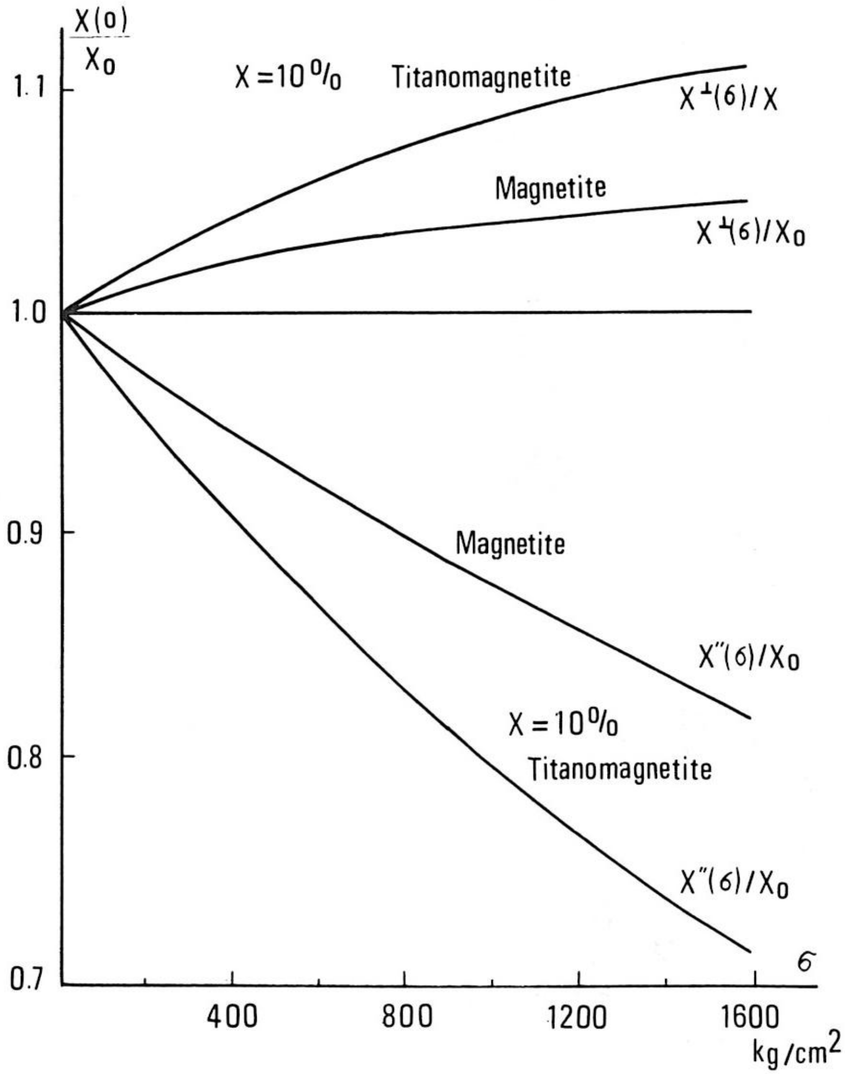


Figure 22.

Theoretical curves of longitudinal and transverse effects of uniaxial compressions on magnetic susceptibility of magnetic minerals. (After Nagata)

A comparison of (13) and (14) with (20) and (21) leads to

$$C = \frac{16}{5\pi} Bhc \quad , \qquad C' = (3/4)C \quad . \tag{23}$$

In the theoretical expressions of α' and C thus obtained, experimentally observable values of the magnetic parameters, λ_S, J_S, and B, of rockforming magnetic minerals are involved. It has been proved by comparison of these values that the theoretical expressions (16), (17), (20), and (21) are very reasonable.

The theories have further predicted that the effects of a uniaxial tension on these irreversible phenomena should be the same as those of a uniaxial compression of the same strength.

On the other hand, the reversible effects of a longitudinal compression on the magnetic susceptibility (Kapitsa 1955, Kern 1961, Stacey 1962, Nagata 1966) and on the remanent magnetization (Stacey 1958) have been theoretically explained by assuming that the rotation of the spontaneous magnetization is responsible for the observed reversible changes. It has been theoretically shown later (Nagata and Carleton 1969a, b) that the movements of the 90° walls driven by a uniaxial compression cannot result in any change in the reversible magnetic susceptibility. Hence, only a possible cause for a change of the susceptibility owing to a uniaxial compression should be a rotation of the spontaneous magnetization, J_S. On the other hand, it has been experimentally proven that the 180° and 90° walls of magnetic domains carrying the hard remanent magnetizations, TRM and CRM, are very tightly fixed in space so that they cannot be moved by a magnetic force less than 3×10^2 Oe or by a mechanical stress smaller than 3 K bar (3×10^3 kg/cm^2). Hence, a rotation of J_S only should be the cause of change in the magnetization caused by a uniaxial compression in this case also.

A unified theory of the longitudinal and transverse effects of a uniaxial compression, σ, on the magnetic susceptibility based on a model of the rotation of J_S can give the dependences of the longitudinal and transverse rotation susceptibilities, $\chi^{\parallel}(\sigma)$ and $\chi^{\perp}(\sigma)$, upon σ by the curves shown in Fig. 22 (Nagata 1970a). These curves are mathematically expressed by

$$\chi^{\parallel}(\sigma) = \frac{\chi_0}{1 + \beta\sigma} \quad , \tag{24}$$

$$\chi^{\perp}(\sigma) = \frac{\chi_0}{(1-\epsilon) - \frac{1}{2}\beta\sigma + \sqrt{\{\epsilon^2 + (\frac{1}{2}\beta\sigma)^2\}}} \quad , \tag{25}$$

$$\chi_0 = \frac{p\, J_S^2}{N J_S^2 + \frac{4Ku}{3\pi}} \quad , \tag{26}$$

with

$$\beta \equiv \frac{3\lambda_S}{N J_S^2 + \frac{4Ku}{3\pi}} \quad , \qquad \epsilon = \frac{\frac{4Ku}{3\pi}}{N J_S^2 + \frac{4Ku}{3\pi}} \tag{27}$$

where Ku, N and p denote respectively, the effective uniaxial anisotropy energy, the average demagnetization factor of rock-forming magnetic minerals and the volume content of the magnetic minerals in a rock. The theoretical curves given in Fig. 22 can qualitatively well stand for the observed data shown in Fig. 14, and the expression of $\chi^{\parallel}(\sigma)$ given by (24) is in agreement with the results obtained previously by Stacey and others. Quantitatively speaking, however, the observed magnetic susceptibility (K) is a sum of the rotation susceptibility (χ) and another kind of susceptibility (χ_d) caused by the displacements of the 180° and 90° domain walls. Putting then,

$$\chi_o = (1-\alpha)\,K_o \;, \qquad \chi_d = \alpha\,K_o \;, \tag{28}$$

we get

$$K^{\parallel}(\sigma) = \chi^{\parallel}(\sigma) + \chi_d = \frac{1+\alpha\beta\sigma}{1+\beta\sigma}\,K_o \;, \tag{29}$$

$$K^{\perp}(\sigma) = \chi^{\perp}(\sigma) + \chi_d = \frac{1-\alpha F(\sigma)}{1-F(\sigma)} \;, \tag{30}$$

with

$$F(\sigma) \equiv (\epsilon + \tfrac{1}{2}\beta\sigma) - \sqrt{\{\epsilon^2 + (\tfrac{1}{2}\beta\sigma)^2\}} \;. \tag{3}$$

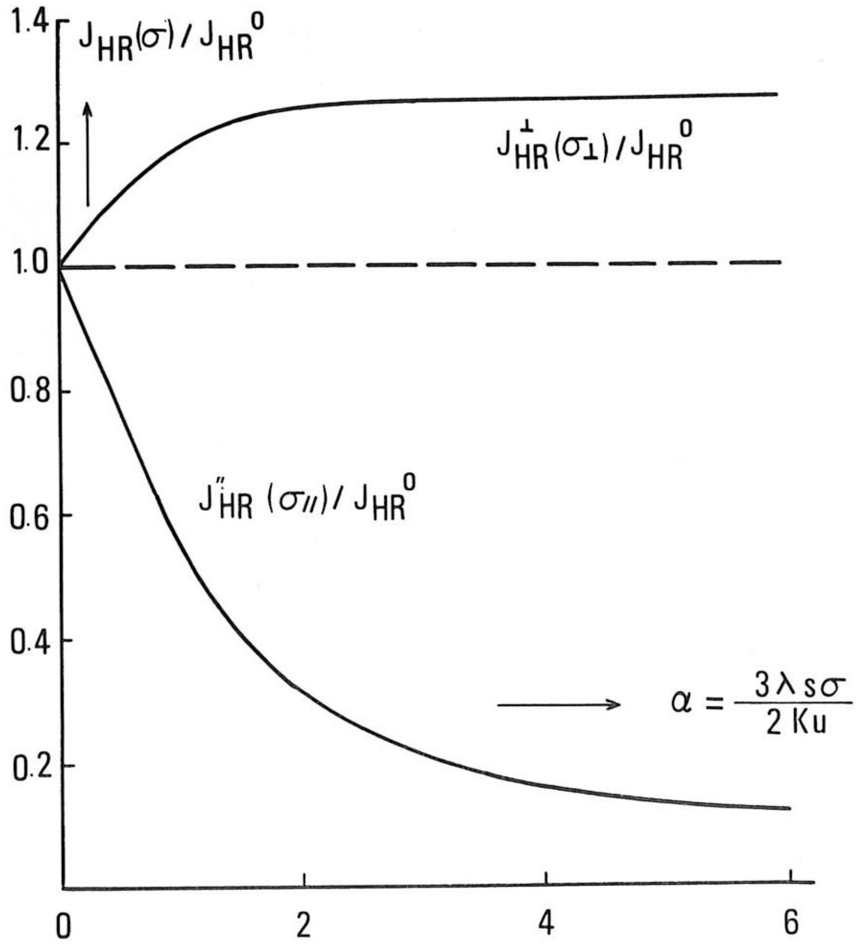


Figure 23. Theoretical curves of longitudinal and transverse effects of uniaxial compressions on hard remanent magnetization (such as TRM) of rocks. (After Nagata)

Table II. Summary of Magnetic Behaviours of Rocks under Stresses

	CATEGORY I Reversible		CATEGORY II Irreversible	
	Susceptibility	TRM, CRM	PRM	Stress Demagnetization
$\sigma \| J$	$K_o (1 - \beta' \sigma)$	$J_{HR} (1 - \beta'' \sigma)$	$+ \quad CH\sigma^*$	$J_{SR} (1 - \alpha' \sigma^* / H)$
$\sigma \perp J$	$K_o (1 + 1/2\, \beta' \sigma)$	$J_{HR} (1 + 1/2\, \beta'' \sigma)$	$+(3/4) CH\sigma^*$	$J_{SR} (1 - (3/4)\alpha' \sigma^* / H)$
$T \| J$	$K_o (1 + \beta' T)$	$J_{HR} (1 + \beta'' T)$	$+ \quad CHT^*$	$J_{SR} (1 - \alpha' T^* / H)$
$T \perp J$	$K_o (1 - 1/2\, \beta' T)$	$J_{HR} (1 - 1/2\, \beta'' T)$	$+(3/4) CHT^*$	$J_{SR} (1 - (3/4)\alpha' T^* / H)$
Remarks	Rotation of J_S		90° wall movement	

$$\left.\begin{aligned} \beta' &= (0.5 \sim 5.0) \times 10^{-4}\ \mathrm{cm^2/kg}, \\ \beta'' &= (0.3 \sim 1.2) \times 10^{-4}\ \mathrm{cm^2/kg}, \\ C &= (0.3 \sim 13.0) \times 10^{-6}\ \frac{\mathrm{emu}}{\mathrm{Oe}}\quad \mathrm{kg}\quad \mathrm{cm^2}, \\ \alpha' &= 0.02 \sim 0.12\ \mathrm{Oe\ cm^2/kg} \end{aligned}\right\}\ \text{for igneous rocks.}$$

Theoretical expressions, (29) and (30), are in exact agreement with empirical formulas, (1) and (2), and now the physical meanings of parameters α, β and ϵ, are theoretically clear. Analyses of α, β and ϵ of the experimental data in terms of p, N, J_S and Ku are, in most cases, self-consistent and satisfactory (e.g., Stacey 1962, Nagata 1966, 1970a). Results of theoretical evaluations of the effects of the longitudinal and transverse compressions on the hard remanent magnetization, J_{HR}, based on a model of the rotation of J_S are illustrated in Fig. 23 (Nagata 1970b). In this diagram, the abscissa is given in units of $\left(\frac{3\lambda_S}{2Ku}\right)\sigma$, where Ku represents the large effective anisotropy energy which is characteristic in TRM and CRM. When $\sigma < 10^3$ kg/cm², the theoretical expressions of $J_{HR}^{\|}(\sigma)$ and $J_{HR}^{\perp}(\sigma)$ are simply represented by

$$J_{HR}^{\|}(\sigma) \simeq J_{HR}^{o}\left(1 - \frac{3\lambda_S}{4Ku}\sigma\right), \tag{31}$$

$$J_{HR}^{\perp}(\sigma) \simeq J_{HR}^{o}\left(1 + \frac{3\lambda_S}{8Ku}\sigma\right). \tag{32}$$

Then, comparing (31) and (32) with empirical formulas, (9) and (10) we get

$$\beta' = \frac{3\lambda_S}{4Ku}, \qquad \gamma = \frac{3\lambda_S}{8Ku}, \tag{33}$$

and therefore

$$\gamma = \tfrac{1}{2}\beta''. \tag{34}$$

Since β'' ranges from 3×10^{-5} to 12×10^{-5} cm²/kg in the observed data and λ_S of the ordinary titanomagnetites is $4 \times 10^{-5} \sim 9 \times 10^{-5}$ cgsemu, Ku is estimated to be $5 \times 10^5 \sim 2 \times 10^6$ ergs/cm². This estimated order of magnitude of Ku seems to be very reasonable for TRM and CRM of igneous rocks.

Thus, the reversible effects of the longitudinal and transverse compressions on the rock magnetization also are theoretically understood. According to the theory, the effect of a uniaxial tension on the reversible phenomena should be reversed as compared with those of a uniaxial compression of the same strength.

In Table II, the main characteristics of the longitudinal and transverse uniaxial stresses (i.e., a uniaxial compression, σ, and a uniaxial tension, T) on the reversible and irreversible phenomena of the rock magnetization are summarized for the case of moderately small stresses and weak magnetic fields. The probable elastic stress within the earth's crust (i.e., $\sigma \lesssim 10^2$ kg/cm^2) and the intensity of geomagnetic field well satisfy the required conditions. The dynamic magnetization and the shock demagnetization proposed by Shapiro and Ivanov may be included into PRM and the stress demagnetization respectively in this table.

It must be remarked here that the reversible effects of Category I should play the major role for the ordinary earth's crust except special cases that crustal rocks have not yet experienced the effect of stress before, as suggested by an example shown in Fig. 13.

5. SEISMO-MAGNETIC EFFECT POSSIBLE GEOMAGNETIC VARIATION ON THE EARTH'S SURFACE CAUSED BY SUBTERRANEAN MECHANICAL STRESSES.

Since the basic relations of the magnetic susceptibility and the remanent magnetization of rocks to mechanical stresses are given in Table II, we can estimate the distribution of possible changes in the magnetization of crustal rocks under the effect of elastic stress which may exist in tectonically active regions as discussed in Sections 2 and 3, provided that models of the distribution of stress in the crust are appropriately assumed. The distribution of magnetization change thus estimated can directly lead to a distribution of anomalous changes of the geomagnetic field which is observable on the ground surface. Stacey (1964) tried to estimate such an anomalous geomagnetic variation as an effect of a possible stress distribution within the earth's crust, and he has called this effect the *seismo-magnetic effect.* As the source of the crustal elastic stress in connection with an earthquake, Stacey assumed a horizontal transcurrent fault of L in length, along which a simple shear is located. Taking the coordinates (x, y) so as that x is along the fault line, y perpendicular to it and the coordinate origin is at the center of the fault, the distribution of shear stress, σ, assumed by him, is expressed as

$$\frac{\sigma}{\sigma^0} = \left(\frac{L}{2}\right)^2 \frac{\left(\frac{L}{2}\right)^2 + y^2 - x^2}{\left[\left(\frac{L}{2}\right)^2 + y^2 + x^2\right]^2} , \tag{35}$$

which satisfies the boundary conditions given by

$$\int_{-\infty}^{\infty} \sigma dx = o, \quad \sigma = \sigma_o = \text{maximum at } (x = y = o),$$

$$\sigma = o \quad \text{at } (x = L/2,\ y = o) \text{ and } (x = -L/2,\ y = o).$$

Decomposing a horizontal shear into a horizontal uniaxial compression and a horizontal uniaxial tensile stress, he assumed linear relationships between the magnetization and the uniaxial stresses in such forms as expressed by

$$\frac{1}{J_{\|}} \frac{\partial J_{\|}}{\partial \sigma} = -1.0 \times 10^{-4} \text{ kg/cm}^2, \quad \frac{1}{J_{\perp}} \frac{\partial J_{\perp}}{\partial \sigma} = +0.5 \times 10^{-4} \text{ kg/cm}^2, \tag{36}$$

$$\frac{1}{J_{\|}} \frac{\partial J_{\|}}{\partial T} = +1.0 \times 10^{-4} \text{ kg/cm}^2, \quad \frac{1}{J_{\perp}} \frac{\partial J_{\perp}}{\partial T} = -0.5 \times 10^{-4} \text{ kg/cm}^2,$$

which are reasonable values viewed from the results of the later studies summarized in the previous section. Assuming further that the vertical distribution of the stress is uniform within a homogeneous layer of 25 km in thickness, Stacey computed the distribution of anomalous changes in the horizontal, vertical and total forces of the geomagnetic field on the top surface of the layer for three cases that the angle between the direction of the original magnetization and the fault line is 0, $\pi/4$ and $\pi/2$. Two examples of the results of the numerical computations are illustrated in Figures 24 and 25 where contours of equal anomalies in the geomagnetic total force are given in unit of the stress induced magnetization at the origin.

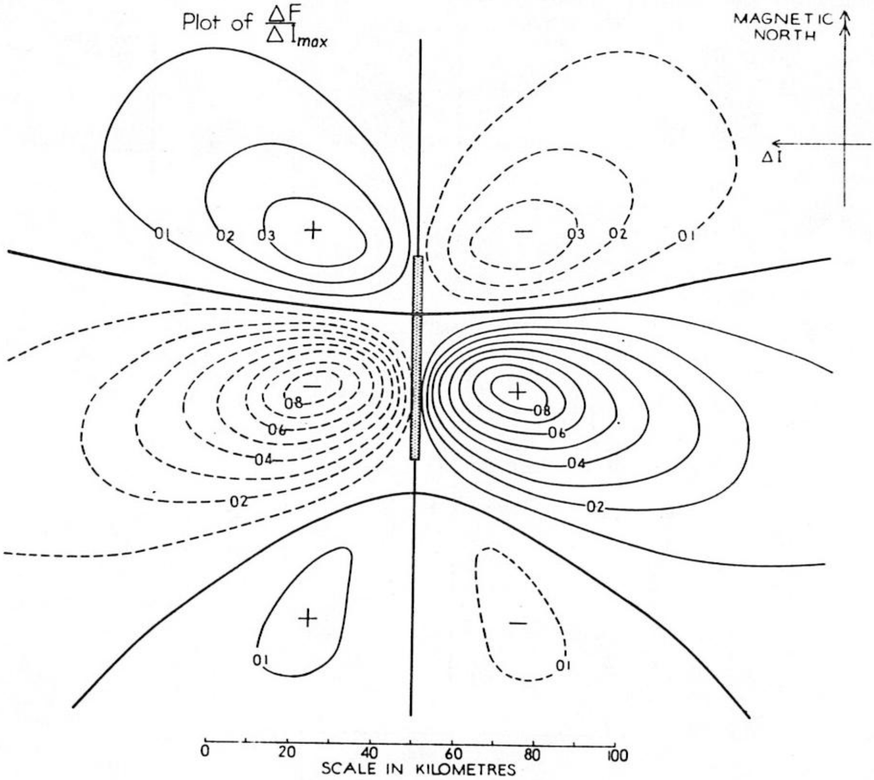


Figure 24.

An example of theoretical geomagnetic anomaly distribution caused by a transcurrent fault. (After Stacey)

When σ_0 = 100 kg/cm^2 and the original horizontal magnetization of the layer is assumed to be 10^{-2} and 10^{-3} emu/cc, the average difference between the positive and negative peaks of the total force patterns amounts to about 40 gammas and 4 gammas respectively.

Yukutake and Tachikawa (1967) have approached this problem in a somewhat different way. They calculated the distribution of anomalous geomagnetic variation on the earth's surface caused by the effect of stress on magnetization of homogeneous rocks within a semi-infinite elastic model of the earth where a hydrostatic pressure, p, is applied from inside to an infinitely long cylindrical surface embedded horizontally in the earth. Fig. 26 shows an example of the distribution of elastic stress within the earth, when p = 100 kg/cm^2, Lame's constants $\lambda = \mu = 10^{12}$ cgs, the depth of the cylinder = 10.5 km and the radius of cylinder = 5 km.

Assuming that the effects of compression and tension on the magnetization of rocks are the same as assumed by Stacey, (namely as given by (36)) and the original magnetization of the rocks is 3 x 10^{-3} emu/cc, they computed the distribution on the earth's surface of anomalous change of the geomagnetic force introduced by the stress for the cases that the inclination of original magnetization (I) is 0° and 50°, and the depth of the cylinder (D) is 10.5 km and 14.5 km, while always p = 100 kg/cm^2 and the radius of cylinder = 5 km. An example of their results is shown in Fig. 27. The difference between the positive and negative peaks in the total force variation amounts to 2.5 gammas for D = 14.5 km and to 5.3 gammas for D = 10.5 km when I = 50°.

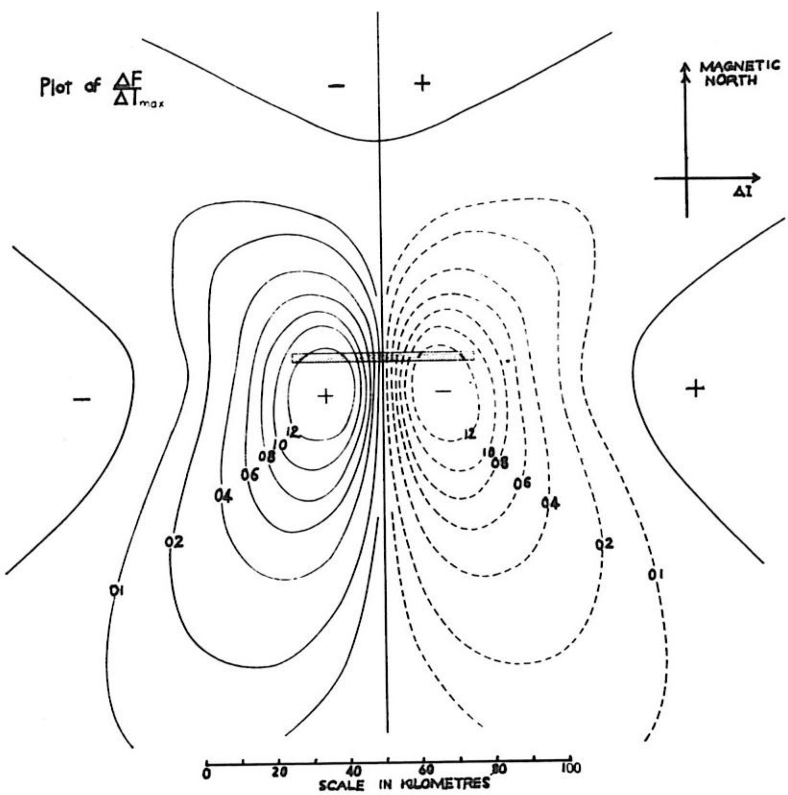


Figure 25.

An example of theoretical geomagnetic anomaly distribution caused by a transcurrent fault. (After Stacey)

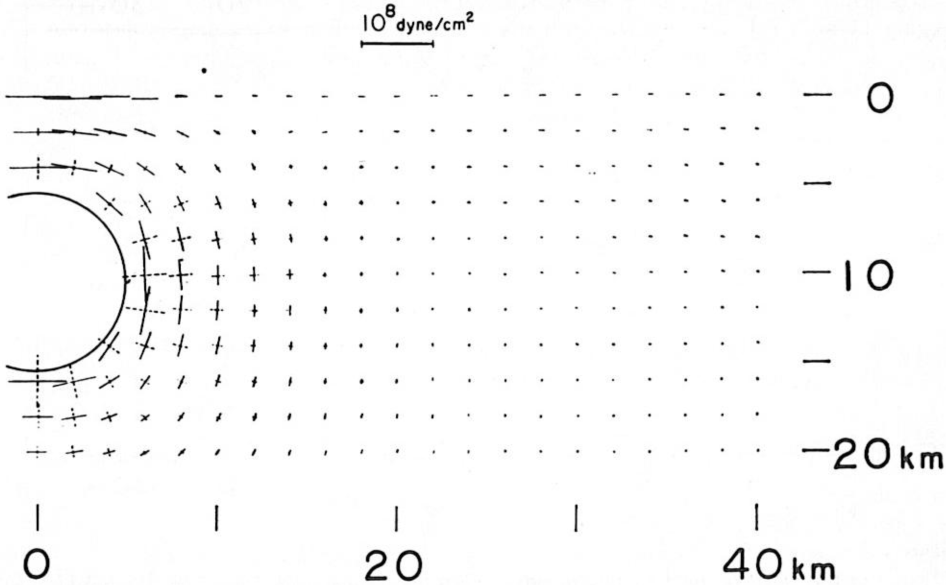


Figure 26.

Distribution of principal stresses when the cylinder is placed at a depth of 10.5 km. Solid lines denote tensile stresses and broken lines compression.
(After Yukutake and Tachikawa)

The maximum strain at the surface in Yukutake-Tachikawa's model amounts to 3.4×10^{-5}, while that in Stacey's model is 10^{-4} if the rigidity of rock is assumed to be 10^{12} dynes/cm^2. As Yukutake and Tachikawa stated, strain changes of 10^{-4} were often observed near the epicenters of great earthquakes. If we assume, therefore, that the maximum strain on the earth's surface is 10^{-4} and the original magnetization of the earth's crust is 3×10^{-3} emu/cc, Stacey's and Yukutake-Tachikawa's models give 12 gammas and 15 gammas (for D = 10.5 km) respectively as the difference between the positive and negative peaks in the total force variation on the earth's surface. The maximum change from the normal value in the total force is about a half of the difference between the two peaks in both cases. Then, we may expect that the maximum change of 6 $\sim$ 7 gammas could be observed in the epicentral area for a great earthquake associated with the maximum strain of 10^{-4} on the earth's surface.

When the focus of a great earthquake is located within a land area, the maximum breaking strain at the earth's surface was often observed to be 10^{-4} or more near the earthquake fault, as shown, for example, in the case of San Andreas fault in 1906 (Richter 1958) or Gomua fault in 1927 (Tsuboi 1933). When the epicenter is located at sea, the remarkable land deformations accompanying the great earthquake in 1946, shown in Figures 1 and 3 for example, indicate that the corresponding strain in only about 3×10^{-5} if we consider that the land deformation represents the release of elastic stress accumulated during the pre-quake period.

It seems thus that anomalous change of 10 gammas or less in the geomagnetic force is the maximum probable value on the land surface as the effect of accumulation of elastic stress within the earth's crust in the epicentral area.

As stated by Rikitake (1968a, b), therefore, only precise magnetic observations by means of modern atomic absolute magnetometers with careful elimination of geomagnetic noises could detect such anomalous geomagnetic variation caused by the crustal stresses.

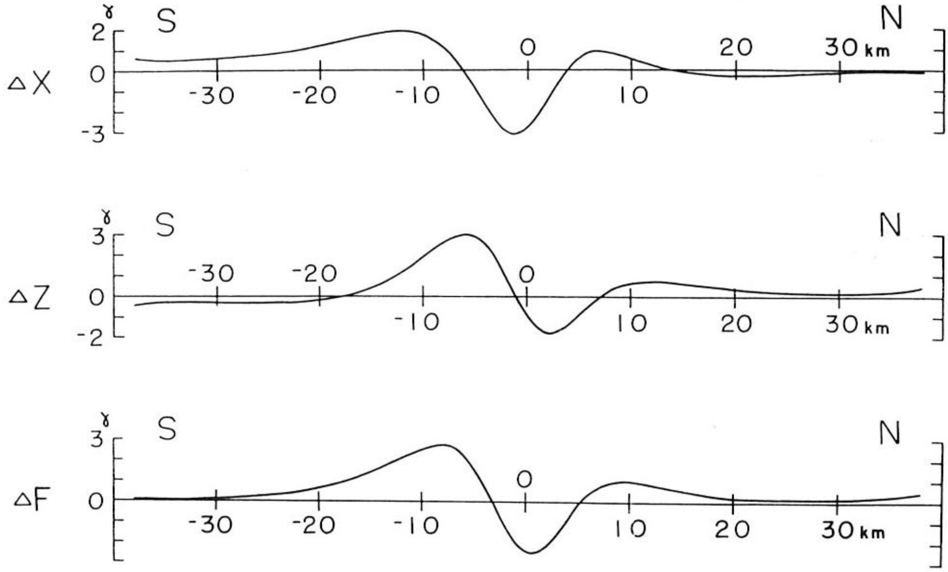


Figure 27.

Changes in the magnetic field along a meridian when the inclination is 50°. From the top to the bottom, the change in the north component ΔX, the vertical component ΔZ and the total force intensity ΔF. (After Yukutake and Tachikawa)

References

Breiner, S.: The piezo-magnetic effect in seismicity active area. Thesis, Stanford Univ., 1967.

Fujita, N.: The magnetic disturbances accompanying the Niigata earthquake. J. Geodetic Soc. Japan, **11**, 8, 1965.

Kalashnikov, A. G.: The possible application of magnetometric method to the question of earthquake prediction. Akad. Nauk. USSR, Geophys. Inst. Trudy, **25**, 162, 1954.

Kalashnikov, A. G. and S. P. Kapitsa: Magnetic susceptibility of rocks under elastic stresses. Izvestia Akad. Nauk. USSR, **86** (3), 521, 1952.

Kapitsa, S. P.: Magnetic properties of eruptive rocks under mechanical stresses. Izvestia Akad. Nauk. USSR, Geophys. Ser. **6**, 489, 1955.

Kato, Y.: Investigation of the changes in the earth's magnetic field accompanying earthquakes and volcanic eruptions. Sci. Rep. Tohoku Univ. Ser. 1, 27, 1, 1939.

Kato, Y. and S. Utashiro: On the changes in the terrestrial magnetic field accompanying the great Nankaido earthquake in 1946. Sci. Rep. Tohoku Univ. Ser. 5, **1**, 40, 1949.

Kern, J. W.: The effect of stress on the susceptibility and magnetization of a partially magnetized multidomain system. J. Geophys. Res., **66**, 3807, 1961.

Milne, J.: Earthquakes in connection with elastic and magnetic phenomena. Trans. Seismological Soc. Japan, **15**, 135, 1890.

Miyabe, N.: Vertical earth movement in Nankai District. Bull. Geographical Survey Inst. Japan, **4**, parts 3 and 4, 1955.

Nagata, T.: Summary of the geophysical investigation on the great earthquake in southwestern Japan on December 21, 1946. Trans. American Geophys. Union, **31**, 1, 1950.

Nagata, T.: Magnetic susceptibility of compressed rocks. J. Geomag, and Geoelect, **18**, 73, 1966.

Nagata, T.: Anisotropic magnetic susceptibility of rocks under mechanical stresses. Pure and Appl. Geophys. 1970a. (In press)

Nagata, T.: Effects of a uniaxial compression on remanent magnetization of igneous rocks. Pure and Appl. Geophys. 1970b. (In press)

Nagata, T. and B. J. Carleton: Notes on piezo-remanent magnetization of igneous rocks. J. Geomag and Geoelect, **20** 115, 1968.

Nagata, T. and B. J. Carleton: Notes on piezo-remanent magnetization of igneous rocks II. J. Geomag and Geoelect, **21** 427, 1969a.

Nagata, T. and B. J. Carleton: Notes on piezo-remanent magnetization of igneous rocks III. J. Geomag and Geoelect, **21**, 623, 1969b.

Ohnaka, M. and H. Kinoshita: Effects of uniaxial compression on remanent magnetization. J. Geomag and Geoelect, **20**, 93, 1968.

Okada, A.: Land deformation of the southern part of the Kii Peninsula, Southwestern Japan. Bull. Earthquake Res. Inst., **38**, 113, 1960.

Okada, S. and T. Nagata: Land deformation of the neighborhood of Muroto Point after the Nankaido great earthquake in 1946. Bull. Earthquake Res. Inst., **31**, 169, 1953.

Petrova, G. N.: "Laboratory estimation of rock remanance stability". USSR, Acad. Press. 1961.

Richter, C. R.: "Elementary Seismology" W. H. Freeman, San Francisco, 1958.

Rikitake, T.: Geomagnetism and earthquake prediction. Tectonophysics, **6** (1), 59, 1968a.

Rikitake, T.: Earthquake prediction, Earth Sci. Rev., **4**, 245, 1968b.

Rikitake, T.: Prediction of magnitude and occurrence time of earthquakes. Bull. Earthquake Res. Inst. **47**, 107, 1969.

Rikitake T. and others: Geomagnetic and geoelectric studies of the Matsushiro earthquake swarm 1, 2, 3, 4 and 5. Bull. Earthquake Res. Inst., **44**, 363, 1966a; **44**, 409, 1966b; **44**, 1335, 1966c; **45**, 89, 1967a; **45**, 395, 1967b.

Rothé, J. P.: Deformation des anomalies magnetiques et seismes. Bull. Bureau Central Seism. Intern., Ser. A., Fax **17**, 1950.

Shapiro, V. A. and N. A. Ivanov: Dynamic remanence and the effect of shock on the remanence of strongly magnetic rocks. Doklady Akad. Nauk. USSR, **173**, 1065, 1967.

Stacey, F. D.: Effect of stress on the remanent magnetization of magnetite bearing rocks. J. Geophys. Res. **63**, 361, 1958.

Stacey, F. D.: Theory of magnetic susceptibility of stressed rocks. Phil. Mag., **7**, 551, 1962.

Stacey, F. D.: Seismo-magnetic effect and the possiblility of forcasting earthquakes. Nature, **200**, 1803, 1963.

Stacey, F. D.: The seismomagnetic effect. Pure and Appl. Geophys., **58**, 5, 1964.

Tanakadate, A. and H. Nagaoke: The disturbance of isomagnetics attending the Mino-Owari earthquake of 1891. J. Coll. Sci. Imperial Univ. Japan, **5**, 149, 1893.

Tazima, M.: Accuracy of recent magnetic survey and locally anomalous behaviour of the geomagnetic secular variation in Japan. Thesis. Univ. Tokyo, 1966.

Tsuboi, C.: Investigation of the deformation of the earth's crust found by precise geodetic means. Japanese J. Astro. Geophys., **10**, 93, 1933.

Tsubokawa, I., Y. Ogawa and T. Hayashi: Crustal movements before and after the Niigata earthquake. J. Geodetic Soc. Japan, **10**,165, 1964.

Undzendov. B. A. and V. A. Shapiro: Seismomagnetic effect in a magnetite deposit. Izvestia Earth Phys., No. 1, 121, 1967.

Yukutake, T. and H. Tachikawa: Geomagnetic variation associated with stress change within a semi-infinite elastic earth caused by a cylindrical force. Bull. Earthquake Res. Inst., **45**, 785, 1967.

SECOND IAGA PLENARY SESSION

The second and final IAGA Plenary Session was held Friday, 12 September at 3:00 p.m. for the purpose of approving resolutions and hearing short summary reports from each Commission.

The 17 scientific resolutions reproduced on pages 122 to 129 were approved after some discussion.

President Nagata indicated that there had been very lengthy discussions about the French proposal to reorganize some of the Unions to minimize the overlap in the study of aeronomy, space and solar-terrestrial relations. He stated that there were still diverse opinions among the Executive Committee members and among Commission Chairmen. The Executive Committee will continue to work actively on this important problem.

Dr. Coulomb, president of IUGG, pointed out that the freedom of Unions must be preserved in considering any reorganization, and that the French proposal should not be considered alone, but rather the entire reorganization needs and alternate solutions should be considered.

The Commission and Joint Committee summary reports as recorded below were given:

COMMISSION I
Report Given by A. P. DeVuyst

During this General Assembly Commission I was involved with the problem of acquisition of geomagnetic data in machine-readable form. The increasing demand for accurate data with high time resolution is a natural consequence of the rapid progress in geomagnetism and all related fields. The scientific session and business meeting therefore had two purposes:

(a) general aspects of the work of handling and exchange of data in machine readable form.

(b) recent progress made in the development of new equipment with semi-automatic or automatic digitization possibilities.

The four review papers covered most of these items and the contributed papers added more details to them. As one very important consequence, agreement was reached on: card and paper tape format of geomagnetic hourly values, and magnetic tape format of geomagnetic hourly and 2.5 minute values (the adopted form is in IAGA News No. 8).

Some real progress has already been made in obtaining digital data semi-automatically or even automatically by some observatories. It is clear, however, that the generalization of these methods needs economically reliable equipment with digital output. It followed from the scientific session and discussions that different research groups are working in this direction.

At this General Assembly the work of Commission I covered only one step on this question of geomagnetic data in machine-readable form, its acquisition, management and exchange.

During the joint scientific session between Commissions I and II agreement was reached on how to develop the World Magnetic Archive. The Chairman of Commission II will report on this.

COMMISSION II
Report Given by B. R. Leaton

The scientific program of Commission II highlighted a session on Methods of Representation of the Earth's Magnetic Field and its Secular Change.

Papers on secular change showed that best results were obtained from observatory data for short periods, but over ten years or more they may be usefully augmented by survey data. The polar current effects are significant and their removal is desirable in evaluating secular change. A progress report was given on the radial dipole representation. It was shown how D, dated back to 1600, may be used to show the movement of the centered dipole. A most thorough dissertation on historical determinations of the positions of the south magnetic dip dipole was given. An ingenious method was given for deriving detailed knowledge of components from a close survey in F along with a scatter of component measurements.

The World Magnetic Survey (WMS) as a special project ends in 1969. Commission II has acted throughout as advisor and helper to the WMS Board especially in recent years, and will continue its functions after the demise of the Board. The culmination of the WMS will be the publication of the WMS Report which is expected early in 1970.

Good progress has been made on the World Magnetic Archive project and the details of agreement have been given in IAGA News No. 8.

A full report of the establishment of the International Geomagnetic Reference Field (IGRF) will be given in the WMS Report. A brief formal statement, including the numerical values of its parameters, has already been published in several journals. The IGRF is already being used quite extensively. Its success so far is very encouraging.

COMMISSION III
Report given by T. Rikitake

Work in the interest of Commission III has been steadily developing. An extensive symposium on geomagnetic secular variation was held. In this, the changes in the intensity of the geomagnetic fields were traced as far back as several thousand years. Measurements on the Hawaiian Islands made it clear that the non-dipole field has been small there over the past five million year period.

The Bullard-Gellman dynamo model, which was in a state of crisis during the meeting at St. Gall, seems to have been revived so that dynamo action is still the most promising way of accounting for the geomagnetic main field.

Conductivity anomalies have been discovered in many countries, even in a very stable portion of the earth such as the British Isles. Some of the anomalies seem to be correlated very well to other geophysical elements such as heat flow and seismic wave velocity.

As for the business matters, Commission III chose three new reporters to replace the reporters who had to resign. Two symposia, on rock magnetism and palaeomagnetism respectively, were proposed.

COMMISSION IV
Report Given by J. A. Jacobs

Two symposia and three special sessions were held. The first symposium on Instabilities in the Magnetosphere was organized by J. A. Jacobs, M. Sugiura and H. B. Liemohn. Four sessions were held and the ensuing discussions, not only in the lecture rooms following each paper, showed the necessity for and the value of such a symposium. In spite of our continued ignorance of many of the processes that occur in the magnetosphere, these sessions helped to delineate those areas where more research is needed and which are most likely to lead to profitable returns. Partly as a result of this symposium, it was decided to recommend that special sessions be held at the next IUGG meeting in Moscow in 1971 on the subject of the interaction of geomagnetic disturbances and particle precipitation phenomena.

The second symposium on Comparison of the Magnetosphere Behaviour with Ground Observations and New Indices of Geophysical Activities was organized by V. A. Troitskaya. Three sessions were held. It is difficult to highlight this symposium but mention must be made of the paper by P. J. Coleman Jr. on Magnetic Field Variations at ATS-1 and on the Earth's Surface. Considerable interest was aroused in these results, particularly in the relatively large amplitude (typically 15γ) compressional oscillations which occur regularly during the main and recovery phases of magnetic storms in the late morning and afternoon (local time) with periods in the range 2-15 minutes. In addition to the three main sessions of this symposium, there were two further meetings for a round table discussion of new indices of geomagnetic activity. These sessions provoked considerable discussion and it was recommended that the subject be considered again in Moscow in 1971. In particular it was decided to investigate carefully the possibility of using geomagnetic micropulsation data as a measure of some of the physical processes occurring in the magnetosphere. Attention should also be paid to the problem of monitoring the positions of the plasmapause.

Three special sessions were held on:

1) Daily variation (organized by D. J. Stone)
2) Micropulsations and magnetic storms.
3) Geomagnetic activity & related phenomena.

Detailed reports of all session (including those in the symposia) will be submitted by the assigned reporters.

COMMISSION V
Report Given by J. G. Roederer

Dr. Roederer summarized the discussions of Working Group V business meetings on the French proposal, and explained the various paragraphs of their proposal (see page 86).

COMMISSION VI AND VII
Report Given by M. Nicolet

The IAGA Commission VII held six scientific sessions during the Assembly, Madrid 1969, encompassing a total of 17 invited papers (20 minutes each) and an equivalent number of contributed papers (10 minutes each).

The first session, chaired by M. Gadsden, was on specific optical instrumentation and intercalibration problems.

The second and third sessions, chaired by K. Ramanathan and D. Hunten, respectively, dealt with recent observations. World coverage by ground stations has been steadily improved over the last years, and satellite data are beginning to contribute to the world wide study of airglow phenomena. Progress is being made on the origin of atmospheric metals.

The third and fourth session were devoted to the interpretation of airglow emissions, and to a survey of available and needed laboratory data on the basic chemical processes. They were chaired by M. Nicolet and H. I. Schiff, respectively. Major advances have recently been made on the full exploitation of upper ionospheric emissions, and in the interpretation of emissions arising in the D region.

Results of the Active Sun Years Program (a joint session with Commission VI) were reported at the final scientific session, chaired by M. H. Rees. It was apparent that there had been a good international response to the scientific proposals generated by this program. The predawn enhancement was seen as a global phenomena of greater complexity than had been realized.

At the business meeting of the Commission two resolutions were passed. The first was to hold a symposium in 1971 in conjunction with Commission VI, and the second was that the French proposal for reorganization of the union be supported in principle and further studied.

COMMISSION VIII
Report Given by B. A. Tinsley

I want to say a few words about highlights of Commission VIII's activities at this meeting. There were eight sessions, six of them as a Symposium on Aeronomic Ionization Processes including Aurora and Airglow, and two on Global Composition Structure of the Thermosphere. It is difficult to select highlights of the session, and of course such a selection must be very subjective, but I would mention three.

Firstly, the new results by Barth on the Upper Atmosphere of Mars. He has revealed enough of the data to stimulate much discussion, and greatly whet our appetite for the remainder of the data. Secondly, the theoretical work by McElroy and Cloutier, which shows how an ionosphere with scale height about half that assumed earlier can be produced by the solar wind flowing into a planetary atmosphere (Roederer also in Commission V). Thirdly, the paper by von Zahn in which he showed that in about 20 rocket mass spectrometer flights in the past few years, the A/N_2 ratios for almost all of the data fix the turbopause height very precisely at 101 ± 2 km, showing much less variability then was previously supposed.

At the Working Group meetings and business meetings of Commission VIII there was considerable interest in the French Proposal concerning the reorganization of several Associations and the creation of a Federation of three new Associations. Generally, people were very much in favor of the main purpose behind the proposal, to reduce the great deal of overlap of subject matter and dispersion of effort among the several International bodies concerned with the upper atmosphere and ionosphere of the earth and other planets, provided the proposal does not result in the creation of yet another body without changing the present bodies. Commission VIII would like to see the proposal followed up.

JOINT IAGA – IAMAP COMMITTEE ON LUNAR VARIATIONS
Report Given by O. Schneider

As an introduction to the business meeting of the Lunar Committee, a review was given by the Chairman on progress made in studies on lunar variations during the last 2 years; this report summarized the main topics of some 50 papers dealing with the theory of atmospheric oscillations in general; the theory of geomagnetic tides; the equivalent ionospheric current system; the phase low of geomagnetic tides and diverse ways of generalizing it; ocean and coast effects; and induction phenomena. Much effort has also been devoted to improving the methods of computation, including both spectral and harmonic analysis, data processing at large, and error determinations. A considerable number of papers report on new numerical determinations of lunar variations in atmospheric pressure, tropospheric winds, ionospheric parameters, and the geomagnetic surface field. An interesting novel result is the first determination of the O_1 tide in atmospheric pressure.

The business meeting of the Committee covered many technical aspects such as tidal nomenclature; data processing appropriate for lunar studies; lunar tables; and the setting up of study groups within the Committee. We also discussed, of course, the implications of the plans for a new structure of the IUGG, the Lunar Committee has suggested to IAGA that a symposium should be held, on Lunar Variations in geophysical effects at large, during the forthcoming IUGG Geophysical Assembly.

At the scientific session, ten original papers were delivered, 5 of them in addition to those announced in IAGA Bulletin 26. The communications dealt with atmospheric tides; geomagnetic tides at low latitude stations; new representations of the equivalent ionospheric current system of lunar variations, and methods for tracing it; ocean, coast, and induction effects; lunar variation in earth currents; numerical aspects of long period tidal terms, and new determinations of height profiles of lunar variations in the ionosphere.

We did not submit resolutions to IAGA, but we feel that one of the items discussed at the business meeting, namely the one dealing with a rational tidal nomenclature, deserves general attention. We hope it will be possible to have it published in the Transactions of this Assembly.

CLOSING IAGA–IASPEI PLENARY SESSION

The joint IAGA–IASPEI General Scientific Assembly was officially closed by a Plenary Session held in the large auditorium, Aula Magna, at 4:00 p.m. on Friday, 12 September. The Rev. Fr. A. Romaña, S. J., president of the Local Organizing Committee again conducted the meeting.

Resolutions of Thanks numbers 1 through 6 as printed on pages 120 to 122 were read in French by M. Nicolet and in English by L. R. Alldredge. Resolution of Thanks from the wives of the participants (No. 7) was read in French by Alice Nicolet and in English by Larita Alldredge. Mrs. J. M. Munuera graciously responded with kind words of appreciation from the wives of the local committee to the wives of the participants.

PROF. V. A. MAGNITSKY,
Vice President of IASPEI

Dear colleagues! Ladies and gentlemen!

For more than 10 days we have had the pleasure of working within these hospitable walls of the Madrid University. We were engaged in various exciting problems of modern geophysics, led discussions, persisted in our opinion, making use of all the given opportunities. We did not often think of those enormous efforts, which made possible preparation of the Assembly. We did not often pay attention to that care ensuring the success of our work. Our attention was never drawn by any organizational troubles. The whole weight of this inconspicuous but tiresome burden was on the shoulders of the members of the Arrangements Committee and of those who helped them. All these days and long months of preparation were the days of selfless and – as we know now – brilliant work for our hosts, our Spanish colleagues. On behalf of the IASPEI allow me to express the deepest gratitude to them.

Our Assembly in Madrid was not quite usual. According to a new statute for the first time the Assembly of IASPEI/IAGA was convened not within the limits of the IUGG General Assembly but as an independent meeting devoted to discussion of scientific problems and only to a small extent to some scientific – organizational questions.

Our science during the last decades is in an extraordinary stage of its development. Twelve years before the flight of the first Soviet artificial satellite had opened a new era even in our field of knowledge. We were the witnesses of many new exciting discoveries and yesterday at our Assembly we heard the information on the first results of operation of the first seismograph in the Moon. This outstanding achievement of our American colleagues has brought us to a new stage in the physics of the Earth. Now, we have a new method at our disposal – the one of comparison. We do not doubt that the time is not far when the scientists of different countries will take the inner structure of other nearest planets as the object of investigation. Both physics and chemistry of our planet, our Earth, will have a new interpretation as physics of one of the family of planets of the solar system in their whole unity and diversity.

If at this Assembly, we observed the first rays of the future of our science, the problems of today naturally have occupied a great place in its work. In addition to traditional approaches, there were vital discussions of the problems which arose yesterday as a result of prominent successes of geophysics in the studies of the sea bottom. New data, new information of first-rate importance was obtained during the last years and that could not but lead to the origin of new concepts, new hypotheses so far certainly far from being undoubtful. We all participated in discussions where scientists of all countries had a chance to put forward their ideas, to compare them with those of their colleagues by means of direct contacts, discussions and even arguments. But we all know that this is the most reliable way to know the truth, to avoid some primitiveness in ideas and conclusions.

It is this that I estimate as the greatest value of such international meetings, namely in this lies the success of our Assembly.

I think that I shall express the opinion of most of my colleagues, if I say, that our Assembly was a great success and the results of the exchange by information, opinions, and discussions will affect in a most favorable way the work of geophysicists in the nearest years. I should like to state a wish that this experience of convening the Assemblies of separate or several parental associations in the intervals between the general assemblies be continued and become a tradition.

Thank you.

PROF. J. G. ROEDERER,
Member of IAGA Executive Committee
Señoras y Señores, Colegas:

Es un placer y una honra para mí haber sido elegido de entre los miembros del Comité Ejecutivo de la Asociación Internacional de Geomagnetismo y Aeronomía para pronunciar las palabras de agradecimiento en lengua española –o más bien, en dialecto argentino.

Esta Asamblea Científica conjunta, va a pasar a la historia por muchas razones. . . primer lugar –aungue éste sea un hechu fortuito– ésta ha sido la primera reunión científica internacional sobre temas geofísicos y espaciales, después de ese momento cardinal en la historia de la humanidad que representa la conquista de la luna, en que resultados científicos preliminares de esa hazaña fueron presentados ante una audiencia internacional de eruditos.

En segundo lugar, esta Asamblea de Madrid ha sido la que ha atraído un número de participantes *no* afiliados a nuestras Asociaciones que supera todo lo esperado. En algunas de nuestras sesiones, este número de no-afiliados ha sobrepasado ampliamente el número de miembros, especialmente en aquéllas en que se trataban temas espaciales. Esto es particularmente significativo y constituye una alentadora reafirmación del prestigio que gozan nuestras Asociaciones en la comunidad científica internacional –y, sin lugar a dudas, del poderoso atractivo que representa una estadia en Madrid!–

Permítaseme, señoras y señores, dedicar unos minutos a algunos de los aspectos científicos más notable discutidos en el seno de la Asociación de Geomagnetismo y Aeronomía. Tengo entendido que el Prof. Magnitsky hará lo mismo sobre la de sismología y física del interior de la tierra.

Nuestra reunión se caracterizó por una eficiente y crucial combinación de trabajos y discusiones sobre exploración espacial, por una parte basada en mediciones directas en el espacio exterior con satélites, y por otra, basada en observaciones desde tierra. Este entrelazamiento de técnicas para un mismo fin es muy significativo. En el pasado ha habido muchos congresos espaciales, pero en general siempre han sido dominados por los grupos y paises que operanon satélites. Este hecho ha excluido en gran parte países más pequeños o en desarrollo. No así aquí, en Madrid, gracias a esta saludable mezcla.

Hemos tenido una serie de sesiones sobre temas espaciales muy variados. Particular atención atrajo, por ejemplo, la sesión sobre la exploración de la luna y de los planetas –la sesión sobre campos eléctricos en la magnetosfera, campo nuevo que aún está en pañales– o la sesión sobre diagnostica de la magnetosfera basada en mediciones terrestres.

Una tercera razón por la cual esta Asamblea conjunta pasará a la historia, viene dada por las discusiones-apasionadas a veces, pero siempre sobrias,-que tuvieron lugar en el seno de nuestras comisiones y en nuestros Comités Ejecutivos, sobre la posible reestructuración de nuestras Asociaciones y nuestra Unión. En otras palabras, un movimiento se puso en marcha aquí, en Madrid, que algún día habrá de determinar el futuro de nuestras Asociaciones. Sólo podemos esperar fervientemente que los pasos dados ahora, nos guién en la dirección correcta en el futuro, en aras de una aún más intensa y aún más beneficiosa cooperación científica internacional.

Pero, señoras y señores, la razón más inmediata por la cual esta Asamblea conjunta va a pasar a la historia, es por la formidable organización de la misma por parte del Comité local, por el ambiente tan cordial en este lugar, por la tan eficiente colaboración de todo el personal local y –por supuesto– por la simpatía que nos dispensaron los madrileños, las madrileñas y todo el pueblo de España.

Par todo ello el Comités Ejecutivos de IAGA y IASPEI me han encomendado extender un muy sincero y muy caluroso agradecimiento a los funcionarios del Gobierno, de la Universidad y a los Científicos de España que han hecho posible esta Asamblea. En particular nuestro especial agradecimiento va al Sr. Vice-Presidente del Gobierno, al Sr. Ministro de Educación y Ciencia, al Sr. Ministro de Información y Turismo, al Sr. Presidente del Consejo Superior de Investigaciones Científicas, al Sr. Director del Instituto Geográfico, a los Sres. Rector de la Universidad y Director de la Escuela Superior de Ingenieros de Caminos, que nos hospedó, al Sr. Alcalde Presidente de Madrid, y a muchos otros más. Y dejando para lo último lo que nos causa gran afecto personal, nuestro muy especial agradecimiento al Rvdo. Padra Romañá y a todos los amigos del Comité Organizador Local.

EXECUTIVE COMMITTEE MINUTES

INTRODUCTION

The Executive Committee met several times during the IAGA General Scientific Assembly held in Madrid, Spain, 1-12 September 1969. The first session was called to order by President Takesi Nagata at 1730 hrs on Monday 1 September. The final session was concluded at 1930 hrs on 12 September. The following Executive Committee members were present:

Takesi Nagata	President
V. A. Troitskaya	Vice President
L. R. Alldredge	General Secretary
J. O. Cardus	Member
M. Nicolet	Member
J. G. Roederer	Member
R. Turajlic	Member

The Secretary had received word prior to the Assembly that the following members could not attend the Assembly:

E. Thellier	Vice President
R. M. Casaverde	Member
F. S. Johnson	Member

Commission Chairmen were invited to attend one of the sessions where the French proposal to reorganize ICSU was discussed.

NEW PERSONNEL

Note was taken of a letter from Dr. E. Thellier to the Secretary indicating his inability to attend the Assembly because of ill health and his desire to retire from all International Administrative responsibility. The Secretary was instructed to write to Dr. Thellier to the effect that the Executive Committee wished to retain him as a Vice President hoping that his health would in time permit full activity, but that because of immediate need a replacement would be found as Reporter for Working Group III-5.

Several resignations were received from Working Group Reporters. After consulting with the proper Commission Chairmen, the following changes were approved:

R. L. Dubois to replace E. Thellier as Reporter for W. G. III-5
K. M. Creer to replace R. R. Doell as Reporter for W. G. III-6
I. Gough to replace K. Whitham as Reporter for W. G. III-3

PUBLICATIONS

The problem of the effectiveness and cost of the IAGA publications program was discussed at length. During the past five years IAGA has paid out $15,817.00 for publications, but has received only $4,208.00 for sales through the IUGG Publications Office in Paris. From an inventory of IAGA publications still held in Paris it is obvious that too many reprints of special issues of scientific journals have been purchased for resale under an IAGA Symposium cover. The sales go badly most likely because the special issue of the journal is available.

It was decided to be more discriminating as to which Symposia should receive IAGA publication support. For the present Assembly, all Symposium convenors are encouraged to have at least selected papers published in a special issue of a journal, but IAGA has pledged support only for the Symposium on "Multidisciplinary Studies of Unusual Regions of the Upper Mantle." In this case IAGA had agreed prior to the Assembly to help JGG (Japan) publish the proceeding of the Symposium by paying up to $1,000.00. For this support IAGA will receive some reprints under a cover with the title IAGA Symposium No. 10.

IAGA is buying only about 200 or 300 copies of IAGA Bulletin No. 26, Program and Abstracts of the Madrid Assembly, for sale in Paris, and will publish only about 1,400 rather than the usual 2,000 copies of IAGA Bulletin No. 27, Transactions of the Madrid Assembly. For good will among IAGA Scientists and for promotional purposes, it was agreed that free copies of the Transactions of the Madrid Assembly should be sent to all participants and members of all Working Groups.

Publication of the WMS final report was considered as a special project. Because of its unique character it should have good sale value. Earlier the Executive Commitee had pledged $2,000.00 toward its publication. Recently the local committee for the Symposium on Description of the Earth's Main Field, Washington, D. C., October 1968, turned into the IAGA Treasury a profit of $482.00 which has also been pledged toward the publication of the WMS final report. Dr. A. Zmuda gave several estimates for the publishing of this report. It was decided that the text of the report should be set in type, 2,000 copies of the text which is 200 pages long (including 66 pages of figures) should be published, and that 1,000 copies of grid values which contain 135 pages (not typeset) should be published. The total cost is estimated at $8,500.00. Father Cardus suggested that the cost could be reduced by publishing in Spain. This will be investigated.

It was agreed that, since the WMS project is an ICSU project passed on to IAGA through IUGG, IUGG should be asked to share in the publication cost of the final report.

A request was made for IAGA to help finance the publication of some new work on magnetic indices. The request was not granted on the grounds that until new indices were accepted as a part of the permanent services the work should be considered as regular research work to be paid for by the institution or individual sponsoring the work. A policy was formulated to the effect that the main contents of IAGA Bulletins 12.1 and 12.2 should not be changed until proposals were approved by the IAGA Executive Committee.

FINANCES:

Informal financial accounts for the years 1967 and 1968 submitted by the Secretary were accepted without comment (formal accounting is required only at the time of General Assemblies.)

The Secretary presented a budget estimate for the four year period 1971-1974 given below as requested by the IUGG General Secretary. There is a general feeling that the entire financial support of the Union must be greatly increased if proper promotion of geophysics is to follow. The budget estimate was approved and it will be formally transmitted to IUGG. The main increases are mainly for increased costs for publications, meetings and administration. The latter point will be very important if future Secretaries are not well subsidized by their place of employment.

ESTIMATE OF INCOME AND EXPENSES
During the Period 1971-1975

	Receipts	
IUGG Allocation		$48,000.
Contracts with UNESCO		2,000.
Sales of Publications		4,000.
	Total Receipts	$54,000.
Cash Assets at start of Period		10,000.
	TOTAL	$64,000

	Expenditures	
Administrative		$10,000.
Publications		16,000.
Assemblies		8,000.
Symposia		10,000.
Scientific Meetings		6,000.
Grants to Permanent Services		5,000.
Miscellaneous		1,000.
	Total Expenditures	$56,000.
Cash Assets at end of Period		8,000.
	TOTAL	$64,000.

IUGG – IUGS LONG RANGE SOLID EARTH PROGRAM

Note was taken of the very recent report of the IUGG-IUGS ad hoc Committee on Long Range Program of Solid Earth Studies. The report outlines a program which makes use of the discoveries made during the UMP and which aims at obtaining information on the thermodynamics and structure of the lithosphere, and suggests an organization which could be set up to implement the program. Discussion of the report was very limited and no objections to the report were voiced.

POTSDAM SYMPOSIUM ON SOLAR DAILY GEOMAGNETIC VARIATIONS

Prof. G. Fanselau in a letter to President Nagata revealed plans for a Symposium on the Solar Daily Geomagnetic Variations to be held in Potsdam shortly before the 12-20 May 1970 Leningrad Symposium on Solar-Terrestrial Physics. As requested by Prof. Fanselau, it was agreed that IAGA would officially sponsor the Symposium without financial cost to IAGA. The first announcement of the Symposium will be carried in IAGA News No. 8.

IUGG GENERAL ASSEMBLY IN 1971 IN MOSCOW

Lengthy discussions regarding the XV IUGG General Assembly were held. The discussion is summarized in the following memorandum which was immediately sent to the IUGG Executive Committee in time for its 13 September 1969 meeting in Madrid:

"IAGA has already sent notice to the IUGG Executive Committee that it would like to cosponsor the following interdisciplinary symposia at the XV General Assembly:

1. Ocean Floor Spreading with IAPSO, IAG, IASPEI
2. Energetics and Dynamics of the Mesosphere and Lower Thermosphere with IAMAP
3. Physics of the Moon with IASPEI and IAVCEI

"In addition IAGA also proposes the following interdisciplinary symposia:

4. Solar Corpuscular Effects on Troposphere and Stratosphere with IAMAP
5. Electric Fields in Space and Their Connection with Atmospheric Effects with IAMAP
6. Automatic Acquisition of Data and Time Series Analysis, with all other Associations
7. Aurora and Airglow – All Aspects, with Commission on Airglow from IAU and Radio Aurora Commission of URSI (although these are not IUGG Associations they will probably want to cooperate)
8. Geomagnetic Aspects of the Structure and Evolution of the Earth and Planets.
9. Morphology and Physics of Magnetospheric Substorms
10. Lunar Variations in Geophysical Phenomena with IASPO, IAG and IAMAP

"Dr. Troitskaya who is a member of the IAGA Executive Committee and knows very well the desires of the USSR Local Committee indicates that there is plenty of room for IAGA to hold a full Association Assembly in Moscow. The IAGA Executive Committee strongly feels a need to do this because of its size and because of the importance of the program it represents. Holding a full scale Association meeting would permit the discussions of many extremely important topics which relate mainly to IAGA itself.

"It is therefore proposed that each IAGA Commission plan full activities for the Moscow Assembly. Each Commission will be encouraged to specify one or two topics for emphasis, but general contributions will also be encouraged along with business meetings for Working Groups and Commissions. Plenary Sessions of the Association will also be necessary so that elections and business can be properly completed."

RESOLUTION

Resolutions of thanks for the fine work of all the local Spanish people, headed by Father Romaña, who helped make the Spanish Assembly so successful were unanimously approved. Many scientific resolutions were also approved. All of these resolutions will be duplicated in IAGA News No. 8 and in IAGA Bulletin No. 27, Transactions of the Madrid Meeting.

NOMINATIONS COMMITTEE

It was agreed that the following scientists should act as a nominating committee to prepare a slate of candidates to lead IAGA during the 1971-1974 period for consideration at the XV IUGG General Assembly to be held in 1971 in Moscow:

T. Nagata – President of IAGA (ex officio member and Chairman)
M. Nicolet – Past President of IAGA
V. Laursen – Past president of IAGA

IAGA-IAMAP JOINT COMMITTEE ON ATMOSPHERIC ELECTRICITY

The name "Planetary and Space Problems of Atmospheric Electricity," was approved for the 9th Working Group of the IAGA-IAMAP Joint Committee on Atmospheric Electricity. This is now official since it was approved earlier by IAMAP as indicated in a letter from Dr. Godson, secretary of IAMAP to Dr. Koenigsfeld dated 11 July 1969.

FRENCH PROPOSAL

Each Commission Chairman expressed the view of their Commission regarding the French proposal. Many points of view were displayed. Most of these are shown in the minutes of the Commission business meetings which will be published in the transactions of the Madrid meeting.

No distinctive point of view was agreed upon. The only decision made on this point was that the only real problem within IUGG which prompted the French proposal is IAGA's relationships to IUCSTP, COSPAR, and URSI. Therefore IAGA must figure pre-eminently in its solution.

The IAGA Executive Committee is continuing to explore solutions to this problem, and at the latest intends to have a mature point of view on May 1970.

It was recommended that IUGG be asked to appoint a committee to study this problem and that IAGA scientists be strongly represented on this study committee.

If later, an ICSU Committee is appointed to study this problem IAGA scientists should form a large part of the IUGG representation.

NEXT MEETING

The next meeting of the Executive Committee will be held at Leningrad at the time of the Inter-union Symposium on Solar-Terrestrial Physics.

REPORTS OF IAGA ORGANIZATIONAL UNITS

COMMISSION I
OBSERVATORIES AND INSTRUMENTS
A. P. DeVuyst – Chairman

SCIENTIFIC SESSIONS

Three sessions on the special topic "Digitization Techniques of Geomagnetic Observations" were held. These sessions followed the program as scheduled in Bulletin 26 except that paper I-14 by G. Royer was not presented and papers I-17 and I-18 were shifted to Commission IV special sessions on "Instabilities in the Magnetosphere". Two new papers were added to the program as follows:

A Digital System for the Recording of Geomagnetic Disturbances – G. Rostoker, and

Recent Progress in the Variable Area Recording of Geomagnetic Variations – Edwin J. Chernosky

REVIEW AND BUSINESS MEETING

The review and business meeting was held on 5 September at 09:00 – 12:00. The meeting was attended by 35 members and 35 guests. Material which is given in detail below under the various working group headings was explained.

Agreement was reached on the need for 2.5 minute sampling rate for semi-automatic digitization of normal magnetograms. It was found desirable to have sampling rate of at least one per minute in automatic digital magnetometers.

No action was taken on proposals for new geomagnetic indices. This will be reconsidered in Moscow in 1971.

The "Bureau International des Poids et Mesures" value of 2,67512 for the gyromagnetic ratio of protons in water was proposed as a new standard (provisional value accepted in 1960 by IAGA is 2,67513). After discussion, the suggestion made by Dr. P. Bender to defer any change until the next General Assembly was accepted.

An ad-hoc working group consisting of A. Nichol (Convenor)

A. DeVuyst	P. Serson	P. Bender
B. R. Leaton	D. Knapp	A. Hahn
K. Wienert	F. Lowes	

was appointed to study the problem of international geomagnetic units and to prepare a short draft report and recommendations for the next General Assembly.

Dr. V. A. Troitskaya presented details of a system called "Autonomous Magnetic Variations Stations of Long Recording" (AMVSLR) being developed in the USSR recording of magnetic data in remote places. Because it is still in the experimental stage, it was decided to delay discussion until the next assembly.

It was agreed that the Commission would propose to the Executive Committee that a symposium on The Automatic Acquisition of Geophysical Data and Time-Series Analysis be held in Moscow in 1971 (see minutes of Executive Committee).

The French proposal regarding the reorganization of Unions within ICSU to minimize overlap of work on aeronomy, space, and solar-terrestrial physics was discussed. It was concluded that:

(a) The French proposal is not generally in the interest of IAGA

(b) To avoid overlapping, a new structure should be considered. It was proposed that a Union of Geomagnetism and Aeronomy be formed which would include Commissions four and five of URSI.

WORKING GROUP I-1, MAGNETIC OBSERVATORIES
K. L. Svendsen – Reporter (For J. H. Nelson)

The business meeting began at 12:00 on September 2, 1969. In the absence of the reporter, J. H. Nelson, the meeting was presided by K. L. Svendsen. The meeting was attended by six members and seven guests.

A report was given by K. L. Svendsen on the information collected from a questionnaire distributed to all institutions operating magnetic observatories. The questionnaire referred to proton-magnetometers and machine readable observatory results. Despite the availability of observatory results on microfilm and in machine readable form in the WDCs, it was agreed that the publication of yearbooks should be continued because it is a criterion for the continuity of the observatory work. An IAGA recommendation to this effect was passed (see scientific resolution No. 1 in this Bulletin).

K. Svendson reported on information collected from a questionnaire as given below.

A Report on Results of the Questionnaire
Concerning Digital Data.

In December 1968, under the auspices of Commission I, a questionnaire was sent to each of the offices which operate magnetic observatories. The aim of the questionnaire was to learn (1) the number of stations equipped with the latest type of magnetometers and related equipment, (2) the number producing their results in machine-readable form, and (3) the extent of observatory-produced machine-readable results.

Results were received from organizations operating a total of 185 observatories. Only three observatories believed to be operating are not included in this study.

Response to the question "Do you have a proton magnetometer?" included 124, or about 70% affirmative. Surely, this is a remarkable achievement in the few years that these magnificent instruments have been available. Of those responding in the negative, 43, or about 2/3, indicated that they expected to have a proton magnetometer within the next five years.

Response to the question "Do you scale hourly values by hand?" included 165 affirmative. Of this number, 40 indicated that they transferred the values to punched cards and 10 that they transferred the values to punched paper tape–a total of 50, or about 30%, of those who are scaling.

We also asked, "What is the first year of data for which the scalings have been transferred?" The answers show that for the years prior to the IGY, hourly values in machine-readable form are available for 15 observatories, all in the northern hemisphere. Twenty-three observatories report that they have machine-readable data as far back as 1960. With the exception of two Antarctic stations, all are still in the northern hemisphere. As the years advanced, more stations joined in until today there are a total of 76 stations putting their values in machine-readable form. The Coast and Geodetic Survey is adding about 12 more stations.

Response to the question "Do you have equipment for semi-automatic or automatic digitization of analog records?" included 42, or about 1/4, affirmative. This probably does not mean that 42 stations have digitizing equipment, but that 42 stations have such equipment available to them. Thirty-three of the 42 use the equipment continuously. Twenty-four derive values at a shorter time interval than hourly. The majority record the values on magnetic tape, but paper tape is the next most preferred medium, with punched cards accounting for the smallest number.

Response to the question "Do you have a magnetometer recording in digital form?" included 23 affirmative, of which six replied that they recorded total intensity only. Of the 23, only 13 use the equipment continuously. Most of the output is on paper tape, but a few use magnetic tape. Rates of field sampling vary from 10 seconds to one hour with about half of the stations recording at one minute intervals. Precision is generally one or two tenths of a gamma.

A copy of this report will be sent to each of the respondents. Included will be a list of addresses. The nearly complete response to this questionnaire provided a good opportunity to prepare an up-to-date list of addresses for organizations operating magnetic observatories (see IAGA News No. 8).

WORKING GROUP I-2, GEOMAGNETIC AND TELLURIC INSTRUMENTATION
P. Serson — Reporter

The business meeting began at 12:00 on September 3, 1969. The Group recommended that IAGA adopt officially the value of the gyromagnetic ratio of protons in water proposed by the Bureau International des Poids et Mesures in place of the provisional value adopted in 1960 (See business meeting, Commission I). One section of a bibliography of magnetic instruments, an annotated listing of over 100 references (by F. Prihmdahl) on fluxgate magnetometers, was distributed and discussed. It was decided to complete the bibliography but to restrict it to articles of practical value for the working geomagnetician. The reporter will circulate a preliminary version for comments and additions.

It was decided that the Working Group I-2 report for the next General Assembly should contain a description of available instruments similar to the reports presented in recent years.

WORKING GROUP I-3, COMPARISON OF MAGNETIC STANDARDS

V. Laursen — Reporter

Since the reorganization in 1963 of the IAGA structure, the continuation of the activities of the IAGA Permanent Service on Comparisons has been entrusted to this Working Group.

The comparison observations have been carried out as in previous report periods by means of calibrated QHM magnetometers sent by air freight from the Rude Skov observatory to the participating observatories and back. In addition the Service on Comparisons has continued to cooperate in the program of the World Magnetic Survey pilot missions by sending sets of calibrated magnetometers with the WMS Experts for the purpose of comparing these magnetometers with the standard magnetometers in the countries visited. During the period under review such comparisons have been carried out by Mr. P. M. McGregor, in charge of the WMS mission to countries in South East Asia. Part of the instrumental equipment of this mission, namely a set of three QHM magnetometers and an Elsec proton magnetometer, was made available by the Australian Bureau of Mineral Resources, whereas a BMZ magnetometer was provided by UNESCO. The QHMs and the BMZ have all been compared at Rude Skov.

As in previous report periods, a set of IAGA QHMs has formed part of the instrumental equipment of the non-magnetic vessel "ZARYA" of the USSR. The constants of these QHMs were checked at Rude Skov when "ZARYA" called at Copenhagen in October 1968.

Here is the complete list of comparisons carried out during the report period:

(1) A comparison by means of QHMs 228, 229 and 230 between Rude Skov and the observatories at Toledo, Almeria, Logrono, Ebro and San Fernando (Spain).

(2) A comparison by means of QHMs 228, 229 and 230 between Rude Skov and the observatory at Lourenco Marques (Mozambique).

(3) A comparison by means of QHMs 50, 51 and 91 between Rude Skov and the observatory at Lourenco Marques (Mocambique).

(4) A comparison by means of QHMs 460, 461 and 462 between Toolangi/Rude Skov and the observatories at Muntinlupa and Baguio (Philippines), and Tangerand (Indonesia). The travelling standards were further compared with survey magnetometers at the repeat station of Tibar (Portuguese Timor).

The results of the comparisons are given below in the form of differences between observatory standards of H. The list also comprises results of comparisons carried out during the preceding report period, insofar as these results could not be included in the 1967 report.

1965, December	Rude Skov – Vienna = -4.4γ (The Vienna standard based on HTM 523932, 551636, 570710)
1966, December	Rude Skov – Pendell = 1.7γ (The Pendeli standard based on Askania travel theodolite)
1967, January	Rude Skov – Kandilli = -34.8γ (The Kandilli standard based on QHM 169, 170 175)
1967, January	Rude Skov – Ksara = -1.0γ (The Ksara standard based on Kew magnetometer)
1967, January	Rude Skov – Teheran = -12.7γ (The Teheran standard based on QHM 336 and 510)
1967, January	Rude Skov – Quetta = -20.1γ (The Quetta standard based on HTM 30, 31, 33)
1967, February	Rude Skov – Misallat = -12.7γ (The Misallat standard based on QHM 159 and Schuster-Smith magnetometer)
1967, May-Oct.	Rude Skov – Toledo = -2.7γ (The Toledo standard based on QHM 218)
1967, June	Rude Skov – Almeria = -45.5γ (The Almeria standard based on QHM 217)
1967, June	Rude Skov – Logrono = -24.0γ (The Logrono standard based on QHM 396)
1967, August	Rude Skov – Ebro = -14.4γ (The Ebro standard based on Ruska magnetometer)
1967, July	Rude Skov – San Fernando = -32.1γ (The San Fernando standard based on QHM 249)
1968, March	Rude Skov – Lourenco Marques = -23.7γ (The Lourenco Marques standard based on QHM 299)

For some of the comparisons carried out during the report period the final results are not yet available.

In view of the fact that the Rude Skov observatory has been serving as a reference station for this program of comparisons, it seems appropriate to point out that the Rude Skov standard can by no means claim to be considered an international standard for horizontal force. In this connection it has been thought that the observatories taking part in the program would be interested in the following summary of all the comparisons which have so far been carried out between Rude Skov and Cheltenham/Fredericksburg by means of QHMs. No comparisons between Rude Skov and Fredericksburg have been carried out during the period under review, and the summary is identical, therefore, with the one given in the 1967 report.

1948, April (QHMs 33, 51, 52) Rude Skov – Cheltenham = 3.0γ
1949, December (QHMs 90, 91, 92) Rude Skov – Cheltenham = –0.6γ
1949, December (QHMs 29, 58) Rude Skov – Cheltenham = 3.1γ
1951, March (QHMs 34, 50) Rude Skov – Cheltenham = 4.6γ
1953, May – September (QHMs 50, 51, 52) Rude Skov – Cheltenham = 2.5γ
1956, August (QHMs 32, 33, 34) Rude Skov – Cheltenham = –1.6γ
1958, October – November (QHMs 477, 478, 479)
Rude Skov – Fredericksburg = 0.6γ
1961, November (QHMs 477, 478, 479) Rude Skov – Fredericksburg = 0.6γ
1966, December (QHMs 477, 478, 479) Rude Skov – Fredericksburg = –0.3γ

Since 1968 the observing conditions at Rude Skov have been somewhat hampered by artificial disturbances from a nearby electric railway line. The accuracy of the measurements has thereby been slightly reduced, but it would seem that observations of H can still be carried out with the accuracy required for comparison purposes.

COMMISSION II
REPRESENTATION OF MAIN MAGNETIC FIELDS
B. R. Leason – Chairman

BUSINESS MEETING AND REVIEW SESSION

The business meeting and review session for Commission II was held on Wednesday morning, 3 September at 09:00. Twenty-five scientists attended. Chairman Leaton presented a general review which follows.

GENERAL REVIEW

Much of the effort of Commission II since the St. Gall assembly has been concentrated into the work of completing the 1965 World Magnetic Survey. The World Magnetic Survey Board, as such, ceases to exist at the end of this year, by which time it is intended that a full report of its activities and results shall be published.

A major step forward in completing these final stages and the collection and analysis of results was the arrangement by the World Magnetic Survey Board of a IAGA Symposium at the National Academy of Sciences in Washington, D.C., U.S.A. in October, 1968. Much of the value of this Symposium is due to the excellent organization by J. H. Nelson and his colleagues of the ESSA Coast & Geodetic Survey, Geomagnetism Division. The papers presented at that Symposium form a significant part of the World Magnetic Survey report which will be dedicated to our late lamented friend and colleague, Harry Vestine.

The Symposium was memorable also as the occasion on which agreement was reached on an International Geomagnetic Reference Field (IGRF). Most of you will know of the difficulties and the long battle to reach this agreement. Dismayed at St. Gall at our lack of agreement, we were collectively resolved that come what may we would reach agreement by Washington. This, I am happy to say, we did and although there are still little ripples of healthy argument going on, we are all pleased that the IGRF values have been published for all to use.

Some of the other principal activities of the Commission during the last two years have been in relation to IAGA Resolutions approved at St. Gall. (See IAGA Bulletin No. 25 or IAGA News No. 6 for a full statement of the resolutions discussed by number below.)

Resolution No. 3 urged all organizations making magnetic surveys to send the data to one or more WDC or to one or more of the three organizations engaged in making world magnetic charts. It takes time for a mechanism of such a resolution to gather momentum. From my own knowledge, this resolution has so far produced no great change in the input of survey data. This may be an anti-climax following the peak of effort of the WMS.

Resolution No. 4 urged all countries to transmit archived magnetic survey data for the years 1840-1900 to the WDCs. I have very little knowledge of any progress in this respect except that made by my own organization. I hope that people will be prepared to give a brief verbal report of any progress that they know of. There will be an opportunity to do this later in this session.

Resolution No. 6 recommended that all mean hourly value data of the geomagnetic field elements be made available in machine readable form through the World Data Centers.

Although this resolution was devised for the specific purpose mentioned within it, this sort of project has naturally become part of a wider project. We are indebted to Professor Chapman for the invention of a very good catch-phrase to express the accretion of all similar efforts into one whole. I refer of course to the World Magnetic Archive. This will be discussed fully in a later session. Although Professor Chapman's initial proposal referred primarily to older data, his catch-phrase seems an excellent one to coordinate several efforts, many of which have been talked about for years and have hardly moved.

Resolution No. 8 recommended the establishment of several World Digital Data Centers (WDDC) for geomagnetism. We must all be aware of the difficulties of persuading our governments to find money for new projects. I am happy to report that there has been physical progress towards the setting up of WDDCs in the USA and UK, of which the one in the USA is by far the more going concern. There has been news recently of a strong hope of setting up a third center in India. More details of the progress towards fully functioning WDDCs will be given in the WMA Session.

World Magnetic Survey (WMS)
Final Report.

The Draft of the final WMS volume was described by J. C. Cain, and discussion and comments were invited. In the discussion, it emerged that the final volume would probably be published in letterpress, 2000 copies, with UNESCO support. A supplementary volume containing IGRF tables and IGRF charts would be produced by photolithography. The total cost would be about $8,500. Leaton showed the preliminary charts and invited comments. It was suggested that the D chart would be improved by the omission of some of the isolines to the N.W. of the north dip pole, that the projection should be stated and maximum and minimum values of foci be indicated, that the 25° line of D should be added in the S. Atlantic, and that the positions of saddle points should be indcated by crosses (D. Knapp).

The International Geomagnetic
Reference Field (IGRF)

Possible future modifications to the IGRF were discussed. It was suggested that modification be deferred as long as possible, consistent with the usefulness of the present IGRF. J. C. Cain suggested that the IGRF should not be changed as soon as 1972, but that it should continue to be compared with new observations. F. J. Lowes requested that adequate notice be given of any proposed change. There were several suggestions as to the most desirable method of making changes which may be summarized as follows:

(i) Produce an entirely new model, to be used from a stated epoch (this would produce a discontinuity between the old and new I.G.R.F's);

(ii) Change only the time-terms, to make the future main field coefficients realistic. This would avoid a discontinuity, but would produce a meaningless S.V. field;

(iii) Correct only time-terms to conform with future estimates. This would avoid a discontinuity, but produce systematic errors in the main field.

No final decision need be made until the time comes for such a change to be made – probably not until after the 1971 meeting.

Survey Data

A paper by D. H. Matthews on the availability of ocean observations of total field, at present filed by Geophysical Institutions, was read by B. R. Leaton. The full text of this paper is reproduced starting on page 29 of IAGA News No. 8. In the ensuing discussion, it was regretted that this wealth of data was not generally available, but it was not clear how funds or personnel could be found for the organization of this data into a form suitable for transmission to WDDC's.

The future of magnetic surveys in the post-WMS era was discussed, and it was suggested that it would be desirable to recommend specific epochs when it would be particularly desirable to re-occupy repeat stations to give greater uniformity to the resulting data, and enable a maximum of the data to be incorporated in charts prepared soon after these epochs. B. R. Leaton suggested that this was most appropriate for Working Group III-2 and it was agreed to pass the recommendation to this Working Group.

B. R. Leaton drew attention to IAGA resolution No. 4 from St. Gall requesting that early magnetic survey data should be retrieved and made available to the WDDC's. A report on the progress of such work by the Institute of Geological Sciences, Herstmonceux, U. K., on early ship swings by Miss Whale, which was read by B. R. Leaton is given below:

"We have many original magnetic survey observations made between 1820 and 1912 in our archives. These were made by officers of Her Majesty's Ships both on board and ashore, and sent with other ship's records to the Hydrographer of the British Navy. The Hydrographer passed the observations on to the Magnetic Department here, to be used in the preparation of magnetic charts. Most of these observations are in manuscript form on sheets of paper and in rough work books, and many have never been published.

We have sorted these papers into decades, and have listed the approximate number of observations made in each 10° x 10° grid in each decade. We have only had time to list the observations of declination, but we also have many observations of inclination and intensity. We have omitted H.M.S. Challenger's many observations as these have been published in full, and also H.M.S. Discovery and H.M.S. Penguin, which together form about a tenth of the total records, because of lack of time.

The distribution has been entered on a world chart for each decade. The actual manuscripts differ greatly in the information given. Some give local time of observation, as well as date and accurate position, while at the other end of the scale are those which give merely month and year, and the name of the nearest port or island.

We have also made a start in converting the data to machine-readable form. The observations will be punched onto cards and a magnetic tape formed containing all the data. This will take some time, as the observations are often given several times in various summaries made by various people, and will need careful editing. We also have records of observations made by ships of other countries, and also by British explorers and scientists going back to the end of the 15th century."

M.H.G. Barsczus reported his progress on early French observations in Africa, and indicated he hoped to complete his compilation before 1971. G. Scheepers drew attention to the summary of early observations in Southern Africa published by Beattie in 1908.

Geomagnetic Units

A recommendation by the British National Committee on the adoption of S. I. units for geomagnetic work met with general approval, but it was considered that the matter was too complex for an immediate decision, and it was recommended that a joint Commission I and II working group should be established to consider the introduction of S.I. units, and report in time for a decision to be taken at the 1971 IAGA meeting.

The French Proposal

Commission II has examined the proposal of the French National Committee both in its business meeting and in its working groups. The following is an attempt at a consensus:

1. Most of the geomagnetic field is of internal origin, but many of its variations occur within the Sun-Earth magnetospheric cavity; these in turn induce internal variations. There is no real separation between the geomagnetism of the magnetosphere and the core. The mechanisms share magnetohydrodynamics and, to a large extent, interest the same scientists, thus knowledge of each domain is necessary for an understanding of the other and many geomagnetic data to combine the effects of both domains. The Commission is therefore not in favor of a split of IAGA.

2. The creation of a Federation imposes another layer in the hierarchy of ICSU. It is important for IUGG to at least retain its relative position. Commission II agrees to the concept of a federation only if all unions are required to form federations. The overall size of a federation should be specified.

3. The scientific part of URSI has largely developed as an adjunct to the technicalities of man-made radio propagation. Commission II therefore considers appropriate the amalgamation of some of URSI (principally its Commission IV) with IUGG. No suggestion is made for the remainder of URSI.

4. The name of the new Union could be *International Union of Geophysics* (IUG). Some readjustment of associations may be desirable. In this context, proposal C of the French National Committee is a natural. It is perhaps unwise to propose division of science by domains. The real division of effort is between dynamical and quasi-static phenomena. It may also be appropriate to consider whether the Geodesy of IUGG would be better off in IAU.

B. R. Leaton invited suggestions for joint scientific symposia for the 1971 meeting. J. C. Cain suggested a symposium on correlations between the geomagnetic field and crust and mantle features. D. G. Knapp suggested Sea Floor Spreading. A. DeVuyst and E. Bullard suggested Recent Developments in Equipment and Methods of Time-Sequence Analysis.

It is noted here that the following additional paper was added to the Commission II Scientific Session on Thursday, 4 September. "Calcul des Composantes du Champ Geomagnetique a Parter d'un Leve de Son Intensite," by Jean-Louis Le Mouel.

WORKING GROUP II-1, LAND AND AIRBORNE SURVEYS

P. Serson – Reporter

The business meeting of Working Group II-1 was held at noon on 2 September. Eighteen scientists were present including: Serson (reporter), Barsczus, DeVuyst, Kautzleben, Le Mouell, Leaton and Stockard.

Two examples were discussed of regional meetings of geomagneticians to coordinate surveys and charts: the Rio de Janeiro meeting of January 1969 (reported by Gama), and the annual meetings of the Democratic Republics of Eastern Europe (reported by Kautzleben). It was agreed that the working group should encourage such meetings, especially in parts of the world where responsibility for surveys and charts is divided among many countries of small area. Barsczus will try to arrange one for Africa (and in fact organized a preliminary planning meeting in Madrid). Serson will consult Turajlic about the possibility of arranging a meeting for southern Europe.

It was agreed that an instruction manual for magnetic surveyors and cartographers would be most valuable, especially to the newer countries. From Dr. Wienert's description of the contents of his WMS-UNESCO manual for magnetic observers, now in press, it appears that instruments, observing techniques and the organizing of land surveys are already well covered. The remaining requirement is for a manual on the analysis of survey data and methods of chart construction. It was agreed that each member of the working group would send Serson a bibliography of published accounts of surveys in his region which include a description of the methodology. Serson will circulate a preliminary list for additions and comments, and then Barscuzus will collate the material and write a suitable introduction.

It is considered that the most useful part of the working group report to be prepared for the Moscow meeting in 1971 will be a complete bibliography. Where possible, the descriptions of national surveys will be grouped in geographical regions. Barsczus will assemble bibliography and prepare a report for Africa, Kautzleben for eastern Europe and Turajlic for southern Europe. Gama will be asked to assemble material for South America, and Serson will collect information for the fest of the Earth.

It was recommended that Commission II support the proposal for a symposium at the next General Assembly on "automatic acquisition of geophysical data and time-series analysis."

WORKING GROUP II-3, ROCKET AND SATELLITE SURVEYS
J. C. Cain – Reporter

The business meeting of Working Group II-3 was held at noon on Thursday, 4 September. Four scientists attended.

In response to the request by the IUCSTP and the acknowledgement that the World Magnetic Survey Board will soon expire, it was suggested that the scope of Commission II be expanded to include representation of fields external to the earth. Accordingly, it was recommended that the title be changed to "Representation of Magnetospheric Fields". The responsibility of this Committee would then be altered to include a statement such as "Treats the analysis and representation of systematic field sources within the magnetospheres of planets of the solar system. These sources shall include those internal to the body and external sources such as quiet-day ionospheric currents, slowly varying trapped plasma and average boundary and tail currents".

In accordance with the above recommendation, it was recommended that the present Working Group II-3 be dissolved and that there be created a new Working Group entitled "External Fields" whose functions would include:

1) Encouraging and reporting on experiments appropriate to the numerical modeling of external fields and assisting in making their data available.

2) Encouraging and reporting on analysis of these data relative to models.

3) Evaluating competing models or representation relative to the available data and reporting to other groups the conclusions. Theoretical bases for such models to be developed in consultation with the appropriate working groups in commissions IV and V.

Proposed membership in this group is to be discussed with A. J. Zmuda and J. G. Roederer. Continuing from the previous group would be J. C. Cain (reporter) and K. Burrows. B. Theile (FDR) was suggested also due to his work on the GDS spacecraft.

(Editor's Note – No official action by IAGA was taken in Madrid on the above proposals since the Madrid Assembly was a scientific assembly and not an organizational assembly. It was felt that the Working Group III could move in the above direction, but that formal reorganization could wait until 1971 in Moscow.)

WORKING GROUP II-4, ANALYSIS OF GEOMAGNETIC FIELDS
A. J. Zmuda – Reporter

Reporter Zmuda reported that, following a suggestion of B. R. Leaton, the International Geomagnetic Reference Field coefficients were published by the Working Group in three journals: Journal of Geophysical Research, Geomagnetism and Geoelectricity and Geomagnetism and Aeronomy.

Review articles in the Working Group's deliberations and on the International Geomagnetic Reference Field (IGRF) will be published in the summary volume "The World Magnetic Survey 1957-1969".

The Working Group decided to contact users of the IGRF and ask them to specify (a) the limitations and advantages of the IGRF and (b) what errors in the IGRF can be tolerated before the IGRF should be changed.

J. C. Cain reported on Working Group II-3 suggestion that its functions should include analysis and representation of external fields. Working Group II-4 endorses the change, but recommends an infusion of Working Group II-4 members into Working Group II-3 to make available the IGRF expertise and to provide continuity between the IGRF and any external reference.

WORKING GROUP II-6, DATA INTERCHANGE

M. Ota – Reporter

The principal concern of Working Group II-6 in Madrid was the World Magnetic Archive (WMA) project. A WMA scientific session was chaired by M. Ota. This problem was proposed by Professor S. Chapman and endorsed by IAGA Executive Committee. In this session, the formats for hourly values of geomagnetic variations and the process for data interchange were discussed.

It was agreed that a questionnaire should be sent to all IUGG National Representatives requesting the following information:

A. Geomagnetic Hourly Values (including eye readings)

1. What data exist in the libraries and archives of your country?
2. What part of these data are in machine-readable form, either in your country or in the World Data Centers?
3. What specific plans exist for converting the remainder of the data (time schedule) to machine-readable form?
4. If unable to convert data to machine-readable form, can copies of data be supplied to others? (Refer to IAGA News No. 8 for desired format.)

B. Magnetograms

1. What magnetograms exist in the libraries and archives of your country?
2. What part of these magnetograms are on microfilm?
3. What specific plans exist for microfilming the remainder?
4. If unable to microfilm the magnetograms, can they be loaned to others?

C. Additional Information

Please add additional comments regarding data which you have but which may not be readily available to others even if data were taken by observatories of another country. Also, please give any information on your country's data which you believe exists only elsewhere, or which you know to have been destroyed.

Formats for punching hourly values and more frequent data on magnetic tape and cards were decided. These recommended formats are reproduced in detail on pages 22-23 of IAGA News No. 8.

In the meeting of the Working Group, it was suggested that the following three scientists were to be added as members of the Working Group.

Mr. C. G. Sucksdorff (Finland), Mr. H. Meyers (USA) and Mr. B. N. Bhargava (India). (Editor's Note – These additions to the Working Group were later approved by the Executive Committee.)

COMMISSION III
MAGNETISM OF THE EARTH'S INTERIOR
T. RIKITAKE – CHAIRMAN

BUSINESS MEETING AND REVIEW SESSION

The session on the Business Meeting and Review of Commission III was started at 12:00, September 11. In his opening remarks, the chairman pointed out the work in the frame-work of Commission III has been steadily developing these two years. For instance, the intensity of the magnetic field of the earth as far back to several thousand years was traced indicating a change of about 10,000-year period. Measurements on the Hawaiian Islands made it clear that the non-dipole field has been persistently small over the past five million years.

Turning to the geomagnetic dynamo, the Bullard-Gellman dynamo model, which was in a critical state at the time of the St. Gall meeting, seems to have been revived, and so some sort of dynamo is still the only way of accounting for the origin of the geomagnetic field. Electrical conductivity anomalies have been found in many countries even in a very stable portion of the earth such as the British Isles. Some of the anomalies seem to be correlated very well with heat flow distribution.

Review reports by the reporters of Working Groups are included under each Working Group heading below.

It was proposed that three of the Working Group Reporters be changed as follows:

WG III-3 K. Whitham to be replaced by D. I. Gough (Canada)

WG III-5 E. Thellier to be replaced by R. L. Dubois (USA)

WG III-6 R. R. Doell to be replaced by K. M. Creer (U. K.)

The following symposia were proposed for the Moscow Assembly:

1) Volcanic Rocks and Their Magnetization to be organized jointly by IAGA and IAVCEI, and

2) Paleomagnetism and Global Tectonics to be organized by IAGA and IASPEI.

Adoption of the MKS system was discussed. It was found that many people want to preserve the electromagnetic unit system. It was decided not to take any action.

The French proposal for reorganizing Unions within ICSU was discussed. Most people are not in favor of splitting IAGA. Especially for electromagnetic induction and related problems, it is nonsense to cut the group at the earth's surface.

The two resolutions, which can be found in the report of WG III-3 on Electromagnetic Induction, were adopted by Commission III and passed on to the General Secretary.

WORKING GROUP III-1, ELECTRODYNAMICS
F. M. Lowes – Reporter

The last two years have seen a renewed interest in geomagnetic dynamos.

While P. H. Roberts and Gibson showed that the original Bullard-Gellman motions were not self-exciting, Lilley has almost certainly shown that slightly modified motions are self-exciting. P. H. Roberts, Gibson and Lortz have made clearer some of the limits to which this type of dynamo is subject.

Work has started on the investigation of periodic dynamos (G. O. Roberts and Childress) and on turbulent dynamos (Moffatt, Krause and Frisch) in both of which small-scale motions feed energy to larger-scale magnetic fields. Whether such small-scale motions are important in the core is disputed.

The suggestion by W.V.R. Malkus that the energy source for the dynamo is precession and not thermal convection is still being investigated by him. Work has also continued on various approaches to understand the more general hydromagnetic properties of the core. R. Hide has continued his investigation of the possibility of hydromagnetic waves in the core.

Attempts continue to extrapolate the main magnetic field down to the core-mantle boundary and to deduce the velocity pattern at the surface of the core. However, many ambiguities remain.

The reporter would like to add Dr. F. Krause, Zentralinstitut Physik der Erde, DDR-15 Potsdam, to the Working Group.

WORKING GROUP III-2, SECULAR CHANGE
V. P. Orlov – Reporter

The Working Group meeting was held at noon on 3 September. In the absence of the Reporter, Dr. Rikitake asked Mr. B. R. Leaton to take the chair.

A suggestion of Commission II that specific epochs be recommended for the re-occupation of repeat stations was discussed. The suggestion was thought too restrictive and was not supported.

During the years 1967-1969 three issues (II, III and IV) of the "Summary of Annual Mean Values of Magnetic Elements at the World Magnetic Observatories" were compiled and published. These "Summaries" were delivered to the Working Group Members, Directors of Magnetic Observatories, and to a number of scientists concerned.

In the beginning of the IGY at Brussels, "Descriptions of Magnetic Observatories," were edited. Since then some changes have taken place at a number of the observatories. Therefore, an attempt has been made to collect some up-to-date information concerning possible changes of sites, equipment, and absolute values comparisons at the world net of observatories. This information is to be published in the next summary.

The Working Group admired the work done by Dr. V. P. Orlov in compiling his catalogues of annual mean values. B. R. Leaton is to write and thank him. It was suggested that B. R. Leaton write to Dr. Orlov to suggest the publication of repeat-station data, say every 10 years.

It was proposed that the following additional members be added to the Working Group: E. Fabiano, (USA), R. Remiot (France) and G. L. M. Scheepers (S. Africa).

WORKING GROUP III-3, ELECTROMAGNETIC INDUCTION
K. Whitham – Reporter

A meeting of the W. G. was held on Thursday, September 4 at noon. The Reporter and four members of the Working Group were present together with nine interested colleagues.

The Reporter, K. Whitham of Canada, explained that it was necessary to resign because of the pressure of other duties. The Chairman of Commission III, Dr. Rikitake, accepted this resignation, effective at the end of the Madrid meeting, and had asked Prof. D. I. Gough of Canada to take over this position.

The death of Dr. B. M. Yanovsky of the USSR since the last meeting was noted with great regret. The W.G. requested the addition of Dr. Rotanova of the USSR to its membership.

A discussion was held about the International System of Units, and its implications for workers in this field. It was decided that it would be unwise and was unnecessary for this W.G. to recommend any change in nomenclature to workers in this field.

A brief review of the world wide level of activity in this field was conducted using the experience of the scientists present. In particular, it was noted with interest that there is a possibility of an increase in activity in Australia and Africa within the next year, if present plans by a number of organizations and individuals come to fruition.

Resolutions Number 10 and 11 (elsewhere in this Bulletin) were passed and it was requested that these be transmitted by Commission III to the IAGA Executive Committee with the request that they be adopted by the IAGA.

It has become evident that workers in this field must consider not only the induction of currents in local conductive structures, but also the possible concentration in such structures of currents induced elsewhere.

The complementary natures of the magnetotelluric and geomagnetic depth -sounding methods must be recognized.

Through the combination of induction studies with models of the seismic velocity distribution in the mantle, and through the exploitation of large computers, striking advances can be expected in the study of the electrical conductivity through the mantle.

WORKING GROUP III-4, ROCK MAGNETISM

C. M. Carmichael – Reporter

The Rock Magnetism Working Group held a very successful, though crowded, session of contributed papers at Madrid. As has been the case for the past few years, most attention was given to the Magnetite-Ulvospinel solid solution series. For this work both natural and synthetic specimens were used including an almost pure synthetic crystal of Ulvospinel. Evidence has been found that single phase magnetites containing more than 50% Ulvospinel can oxidize at low temperature in a rather special way. The result is a magnetization, that must be chemical in nature, having a Curie temperature of 500-520°C. The crystals remain optically single phase which probably means that oxidation has produced phases on a scale so fine that they are not optically resolved.

Work to correlate directly observed domain configurations and dislocation densities with the magnetic coercivity spectra of rocks containing small single phase magnetite grains has been quite successful. A magnesium bearing magnetite has been found to have some unusual partial reversal properties and work on iron hydroxides in synthetic sediments suggests that they can record the ancient earth's field.

WORKING GROUP III-5, ARCHEOMAGNETISM

E. Thellier – Reporter

In the absence of Prof. Thellier, the reporter, Dr. Dubois made the following report.

During 1961-69 many new results have been obtained concerning variations in the geomagnetic field. Considerable new data have been presented on paleointensity of the field. These data have been obtained by various experimental methods. Recent publications have summarized much of the data. New determinations of declination and inclination have been made in various parts of the world–England, India, Mount

Etna area, Bulgaria, Yugoslavia, Japan and United States. This work extends the area from which data is available and the zone range covered.

Considerable emphasis has been given recently by various workers concerning the problem of secular variation as determined by archeomagnetism.

Future work will concern paleointensity measurements as well as obtaining new data on variations in declination and inclination in various parts of the world.

The archeomagnetism working group met on September 8 with Drs. Abrahamsen, Bucha, Bulatskaia, DuBois and Schwarz in attendance.

The group stated their great appreciation and sincere regard for the personal efforts and general leadership given the working group in archeomagnetism by Prof. Thellier during the past years. (See earlier note that Prof. R. L. DuBois has replaced Prof. E. Thellier as reporter.)

Dr. Sither suggested that a note be sent out to archeologists of the world alerting them to the value and need for samples of baked clay materials for paleochemistry determinations.

The program for the forthcoming Moscow meeting was discussed and it was recommended that a full scientific session in Archeomagnetism and Variations in the Geomagnetic Field be held. In detail the following topics would be scheduled:

a. Measurements and collection techniques.
b. Presentation of data from the world.
c. Mineralizing of archeomagnetic samples.
d. Effects of changes in the magnetic field on C_{14} availability.

The group considers that such a program is very important to the future research efforts of workers in archeomagnetism.

Discussions concerning the sending of archeomagnetism data to the World Data Centers was deferred.

WORKING GROUP III-6, PALEOMAGNETISM
R. R. Doell – Reporter

Progress on most paleomagnetic subjects proceeded at a moderate pace during the past two years. Of particular note are the studies of paleozon paleomagnetism of the USSR and of deep sea cores by U. S. workers.

There appears to be a tendency to increase, somewhat, studies of ancient geomagnetic intensities in comparison with those studies of direction alone. It seems quite certain that this tendency will continue in the future.

Paleosecular variation contributions played a relatively large role in the Secular Variation symposium at Madrid. The principle finding seems to be that secular variations during the last several millions of years has not been markedly different from the present secular variations.

WORKING GROUP III-7, GEOMAGNETIC ANOMALIES
A. Hahn – Reporter

In the session on geomagnetic anomalies two papers were presented.

In the first one, given by J. Cain, USA, an anomaly chart of the US was shown, which had been compiled of measurements of "Cosmos 49". In one selected area of this satellite-borne survey the anomalies clearly correspond to those measured at the surface. Most of the negative anomalies in the western part covered areas with high heat flow values.

In the second paper Mrs. E. Oni, Nigeria, reported results of 3-component ground measurements near the magnetic equator. In some cases the magnetic bodies were veins striking strictly parallel to the magnetic meridian over a long distance thus producing in EW-profiles anomalies which were in H (and F) at least a hundred times smaller than in Z. Considering the background noise, veins of this situation can only be found by Z measurements. Paleomagnetic aspects were discussed.

In the business meeting, the relations between the magnetism and the petrographic description of rocks as far as they affect the interpretation of anomalies have been considered. It was concluded that an ad hoc committee (Bullerwell, Hahn, Roche) should prepare outlines for a symposium on this subject.

Concerning the interpretation of local anomalies in the T-profiles of "Project Magnet" it was decided to invite institutes which are interested in such an interpretation in some part of the world to participate in the establishing of a world chart which will show measures for the depth and the importance of the respective magnetic masses.

The work on a compilation of a magnetic chart of Europe which has been concluded at the St. Gall meeting is continuing.

COMMISSION IV
MAGNETIC VARIATIONS AND DISTURBANCES

J. A. Jacobs – Chairman

The French proposal for reorganizing some of the ICSU Unions was discussed at considerable length by IAGA Commission IV. There was general sympathy with the philosophy behind the proposal, although worries were expressed as to the exact mechanism which would be used to create these new unions and its effect on IAGA as a whole.

It was proposed by W. Campbell, and seconded by E. Selzer that:

a. IAGA consider clearer sub-divisions and possible restructuring within IAGA itself along lines of common research interests.

b. IAGA advise IUCSTP of their duties and responsibilities for international organization coordination.

This was carried unanimously.

It was then proposed by H. B. Liemohn, seconded by G. F. Kenney that Commission IV endorse the recommendation of Commission V – in particular – that a special committee be appointed by ICSU, consisting of scientists active in the fields of aeronomy and physics of the ionosphere, magnetosphere and interplanetary space, with the specific task to study and propose plans for the establishment of a new Union of Solar Terrestrial Physics (Solar-Planetary Physics). This was also carried unanimously.

SCIENTIFIC SESSIONS

Geomagnetic Activity and Related Phenomena

This session was held Thursday morning, 4 September.

Changes in the program were as follows:

Paper IV-3 by R. Shapiro was cancelled.

Papers IV-8 and IV-11 (b) were transferred to the Symposium on Comparison of the Magnetospheric Behavior with Ground Observations and New Indices of Geophysical Activities.

The following two papers were transferred to this session from Commission I sessions.

I-17 Reimer, D., – Automatic System for Real-Time Calculation of the Position of an Auroral Electrojet (Read by H. Heinrich)

I-18 Heinrich, H. – Investigation of the Polar Electrojet

Paper IV-11 (a) was replaced by the paper, Two Basic Modes of Interaction between the Solar Wind and the Magnetosphere by A. Nishida, K. Maezawa, N. F. Ness and J. H. Binsack

Micropulsations and Magnetic Storms
(Reported by E. Selzer)

This session contained a number of very good papers but unfortunately there was insufficient time for them all to be read. Only six were presented – those by H. R. Radoski, F. Glangeaud (2 papers), J. Roquet (2 papers) and W. H. Campbell.

The paper by M. J. Channon and D. Orr was given at the end of the business meeting of Commission IV on Monday morning, September 8th. Of the remaining papers, IV-19 (Abramov, L.A. et al.), IV-20(b) (Korosheva, O.V.), and IV-20(c) (Ohl, G.I. et al.) had been withdrawn. Thus only two papers IV-20 (Heacock, R. R. et al.) and IV-20(a) (Barbansky, L.N. et al.) had to be omitted because of lack of time. All of the papers which were presented gave a direct approach to problems concerning micropulsations and magnetic storms. The following comments are appropriate:

Paper IV-12 H. R. Radoski discussed a theoretical treatment of hydromagnetic wave polarization.

Papers IV-13 to IV-16 discussed results recently obtained by French groups in equatorial, mid- and high latitude stations (along a meridian) including, among other topics, propagation times, polarization properties, spectral structures and electrojet effects.

Paper IV-17 W. H. Campbell gave a good review of micropulsations, in connection with conjugacy effects and ionospheric influences.

Paper IV-18 M. J. Channon and D. Orr dealt with the characteristic aspects of equatorial geomagnetic pulsations.

All these papers gave rise to constructive discussions.

Instabilities in the Magnetosphere
(Reported by J. A. Jacobs, M. Sugiura, H. B. Leimohn and J. W. Dungey)

In session one Papers IV-22 by B. Hultquist and IV-23 by B. Bertotti were withdrawn.

This was the first of four special sessions on Instabilities in the Magnetosphere and the withdrawal of the above two papers gave time for lively discussion. J. L. Scaf gave a review paper on OGO-5 experiments which yielded information, not only on electromagnetic plasma waves in the magnetosphere, but also on electrostatic waves. He stressed the importance of these electrostatic signals as strong sources of turbulence. J. W. Dungey then presented a theory on VLF emissions and was followed by another review paper by R. L. Dowden on VLF and ULF emission and propagation in the magnetosphere. R. L. Dowden pointed out our ignorance as well as our knowledge in such studies and the diversity of opinions which were expressed in the ensuing discussions of both these papers illustrated well the value of these four special sessions. The meeting closed with a theoretical study by Y. Inoue on the generation and occurrence of geomagnetic pulsations in the magnetosphere.

In session two held Saturday morning, 6 September, changes in the program were as follows:

Paper IV-30 by N. M. Brice was cancelled.

Paper IV-31 by V. A. Troitskaya and A. V. Guljelmi was transferred to the Symposium on Comparison of the Magnetospheric Behavior with Ground Observations and New Indices of Geophysical Activities.

Paper IV-32 the authors should read: F. Z. Feigin and V. L. Yakimenko.

Session three was held Monday, 8 September. A few of the highlights are given below:

In paper IV-34, Dr. Frank indicated that rapid variations of low energy particle populations are attributed to small changes in geomagnetic field topology. Average pitch angle distributions have the form $\sin^m\alpha$ with $m = 1$. A new graytone display summarizes 10^6 bits of energy distribution data in one figure. Energy and pitch angle data are available on request.

In paper IV-40, Dr. Kern gave an analytic solution which fits the old Axford-Hines qualitative convection theroy. Questions from the audience implied that this new mechanism is unstable and untenable.

Paper IV-35 by Chirikov was given by V. L. Yakimenko. It presented a mathematical description of a proton drift instability. Diffusion rate and particle lifetime agree reasonably well with laboratory experiments.

Paper IV-36 by Lanzerotti, et al., indicated that storm data from several experiments on a satellite at $L = 5$ showed 4 minute oscillations. Drift mirror instability gives a good fit to some physical parameters but not all.

Paper IV-37 by Eticheto, et al., described rocket experiments at Kerguelen which measured VLF noise and particle precipitation and found good correlation between loss cone flux and dawn chorus. This result is clearly consistent with cyclotron-resonance amplification but does not prove it.

Paper IV-38 by Taylor was withdrawn (author was not present).

Paper IV-39, Dr. Reid described a macroscopic theory of drift dissipative instability in the dynamo region of the E-layer. Growth rates and wavelengths agree with observations of small scale irregularities which are manifest in spread F, sporadic E, radio star scintillations and situations in barium clouds.

Session four was held Tuesday afternoon, 9 September. The following changes were made in the program:

Paper IV-54 was replaced by a paper by Sugiura, M., T. L. Skillman, B. C. Ledley and J. P. Heppner entitled "An Instability Phenomenon Observed in the Magnetosphere near Its Boundary and in the Magnetosheath."

Paper IV-58 by R. E. LaQuey was cancelled.

The Kelvin-Helmholtz instability of the magnetopause was emphasized with reports on the general theory, polarization of disturbances in satellite data and the seasonal variation of Kp. Several papers dealt with oscillations in the tail and two concerned oscillations in the magnetosheath.

Symposium on Comparison of the Magnetospheric Behavior with Ground Observations and New Indices of Geophysical Activities (Reported by V. A. Troitskaya)

There was a major change in the order of the papers listed for this symposium in Bulletin No. 26, but most of the papers listed there were given. Two papers were deleted:

IV-79 Dorman, L. I: Estimate of the Properties of Magnetospheric Tail According to Ground-Based Cosmic Ray Observations

IV-80 Fairfield, D.: Geomagnetic Field – Solar Wind Relations

The following papers were added to the program:

Iijima, K. and T. Nagata: The Constitution of Magnetospheric Storms

Nishida, A., K. Maezawa, N. F. Ness and J. H. Brisack: Geomagnetic Evidence for Two Basic Modes of Interaction between the Solar Wind and the Magnetosphere.

Mainstone, J. S.: Pc and Pi Micropulsations and Eigenmodes of the Magnetospheric Cavity

Troitskaya, V. A. and A. V. Guljelmi: Hydromagnetic Diagnostic of Plasma in the Magnetosphere

Benediktov, E. A., et al. (Paper IV-llb) moved to this program

Campbell, W. H. (Paper IV-17) moved to this program

Schlich, R. and F. Gadat: Correlation Entre Les Orages Magnetiques a Debut Brusque et les Micropulsations

Ungstrup, E.: VLF Raytracing in Aurora

In two separate sessions new indices of magnetic activity were discussed. The two main topics were:

(a) Potential new indices of activity based on new knowledge of the physics of the magnetosphere (positions of the auroral oval, the plasmosphere and the boundary of the magnetosphere, etc.,) and

(b) Ways to calculate and distribute the already established indices (AE, Dst).

The results of these discussions were formulated in the resolutions presented to IAGA.

It was suggested that a session with invited speakers on new indices of activity should be held in Moscow in 1971. Dr. Sugiura has agreed to be the convenor of this special session.

Daily Variations
(Reported by D. J. Stone)

There were some changes in the program from that given in IAGA Bulletin No. 26. The paper by J. L. Redding was not presented and the paper by V. M. Mishin and G. V. Popov "About the Field Aligned Currents in the Magnetosphere" was given in the session Electric Fields in the Magnetosphere. The paper by J. C. Cain and D. G. Osborne "OGO-4 Observations of Equatorial Magnetic Field Variations" was incorrectly scheduled in Bulletin 26 as paper II-15 and was given in this session. Additional papers by A. T. Price and B. Hobbs "Surface Integrals for Geomagnetic Studies" and by S. Kato "Possible Electron Temperature Elevation by Joule Heating along the Equatorial Electrojet," were also included in the session.

The papers given in the session fall logically into three groups. The papers of N. A. Mishina et al., C. V. Wagner and D. J. Stone, discussed aspects of the morphological features of Daily Variations while that of A. T. Price and B. Hobbs added theoretical formulas useful in the determination of representative current systems.

The papers of D. Mohlmann and C. U. Wagner, D. Van Sabben and A. T. Price attempted to further the theory of Sq currents in a three dimensional model. The papers of D. G. Rivers, K. Burrows, J. C. Cain and D. G. Osborne presented equatorial results. A lively discussion followed Burrows' paper concerning whether his results were consistent with those of Cain and Osborne. Cain and Osborne's OGO-4 results were received with much interest. Finally the paper of S. Kato made the suggestion that it was experimentally worthwhile checking electron density and temperature at the equator by using rocket probes.

WORKING GROUP IV-1, MORPHOLOGY AND INDICES

D. van Sabben – Reporter

The main joint activity of the working group has been the composition of a questionnaire on magnetic disturbance data, concerning the present needs of the scientific community as to the publication of this data. An inquiry into these needs had become necessary because of the ever growing amount of data reported by the stations, the growing cost of their publication and the questioned value of some of the data. A draft questionnaire was sent to the members of the working group in July 1968. They responded with valuable suggestions for improvement. Between December, 1968 and April, 1969, the questionnaire was sent in its final form to almost 1000 addresses from which 223 replies were received. The most important results are given at the end of this report, together with the conclusions to be discussed during the Madrid Assembly. In connection with this questionnaire it may be recalled to mind that at present the following data are published by the *International Service of Geomagnetic Indices* (De Bilt, Gottingen, Tortosa), for which IAGA-commission IV acts as the advisory board:

a. In the yearly IAGA-bulletins 12.1 and 12.2: Indices K, C, Ci, Kp, ap, Ap, Cp and selected quiet and disturbed days, rapid variations ssc, si, sfe, bays, pi2, pg, pc4 and pc5 and minor disturbances from normal speed records.

b. In the three-monthly bulletins: Indices Kp and Ci, preliminary reports on rapid variations from normal speed records, pulsations pi1, 2 and pc1, 2, 3, 4, 5 from quick run records. Late reports on quick run data appear in a yearly supplement.

c. In the monthly reports from Gottingen: Kp with "musical diagram" and R9 – C9 diagram. From De Biltj Selected days and Ci-indices

Since the foregoing Assembly in 1967 the following IAGA-bulletins have appeared:

12s1 and 12t1: K and C-indices 1964 and 1965.

12r2, 12s2 and 12t2: Rapid variations 1963, 1964 and 1965.

The monthly and quarterly reports appear with a lag of less than one month and about six months respectively.

In accordance with Resolution 13 of the IAGA-Assembly 1967, Dr. Mayaud has determined 3-hourly planetary indices Kn and Ks for the Northern and Southern Hemispheres. They are published in:

Indices Kn, Ks et Km, 1964-1967, par P. N. Mayaud. Ed. du CNRS, Paris, 1968. In the introduction of this book, an explanation is given of the meaning and method of determination of Kn and Ks, their mean value Km, corresponding amplitudes a, etc. (French and English text). Values for 1968 are not yet published, but monthly publication of a preliminary indices has started in the beginning of 1969. Dr. Mayaud continues to take much trouble in improving the methods of determination of the K-indices at the observatories. He visited some of them.

Other recent publications on magnetic indices were:

Provisional Hourly Values of Equatorial Dst for 1964, 1965, 1966 and 1967 by M. Segiura and S. J. Cain, Goddard Space Flight Center, Maryland, U.S.A., Feb. 1969. *Hourly Values of Auroral Electrojet Activity Index* for 1963 by C. Echols, Y. S. Wong and T. N. Davis, Geophysical Inst. of Alaska, Scientific Report UAG. R-200, March 1968.

(A.E. indices for the years 1961, 1962, 1964 and 1960 have been published earlier). A new daily index x for variability of disturbance is proposed in the paper: Classification of Days, by G. Fanselau. Gerlands Beitrage zur Geophysik, Vol. 77, Heft 1, 1968, p. 42-49.

A study of the reporting of pulsations at 5 neighboring stations in Europe has been made by A. Korchunov. He concludes that in many cases the observers classify the same phenomenon in different ways, either as pi or as pc. The instructions for the reporting of pulsations should be improved.

A study of 5 solar flare effects of the years 1959, 1960 and 1961 by D. van Sabben, has been published in JATP, vol 30 (1968) p. 1641-1648. Their equivalent ionospheric current systems were compared with those of the daily variation at the times of the sfe's. Some remarkable differences were found.

Main Results of the Questionnaire on Magnetic Disturbance Data.

In the introduction to the questionnaire, it was suggested to transform the IAGA-bulletin 12 into a publication, containing planetary and other elaborated indices, references (only) to indices of individual stations and further the most important rapid variations.

From the 223 replies that have been received, 135 were in favor of transforming, 42 persons wished to maintain the present form and 46 had no preference. However, the replies to the detailed questions are in one point in contradiction with these figures: 57 persons still favor the publication of *K-indices of individual stations* and 52 do not.

On the other hand there are only 6 persons who would like to maintain the laborious arranging of the K-indices in columns for every 3-hour interval. 146 replied that it is sufficient to give them station by station, if at all. The interest in the publication of *C-indices of individual stations* is definitely less (28 positive and 63 negative answers), although still 70 persons wish to know the average value Ci, which implies a continued reporting of C by the stations. Continued publication of the selected *5 quiet and 5 disturbed days* of the month is favoured by 157 persons (only 4 replied negative). There are some suggestions to take account of the absolute level of disturbance. Publication of data on *ssc's, si's and sfe's* (clear cases) is appreciated by 164, 128 and 144 persons respectively. Somewhat less appreciated are the data on *bays* (bs: 109, bp: 102) and uncertain sfe's (99). There is still less interest in publication of *pulsations from normal speed records* (about 50 positive replies, against 40 negative) and *minor disturbances* (41 positive against 49 negative). Some more are in favour of *pulsations from quick-run records* (65 against 35). 99 persons think that IAGA should publish data on *principal magnetic storms* (42 reply: no). Many suggestions were given as to the data to be listed. Interest in the *times of ssc's or si's from quick run records* was expressed by 87 persons. 73 replied not to be interested. The *listing of bays* has no scientific value according to 50 persons; 46 are of the opposite view. An indication of period and amplitude of pg's is wanted by 53 persons; 70 replied negatively.

It is concluded by the reporter that at least the following points have to be discussed by Working Group IV-1 (during its meeting on September 2nd in Madrid) and where necessary transformed into proposals to be considered by Commission IV.

a. Adoption and publication of new (semi-)planetary elaborated indices Kn, Ks, Km, Dst, AE.

b. Discontinuation of the publication of K-indices from individual stations, or at least: Simplification of the listing of K by putting them station by station instead of arranging all K's of the same 3-hour period in one column.

c. The desirability to include other existing indices (χ, ω(n), solar) or planned indices (interplanetary, Sq).

d. Addition to the lists of international quiet and disturbed days of some information on the absolute level of disturbance of the selected days.

e. Restriction of the amount of published data on bays and pulsations from normal speed records by mentioning only the outstanding cases.

f. Discontinuation of the publication of "minor disturbances", reported by one station only.

g. Improvement of the publication of pulsation data from quick run records in cooperation with Working Group IV-5 on micropulsations.

h. The inclusion of data on principal magnetic storms in the IAGA-bulletins (monthly, quarterly, yearly).

i. The desirability to publish exact times of ssc's and si's, to be reported by stations with quick run records.

j. Reduction of the publication lag of the IAGA-bulletins.

Not included in these points are the following interesting remarks, made in the replies to the questionnaire:

1. In publishing data on rapid variations it is better to make for each phenomenon, one combined list for the data from both normal speed and quick run records.

2. If it is not possible to publish all information, the yearly IAGA bulletins 12 are of little value and it would be sufficient to have only the three-monthly bulletins, together with the data stored at the WDC's.

3. Changes might better be postponed until the consequences of automatization of magnetic observatory work will be better known.

It will be necessary to take account of the publications of others (e.g. "Solar Geophysical Data" from ESSA) in order to make the IAGA-publications as efficient as possible.

WORKING GROUP IV-2, DAILY VARIATIONS
D. J. Stone – Reporter

At the XIV General Assembly in St. Gall, the working groups of Commission IV were reorganized and the working group on Sq was replaced by this working group with the wider responsibility of dealing with Daily Variations. The present membership, which was chosen to provide both representatives from the main research groups working on Daily Variation problems, and also, as far as possible, a reasonable geographical distribution of members, is given in IAGA News No. 7.

The group has not met formally since the St. Gall assembly. The main activity since that time has been the organization and support of the special session on Daily Variations to be held on 9th September at Madrid. Matters of common interest with other working groups exist and this is particularly true of Working Group 3, Equatorial Electrojet. Close liaison between these two groups has been established and maintained by the reporters for each group being a member of the other. In particular, at the recent Symposium on Equatorial Aeronomy at Ahmedabad in February, 1969, the need for some time to be devoted at Madrid to papers relating to equatorial effects was realized. Because these are also very relevant to Daily Variation problems, it seemed natural to cooperate in presenting these papers, and they have, therefore, been included in the Daily Variation Scientific Session. In total, 11 papers are scheduled to be presented and the program looks to be of wide interest.

A further activity of the group has been to examine the need for an additional meeting subsequent to the Madrid meeting of a limited number of persons especially interested in Daily Variations problems. This meeting would function as a working seminar rather than a conference, with discussion of present problems and would attempt to coordinate research interests and determine the best methods of solution of the problems.

A business meeting was held on 5th September. At this meeting, Dr. C. U. Wagner circulated the first draft of program details of an International Symposium on Solar Daily Geomagnetic Variations to be held in Postdam, GDR in April or May, 1970. This Symposium is the practical outcome of the discussions referred to above and was enthusiastically received by the working group who expressed gratitude for the facilities offered by the German Democratic Republic.

The Working Group was asked to consider the recommendations made by the IUCSTP at a meeting held in London in January 1969. The only recommendation directly relevant to this Working Group is number 26, concerning the schedule for submitting Standard Magnetograms to WDCs which aims to try to ensure that all magnetograms are submitted promptly to WDCs. This is clearly in the interest of this Working Group and so should be supported as strongly as possible.

Of the 27 resolutions passed at St. Gall, quite a number are directly related to the Working Group. In particular, resolutions 2, 6, 8, 14, 24 are all concerned with the provision of machine readable data. Some progress has been made in this matter, but the problem has by no means been overcome and the resolutions are still valid. Attention is drawn also to resolution 9.

Progress in the last two years in daily variation problems has been steady, rather than spectacular, and much remains to be done. There are four main areas which must be successfully tackled. There is the problem of obtaining definitive worldwide analyses of both Sq and L which make use of all the available data and the most accurate methods of evaluation. There is the developing problem of extending the methods of these analyses to take account of satellite data. At present, representative current systems in a thin shell can be obtained but the problems of using a more realistic three dimensional model of the ionosphere remain. Finally, there is the question of what part the magnetospheric phenomena play in the production of daily variation fields. No detailed list of relevant publications is given but attention is drawn to two recent review papers entitled "Variation in Geomagnetic Field" and "Daily Variations" by H. Maeda, Space Science Reviews 8, pp 555-590, 1968, and A. T. Price, Space Science Reviews 9, pp 151-197, 1969, respectively, which contain extensive referenes.

WORKING GROUP IV-3, EQUATORIAL ELECTROJET
D. G. Osborne – Reporter

Although the reporter, Dr. D. G. Osborne, was unable to attend the conference, a business meeting of the working group was held on 4 September. General matters were discussed by those present. The most important point to emerge was the need for collaboration between the separate groups studying the Electrojet in different parts of the world, and it was requested that Dr. D. G. Osborne write to all persons interested in Electrojet matters to ascertain their plans for any observational experiments so that a comprehensive list of experimental studies could be produced and circulated. Father Mayaud informed those present of French plans and asked for the support of the working group, which was agreed.

This brief report was prepared on the request of the Chairman of Commission IV by D. J. Stone.

WORKING GROUP IV-5, MICROPULSATIONS
V. A. Troitskaya – Reporter

The network of micropulsations stations and methods of observing and processing of data were discussed on the basis of two circulars distributed by Father Romaña, Dr. Caner, Dr. Liemohn and Dr. Kenney.

The questions on time accuracy and technical parameters were surveyed. A committee was established with the requirement to prepare a complete list of micropulsation stations, having high sensitivity equipment. The committee is to investigate the question of desirable parameters for standard equipment for pulsation registration in a worldwide network of stations. The chairman of the committee is Dr. Campbell. Members are Dr. Stuart, Dr. Glangeaud, Dr. Raspopov, Dr. Kenney, Dr. Caner and Dr. Saito. The results of the committee work should be reported at the Moscow meeting in 1971.

A new schedule on quick run registration of the pulsations on the existing global network of stations was adopted. Instead of a gliding schedule of registration, the following was adopted:

The quick run registration of pulsations will be conducted each third week of the months of equinoxes and solstices (December, March, June, and September). This new schedule must be published in the International Geophysical Calendar (Miss V. Lincoln).

There were many discussions on the existing classifications, but it was a general feeling that it should not be changed in order not to confuse the scientific community. The suggestion of Dr. Korshunov was discussed on the classification of rapid variations. His suggestion was to adopt GP pulsations for Pc 2-4 and Pi 2, and the term micropulsations for the Pi-1 and Pc-1 groups. This suggestion was not accepted.

Some suggestions on the resolutions of IUCSTP were distributed for further comments.

A new procedure for publication of the results of rapid variations processing was adopted. The lists from the observatories must continue to flow to Father Romaña. Only cases when the phenomenon was recorded by not less than 10 stations will be presented for publication (Dr. van Sabben).

Some new results and directions of research were discussed as well as plans for cooperative research in the field of micropulsations. Topics for discussion at the Moscow Assembly were proposed as follows:

1. Discussion of the model of standard equipment for pulsations.
2. Interconnection of micropulsation behavior on the day and night side.
3. The latest data on latitudinal dependence of pulsation periods.
4. The question of the existence of proper oscillations of the magnetosphere.
5. The influence of the ionosphere on micropulsations observed on the Earth's surface. Reconstitution of the primary field above the ionosphere.
6. Recent results of comparison of satellite and surface observations of pulsations which help to improve the methods of magnetosphere diagnostics and verification of models of pulsation generation.
7. The state of theories of different types of pulsations.
8. Discussion of new indices of geophysical activity based on micropulsations.

Three full days will be required in Moscow to cover these topics.

WORKING GROUP IV-6, MAGNETOSPHERIC FIELD VARIATIONS

M. Sugiura – Reporter

As part of the activity of the Working Group Drs. J. A. Jacobs, H. B. Liemohn and M. Sugiura organized Special Sessions on Instabilities in the Magnetosphere, to summarize the present status of our knowledge of wave phenomena and disturbances in the magnetosphere. These special sessions were timely and gave an excellent opportunity to review a wide range of instability phenomena both theoretically and experimentally.

Another important activity of this Working Group is the publication of the Dst and AE indices, which are not recognized as useful geomagnetic indices. Efforts are being made to make these indices available on a regular basis with a minimum time delay. To obtain this goal, closer cooperation of those observatories whose records are used in the derivation of the indices are needed and IAGA action is urgently desired.

At the Working Group meeting held on 9 September, Dr. Sarabhai's new interpretation of the diurnal geomagnetic variation was discussed. He attributes a large part of this variation to a magnetospheric current system. Dr. R. Hutton studied the same subject with a different method of analysis and obtained results that suggest that a more careful study is required to determine whether or not Dr. Sarabhai's interpretation is correct.

WORKING GROUP IV-7, CONJUGATE POINTS

R. Schlich – Reporter

The Working Group met on 10 September. Thirteen scientists including only three official members of the Working Group (see IAGA News No. 7) were present.

Since the last meeting in 1967 at St. Gall, there has been no official meeting of this Group. Discussions about conjugate point studies and planning of conjugate point experiments have been organized during several international meetings and by individual arrangements. According to the information which was sent to the reporter, conjugate point experiments are still in progress at the following sites:

GREAT WHALE RIVER – BYRD
THULE – VOSTOK
BEYKJAVIK – SYOWA
SOGRA – KERGUELEN
HUROUQUE – HERMANUS

Conjugate point experiments between DOLGOSCHELIE (U.S.S.R.) and HEARD ISLAND and between PSKOV (U.S.S.R.) AND CROZET ISLAND (Indian Ocean) are under consideration.

A Symposium on Conjugate Point Studies (French-Soviet experiments) was held at BOROK (U.S.S.R.) from 2nd to 14th July 1969. French and Soviet scientists had the opportunity to discuss the latest results obtained during their experiments (45 communications were presented), to consider unsolved questions which can be answered by conjugate point studies and also to fix the scientific program for the coming years.

At London, 27 to 31 January 1969, during the First Conference on Solar Terrestrial Physics Program for the International Years of the Active Sun (1969 – 1971), the Working Group on "Conjugate Point Experiments" (W.G. 5) met twice and made several recommendations for specific programs of research, for the continuation and addition of conjugate station pairs and for techniques for conducting conjugate point experiments. These recommendations are published in S.T.P. Notes No. 4.

The IAGA Commission IV-7 Working Group on conjugate points, noting the various recommendations given by I.U.C.S.T.P. at the London Meeting concerning conjugate point experiments, *endorses* these recommendations and considers them as part of the list of recommendations which follows:

Considering the scientific value of the experiments conducted at the conjugate stations Kerguelen and Sogra for the study of the structure and dynamics of the magnetosphere and the need to reach a more precise definition of conjugacy, the IAGA Commission IV, Working Group on Conjugate Points *recommends* that two additional pairs of conjugate stations be put in operation at the following locations: CROZET (Indian Ocean) and PSKOV (U.S.S.R.), HEARD (Indian Ocean) and DOLGOSCHELIE (U.S.S.R.).

The IAGA Commission IV-7 Working Group on Conjugate Points, in view of the interest in the organization of complex geophysical observations at conjugate points located in Australia and U.S.S.R., *asks* the appropriate Institutes in these countries to take all possible steps towards establishing this cooperation.

The IAGA Commission IV-7 Working Group on Conjugate Points continues to look with favor upon the continuing conjugate points programs concerning geomagnetic field phenomena at GREAT WHALE RIVER (Canada) and BYRD Station (Antarctica) and *wishes to encourage* the efforts by putting into orbit a geostationary satellite with a sensitive magnetometer near the field line connecting these stations.

COMMISSION V
SOLAR-MAGNETOSPHERE RELATIONS
J. G. Roederer – Chairman

SCIENTIFIC SESSIONS

Cosmic Rays, Solar Wind and General Magnetospheric Physics

Two sessions were held on September 2 in the afternoon and on September 3 in the morning. The first session was chaired by Professor H. Trefall. At the beginning, the Commission V Chairman welcomed all speakers and participants and explained the scope of these particular sessions. He remarked that, in view of several other international events in 1968, 1969 and 1970 in the field of Solar-Terrestrial Physics, Commission V had to choose very carefully subjects that would not conflict with these other meetings. In particular, the topic of cosmic rays was out, since IUPAP was holding its bi-annual conference in Budapest at the same time as the Madrid Assembly. On the other hand, the International Symposium on Physics of the Magnetosphere (Washington, D. C., September 1968) and the coming International Symposium on Solar-Terrestrial Physics (Leningrad, May, 1970) covered a wide spectrum of Commission V's fields of interest. This is why this Commission has selected the subjects: Solar Interactions with the Earth, Moon, and Planets; Models of the Earth's Radiation Environment, and Electric Fields in the Magnetosphere as the three main topics for Madrid. However – and quite fortunately – enough other papers had been submitted to justify sessions on broader Commission V topics.

The papers presented at these two general sessions were as listed in IAGA Bulletin No. 26, except that papers V-1 by S. N. Vernov and L. I. Dorman, and V-6 by F. deMendonca, F. Albernhe, and F. Cambou were not presented.

An audience of about 150 people attended both sessions. Very lively discussions followed almost every paper. In paper V-2, Dr. Hartle presented results of computations of solar wind parameters, in particular velocity, density and temperature based on the two-fluid model. Dr. Roederer (V-3) presented numerical computations of diurnal and seasonal conjugate point displacements. Paper V-4 was presented by Dr. Mishin who criticized the concept of the "auroral oval,' claiming that the latter was mainly a result of poor resolution of the observations. He presented some evidence for auroral precipitation along two concentric circles at 65° and 78° invariant latitude, rather than along an oval shaped path.

Finally, Dr. Dessler (V-5) gave a critical discussion of the question of solar proton entry into the geomagnetic tail, confronting the field line connection model with a purely diffusive mechanism, and presenting arguments in favor of the latter.

During the second Session, devoted to electron precipitation and trapped particle diffusion, two papers (V-7 and V-8) were presented by Drs. Trefall and Kremser, on results of a cooperative effort by various European groups to study systematically the time-space morphology of high latitude electron precipitations. The role of the latitudinal position of the polar electrojet, separating two distinct zones of precipitation, was discussed in detail. H. Reme (V-9) presented interesting results of pitch angle distribution measurements, low energy electrons and protons, with a sounding rocket during a precipitation event. The two last papers (V-10 and V-11) read by Drs. G. Laval and A. Eviatar respectively, covered the topic of trapped particle diffusion in an asymmetric magnetic field.

Solar Wind Interactions with the Earth, Moon and Planets
(Convened and reported by Norman F. Ness)

The Commission V special session on Solar Wind Interactions with Earth, Moon and Planets was held on Wenesday afternoon, Sept. 3 and all day Thursday, Sept. 4. The first session concentrated on Mars and Venus and was well attended. Evidence confirming the existence of a bow shock around Venus was presented from the USA spacecraft Mariner V and a cautious approval of such a phenomenon was given by the USSR space probe Venera 6 in this year. Reinterpretation of Mariner IV data on Mars suggests the existence of a bow shock wave was established by those measurements. The solar wind has a profound effect on the high atmospheres of both planets since they have no magnetic field to deflect the plasma flow. The second session was concerned with the Moon and especially its internal electrical conductivity as it may affect the propagation of waves or discontinuities in the interplanetary medium. Some arguments developed as to the completeness of those solutions which assumed only a magnetic excitation without regard to the Lorentz transformed electric field excitation which results from the convected solar wind magnetic field. The Moon represents the weakest interaction with the solar wind yet known because being devoid of any sensible atmosphere it behaves as a particle and plasma sink. Both Venus and Mars represent the moderate interaction of a planet with an atmosphere and ionosphere while the Earth represents the strongest interaction. In these three cases, considerable success in describing the flow of the collisionless magnetized plasma past the obstacle by the use of a (continuous) fluid dynamic analogy has been demonstrate. For the moon, a kinetic individual particle approach offers the most success. The third session dealt with more general problems of the solar wind flow and its effects on planetary or magnetic field topologies. In summary, it is now well established that the study of planetary atmospheres will have to consider the solar wind explicitly in determining the high altitude boundary conditions and that an important technique to study the conductivity of the Moon is available and is being developed.

All of the papers were given as scheduled in IAGA Bulletin No. 26 except papers V–12 by M. B. McElroy, V–17 by J. Davis, V–32 by K. W. Behannon and V–33 by N. Brice, which were cancelled.

Models of the Earth's Radiation Environment

The special sessions on this topic were organized and chaired by James I. Vette. The emphasis in the first session was on the long term behavior of the inner zone particle fluxes. Only one measurement has been reported on the longitudinal variation of proton fluxes at low altitude. It would be desirable to verify this. It was clear that electrons below one MeV have decayed to their natural background levels. Responses to several magnetic storms are similar to outer zone electrons. There was one interesting event in which increases in the flux maximized around L=1.3 and L=2.6. This seems to indicate that the acceleration is caused by resonant conditions. Some of the behavior seemed to be adiabatic but these events have not yet been studied in that way. The high energy electron decay from Starfish could not be monitored by detectors on 1963–38C after December, 1968 because of the proton background.

The time behavior of high energy protons at low altitude has now been understood in terms of atmospheric losses coupled with the Starfish redistribution. The flux levels remained steady during the period between 1963 and 1966 because of the combination of these two effects. It was shown that the secular changes in the earth's magnetic field represent a diffusive source which is much greater than the neutron (albedo) decay source. This suggests that a detailed look at other diffusive mechanisms such as pitch angle scattering should be done in this region. The emulsion data suggests that the semi-annual variation of the atmosphere can be seen in the proton fluxes.

There is a model environment being prepared from the emulsion data for energies >55 MeV for altitudes up to 750 km which should be of interest to the engineering community.

The initial discussions of the outer zone emphasized the importance of convective electric fields in understanding particle acceleration and trapping boundaries. There was discussion on the lifetime of electrons near the plasmapause but it was recognized that these empirical lifetimes may be misleading.

The second session was held on 6 September. This session was concerned mainly with the outer zone particles. The low energy measurements between 50eV and 50,000 eV reveal many new important facts about the magnetosphere. There are large time variations of both electrons and protons with a deep penetration into the magnetosphere during magnetic storms. The ring current particles are within this energy band and show local time asymmetries. The injection of protons for the ring current occurs in local evening and starts well before it is seen by D_{ST} measurements on the ground. Low energy electrons have a transition region at the plasmapause.

The outer zone electrons in the energy range above 40 KeV do not exhibit much change over a solar cycle when average values are considered. This only applies for L≥5. The main solar cycle effect seems to be on filling of the slot region with higher average fluxes producing a shift in the intensity maximum and the slot minimum.

The outer zone protons in the range 100KeV – 170I KeV show a time variability which increases with L value. The changes occur during magnetic storms, starting when polar substorms occur. A detailed extraction of the adiabatic effects has been made. This reveals non-adiabatic effects for all storms studied, with the degree of variation increasing with the L value. The protons return to quiet time values by a non-adiabatic diffusion process.

Paper V–40 by S. M. Blakenship was not presented. A paper by N. L. Sanders and A. Rosen on Study of the Response of E> 0.3 MeV and E> 0.5 MeV Electrons in the Inner Zone to Magnetic activity was added to the program.

The third session was held on 8 September. It was devoted to the synchronous orbit region and the geomagnetic tail. The electron measurements from ATS–1, OV25, OGO–1, and OGO–3 reveal a drift loss cone effect which is a manifestation of L shell splitting. The bunching of electrons during perturbations causes drift echoes which are seen in the fluxes. Electron levels at L=6.6 only reach high values during extended quiet periods. Magnetic substorms cause a reduction of electron fluxes for energies greater than 150 KeV. Lower energy electrons are injected near midnight during these periods.

Solar protons have free access to the synchronous region with very little attenuation of even 1 MeV protons. No existing model magnetosphere can be used to explain this fact. These solar protons are not trapped permanently and can be accelerated by sudden commencement storms. Trapped protons at this altitude have been measured in the 0.065–3.6 MeV range in such a manner that the east-west asymetry can be detected. This will provide an accurate radial gradient of these fluxes. The drift loss cone effect for protons is also observed.

The plasma sheet at lunar distances exhibits nearly the same properties as at 12 R_e except that the average particle energies are lower. The solar wind thermal pressure is correlated with the plasma electron fluxes but it is the solar wind velocity that is correlated with the average electron energy.

There is still disagreement on how the solar protons enter the magnetosphere. both field line merging and diffusion advocates strongly defended their positions in the discussion.

The electron island events seen in the magnetic tail occur at lunar distances but the average intensity is less than near the earth. It appears that these events are caused by the expansion of the plasma sheet, and particle acceleration to relativistic energies is possible. This acceleration to high energies is of interest to cosmic ray production but the intensities are too small to have any magnetospheric effect.

Paper V–49 by T. White was not presented, but A. J. Masley presented an unscheduled paper on Solar Cosmic Ray Activity Near Sunspot Maximum.

Electric Fields in the Magnetosphere

Special sessions on this topic were convened by R. Lust and G. Haerendel. The first session was held Monday afternoon, 8 September 1969. The session was opened by Dr. Storey discussing the different methods to measure dc and ac electric fields by electric probes from sounding rockets and satellites.

Another paper (V–52) discussed the possibility of measuring electric fields by probes. The other papers were concerned with the release of barium clouds to determine electric fields. New methods have been given about electric fields in the auroral zone within the polar region (V–56 and V–57). The observed directions of the electric fields do not agree with the observations of magnetic perturbations in the polar region. The observations in the ionosphere also give information about magnetospheric motions (V–57). In paper V–65 the observed striations in artificial clouds were explained by an instability and attributed to a density gradient. Paper V–53 was not given.

The second session was held on Tuesday, September 9. Papers V–61 by V. M. Mishin et al., V–62 by L. L. Van'Yan et al., V–65 by H. Volk and G. Haerendel, and V–67 by U. V. Fahleson which had been scheduled were not given. Paper V–72 by B. E. Brunelli was moved up to this session from a later session.

Of particular interest to the audience were the different views of Dr. Willis and Dr. Block on the coupling of magnetospheric fields to the ionosphere and the widely varying time constants for the momentum exchange between both regions. An animated discussion was devoted to this subject.

The analysis of the Alibag magnetograms by Sarabhai and Nair in terms of partial ring currents on the night side of the earth supports other recent evidence for a strong magnetospheric contribution to magnetic perturbations that were formerly believed to arise predominantly from ionospheric currents.

The papers of Wagner and Matsushita demonstrated the continuing interest in the physics of the Sq current system.

The third session was held on the morning of Wednesday 10 September.

The opening speaker was Dr. P. J. Coleman. He presented a detailed model of the flow in the Chapman-Ferrano boundary layer, taking account of the electric fields induced by the flow of the solar wind plasma across the residual magnetic field in the layer. These fields drive currents in the magnetospheric plasma, that dissipate, in the ionosphere, the energy that they extract from the solar wind. The accompanying drag on the boundary layer is responsible for the circulation of the magnetospheric plasma and the formation of the earth's magnetic tail. In the subsequent discussion, the speaker mentioned that this drag mechanism does not involve the magnetic field in the solar wind (Paper no. V–68).

The second speaker was Dr. K. A. Anderson (V–69). He described how information about evidence for an open magnetosphere and limits on the electric field in the magnetosphere can be obtained from the study of the "particle shadow" of the moon, using data from a lunar orbiting satellite. He concluded that most of the field lines on the magnetotail at 60 Re geocentric distance are connected to the interplanetary magnetic field, and placed an upper limit of 3×10^{-4} volts/meter on the local electric field.

The principal author of the third scheduled speaker Dr. F. L. Scarf was unexpectedly recalled to the U. S. A. His paper on "Pioneer 8 and 9 electric field measurements in the magnetosheath and extended geomagnetic tail" was presented on his behalf by Dr. C. T. Russell.

Characteristic plasma disturbances and associated changes in V.L.F. electric field levels have been observed in the magnetosheath and during distant ($r \simeq 500$ Ro) geomagnetic tail traversals. Variations in plasma flux, velocity, flow direction, and distribution shape have been correlated with simultaneous changes in oscillation amplitudes when magnetic field "holes" or other plasma discontinuities were detected in these regions (paper No. V–70).

Dr. E. Rieger presented a paper by himself and co-workers on the "Barium ion cloud experiment in the magnetosphere" performed by means of the HEOS–1 satellite. Two aspects of the experiment were presented: the expansion of the cloud, which was accompanied by a magnetic perturbation detectable on board the satellite, and the momentum change of the cloud, as a result of its interaction with the ambient magnetic field and plasma. A number of excellent photographs were projected, showing the cloud at various stages of its expansion, in the course of which it became elongated parallel to the magnetic field (Paper no. V–71).

Paper no. V–72 by Dr. B. E. Brunelli on the "Magnetospheric electric field and the earth's rotation" was given in a previous session. The next speaker was Miss S. Lacourly, on the subject of the "Estimation of the electric field in the far magnetosphere as decided from the spectral characteristics of some irregular geomagnetic micropulsations". On the assumption that the phenomena in question (IPDP's) are produced in the equatorial plane by a cyclotron resonance instability involving 5-50 KeV protons, the instantaneous frequency of the emission can be related to the L-value of the source region. Variations of this frequency are explained as resulting from radial diffusion of the protons under the influence of magnetospheric electric fields. Values of 0.2 – 0.8 mv/m are found beyond the plasmapause (Paper no. V–73).

Dr. O. Raspopov then presented his paper "On the diagnostic of the electric fields in the magnetosphere". This paper was originally programmed in a session of Commission IV. He showed how consideration of the unipolar induction field due to the rotation of the earth, together with the electric field of auroral substorms, leads to a theoretical shape for the plasmapause which is close to the observed one. (Paper no. IV–80).

Dr. J. G. Roederer spoke next on the "Estimation of the electric field in the quiet magnetosphere as deduced from trapped particle flux asymmetries". He has developed a computer code that calculates the spatial variations of the distribution functions of trapped particles under adiabatic conditions and in the presence of a steady electric field. A Brice-type electric field (co-rotation + cross-tail) can explain the observed asymmetry reasonably well, if the cross-tail potential at quiet times is assumed to be ~1.0 KV/earth radius. (Paper no. V–75).

In a companion paper entitled "The effect of a time-dependent electric field on trapped particle fluxes", Dr. E. W. Hones described how he has used the same computer program to study the behaviour of trapped equatorial electrons at synchronous orbit altitude, under the influence of idealized substorm electric fields. The effect of such time-varying fields is to induce "drift-periodic echoes" in the particle distribution, with a maximum efficiency for particles whose drift period is in resonance with the duration of a typical perturbation. The effect on protons turns out to be particularly drastic, especially on the dusk side of the magnetosphere (Paper no. V–74).

Finally Dr. L. Katz spoke on the "Polar electric field at times of magnetic disturbance". On one such occasion, energetic proton fluxes were detected coming up the magnetic field lines from the earth at high magnetic latitudes. They suggest the existence of an electric field of 0.14 volts/meter parallel to the polar magnetic field lines. (Paper no. V–76).

BUSINESS MEETING – THE FRENCH PROPOSAL

IAGA Commission V on Solar-Magnetosphere Relations, having duly examined the proposal made by the French National Committee of Geodesy and Geophysics concerning a plan to create a Federation of three International Unions, has reached unanimous agreement among the members present on the following points:

1. Commission V acknowledges the existence of important overlaps in certain fields of activity of IAGA Commissions IV, V, VI, VII, VIII and part of II with URSI Commissions III, IV and VIII and with the Commission of Cosmic Rays of IUPAP, mainly resulting from the rapid expansion of upper atmosphere and space research that took place in recent years.

2. Commission V considers the very existence of IUCSTP and COSPAR and the favorable and efficient response by the space science community to their plans of international coordination of short term projects, as a clear evidence of the need for a reorganization within ICSU.

3. Commission V agrees in principle with the idea to create three Unions, related to (1) internal geophysics, (2) meteorology and hydrology and (3) the earth's particle and field environment, respectively. These Unions may be grouped into a Federation, although Commission V notes that the institutional status of such a Federation has not been clearly defined in the proposal by the French National Committee, and thus it has no strong opinion about this latter point.

4. Commission V furthermore agrees with the French National Committee proposal

(i) to group IAG, IASPEI and IAVCEI as well as the parts of IAGA concerned with internal magnetism, in one Union of Internal Geophysics;

(ii) to group IASH, IAPSO and IAMAP in one Union of Meteorology and Physics of the Hydrosphere.

5. Commission V strongly and emphatically disagrees with the proposition to convert the remaining Commissions of IAGA into what would become a mere appendix to the present structure of URSI.

In consequence of the above, Commission V proposes that a Special Committee be appointed by ICSU, consisting of scientists active in the fields of aeronomy and physics of the ionosphere, magnetosphere and interplanetary space, with the specific task to study and propose plans for the establishment of a new Union of Solar-Terrestrial Physics (or Solar-Planetary Physics) eventually to be confederated with the other two Unions mentioned in 4 above.

This new Union would blend together IAGA Commissions IV, V, VI, VII, VIII and part of II, URSI Commissions III, IV, and VIII part of the IUPAP Cosmic Ray Commissions (the part dealing with Cosmic Ray modulation – the other part should be diverted to IAU), IUCSTP, and eventually COSPAR and some relevant Commissions of IAU. However, Commission V wants to emphasize that the proposed structure of the new Union should by no means be biased by, or based on the structure of the above mentioned Commissions and Committees. Moreover, it is the opinion of Commission V that the Special Committee should totally ignore existing structures and develop a new structure based on specific disciplines and/or physical processes ruling the planetary and solar environments.

The members of this Special Committee should be appointed as individuals and not as representatives of existing ICSU bodies. This Special Committee should be extablished at once, starting action by correspondence and meet at the latest during the International Symposium on Solar-Terrestrial Physics in May, 1970.

Commission V would like to point out that although the names of IAGA, IUCSTP and possibly COSPAR would disappear according to its proposal, the scientific members of these organizations would undoubtedly constitute the major nucleus of the new Union.

With respect to URSI (without its Commissions III, IV and VIII) it is suggested that it could be included as a fourth member of the Federation of Unions.

Finally, IAGA Commission V expresses the hope that until the day a new structure emerges and is put into operation, countries and individual scientists will continue to support vigorously all involved ICSU bodies in their present structure, in order to ensure due continuity of the process of expansion of international scientific cooperation that is presently taking place.

COMMISSION VI
AURORA
S. Omholt – Chairman

BUSINESS MEETING

The business meeting was held on September 2, 16:00. No formal reports from the working groups or reporters were prepared for this meeting. It was agreed among working group members, the reporters and the commission chairman at St. Gall in 1967 that the reporters should, with the aid of their working groups, prepare reports of the scientific progress in their fields during the four year period 1967–70 for presentation at the 1971 General Assembly and that also a major scientific session or symposium should be held at that time.

The business of the working group on morphology has been largely covered by the inter-commission (VI and VII) Aurora and Airglow Program Committee (AAPC) for the active sun years, of which the Working Group Reporter has been a member.

The Working Group on Radio Aurora has made recommendations on the nomenclature of radio aurora. This was discussed at an ad hoc meeting at the recent URSI meeting. A short report to the Commission was given by Dr. Forsythe. The full report and recommendation will be circulated when they are finished.

Commission VI also discussed the proposal from the French National Committee to create a new Federation of three International Scientific Unions. Since the idea was not presented to the Commission beforehand it was difficult to make any recommendation, but it was generally felt that the proposal deserves serious consideration.

SCIENTIFIC SESSIONS

Apart from the inter-commission symposium on "Aeronomic Ionization Processes including Aurora and Airglow" and the joint session with Commission VII on the Active Sun Years Program only one scientific session was held, on September 3, 16:30. The papers focused on two important problems in auroral physics: The first is the problem of the relations between the instantaneous precipitation zones of electrons and protons as revealed by optical observations. The second is the relation between the radio aurora, optical aurora and the auroral electrojet. (A paper by G. Lange-Hesse, an addendum to the printed program).

COMMISSION VII
AIRGLOW
G. M. Weill – Chairman

BUSINESS MEETING

The only business which was transacted related to the publication of papers presented during the scientific sessions. It was resolved that they should be published contiguously and they will appear in "Annales de Géophysique" (about 15 papers).

COMMISSION VIII
UPPER ATMOSPHERES
A. Dessler – Chairman

BUSINESS MEETING

A business meeting of IAGA Commission VIII was held at 16:00 on Tuesday, 9 Sept 1969. The following statement was approved unanimously: IAGA Commission VIII on Upper Atmospheres views with concern the relatively large number of international scientific organizations with overlapping interests that result in several international meetings each year with significant duplication of topics. We, therefore, are sympathetic with the spirit of the proposal made by the French National Committee for Geodesy and Geophysics. Recognizing that many details of any proposed reorganization within ICSU need to be carefully considered, we recommend that an appropriate committee be formed to consider how best to reorganize the international scientific bodies is as to minimize the present extensive overlap of activities.

SYMPOSIUM ON AERONOMIC IONIZATION PROCESSES INCLUDING AURORA AND AIRGLOW

(Convened by M. Nicolet, Reported by A. Aiken)

The IAGA symposium "Aeronomic Ionization Processes including Aurora and Airglow" was convened under the chairmanship of Dr. M. Nicolet during the IAGA General Assembly in Madrid, 2–6 September 1969. The symposium dealt with most aspects of the ionization and airglow excitation processes as they occur in a planetary atmosphere. The atmospheres of Mars and Venus were included with that of the Earth in the discussion. It is planned to publish invited and contributed papers not previously published in Annales de Géophysique. A summary of the conference follows.

Solar Radiation

A new table of EUX fluxes to replace the one which recently appeared in the *Annals of the IQSY,* was distributed. New information shows that the integral fluxes listed in the Annals are overestimated.

The poor quantitative correspondence between 10 cm (100% variation) flux and radiations such as 304 Å (30–40% variation) was discussed. Recent results from the OSO spacecraft indicate that active regions in the 2 – 8 Å range may be seen for as many as 20 of the 27 day cycle. Bursts of ionization $\lambda < \frac{1}{I}$ Å were reported with durations of a minute or so and which appeared before the rise of 2 – 8 Å flux and were correlated with solar microwave bursts and ionospheric sudden frequency deviations.

D Region

The discrepancy between the measured values of nitric oxide 2 x 10^8 at 80 km and the maximum calculated value of 1.5 x 10^7 was pointed out. New sources of ionization which have been proposed in the last two years include particle ionization at mid latitudes, $O_2('\Delta_g) + h\upsilon \rightarrow O_2^+ + e)$, and galactic X-ray sources which are important at night. A review of the rapid progress in ion chemistry was given and a model proposed which would explain the $H_5O_2^+$ distribution seen by ion mass spectrometers in terms of a formation mechanism which changes $O_2^+ \rightarrow O_4^+ \rightarrow O_2^+ \cdot H_2O \rightarrow H_5O_2^+$ was proposed. The rate coefficients of several negative ion reactions of possible importance in the lower ionosphere were given. The importance of three body reactions was stressed.

The changes of the lower ionosphere as deduced from radio wave absorpiton were discussed for sunrise conditions, the winter anomaly and magnetic storms. It was observed that absorption at sunrise occurs in three steps initiated at zenith angles of 98°, 94° and 85°. A larger sunrise effect occured at solar maximum than at solar minimum. There appeared to be a smaller negative ion concentration in winter than in summer. The source of ionization for the winter anomaly appears to be above 80 km. No anomaly was observed unless the zenith angle at noon was greater than 60°. Shipboard observations showed that no effect occurred below 49° latitude in apparent disagreement with other investigation. The effect of particles during magnetic storms was stressed.

Ionization of Meteoric Origin

Two review papers were presented on this topic. The first, Kaiser, dealt extensively with ablation phenomena. Results of calculations on particle size as atmospheric density were presented. Particles between 10 and 100 μ have a nearly constant ablation altitude. Ion pair production functions were discussed together with the electron density distribution in the meteor tail. Decay studies of electron density and luminosity seem to require a three body loss process. The existence of a sunrise effect below 93 km was noted.

Details of the formation and loss processes as they apply the distribution of metallic ions were shown by Swider. In addition to photoionization, charge exchange processes which form metallics can occur. As far as loss processes are concerned, radiative recombination is slow and operative above 100 km. Below this altitude it is necessary to consider three body loss processes such as

$$Mg^+ + O_2 + Ar \rightarrow MgO_2{}^+ + Ar.$$

The possible importance of hydrate formation by means of reactions such as

$$Na^+ + H_2O + O_2 \rightarrow (Na^\circ\ H_2O)^+ + O_2$$

was discussed.

E and F Region.

Very little new information was presented on the formation of the E and F ionospheric regions. Their relations to airglow emissions such as 6300 Å and 5577 Å was not reviewed in spite of the fact that there have been important advances during the last two years. For instance, in the equatorial ionosphere, downward motion of the F region, after midnight, which has been detected by rockets and ground based backscatter experiments, is accompanied by an enhancement of 6300 Å emission. Also satellite detection of ultraviolet oxygen emissions, such as 1304 Å, has been suggested as an evidence of radiative recombination of O^+.

Soft energy electron measurements as determined by a spectrometer aboard the ISIS satellite were given for the energy range 15 eV to 15 KeV. It was found that photoelectrons were detected at 3500 km to be moving from conjugate points. Within 10 to 15 percent, it was observed that the upward and downward fluxes of electrons were the same. This result would indicate that there is no deposition of electrons to heat the ionosphere, in disagreement with a rocket observation which detects a slight temperature gradient and requires a heat impact. Fluxes of 2×10^8 electron/cm^2 sec were observed with an average energy of 18.5 eV per particle. No particles were observed above 60 eV and the spectrum was such, that it fell to 1/2 by 30 eV and decreased much faster for larger energies.

The conflicting evidence for diffusive equilibrium in the distribution of He^+ and H^+ was reviewed. Comparison of two rocket flights, one in 1966 and the other several years earlier, showed that production and loss of He^+ were balanced in the NRL flight of 1966 and not for the earlier results of GSFC. On the other hand, satellite measurements report a high latitude trough for O^+ as well as He^+ and H^+. The size of the trough decreases as the angle between the midlatitude dipole equator and the subsolar point decreases. This would appear to rule out diffusive equilibrium.

High Latitude Phenomena Including the Polar Cap and Aurora.

The distribution of ionization within the polar cap was reviewed. It was observed that the winter F region has an average density of 10^5 electrons/cc. It appears that there is insufficient direct electron precipitation of energy > 1000 eV to maintain this level of ionization. Observations have shown that there is an enhancement in the flux of 46 – 280 eV electrons at latitudes between 75 and 80° North. There is a correlation enhancement of the 6300 Å emission rate. The polar cap appears to be surrounded by this region of enhanced ionization so that there exists a polar trough. Emission measurements at 6300 Å, carried out during the IGY, did not indicate a similar trough.

The maintenance of the polar cap ionization as well as the effect of transport from the 75 – 80° enhancement region is unsolved.

Magnetic storm phenomena during polar cap events show that when a sudden commencement coincides with a polar cap event, auroral zone phenomena transfer into the polar cap region.

Several papers dealt with the deposition of primary auroral electrons and the altitude distribution of secondary electrons. Monte Carlo calculations taking into account the effect of electron straggling and bremstrahlung were presented. Calculations of the secondary electron spectrum using a power law energy spectrum for primary particles leads to a double peak in the altitude distribution of the secondaries. The importance of the dissociative ionization reactions

$$N_2 + e \rightarrow N + N^+ + 2e$$

and

$$O_2 + e \rightarrow O + O^+ D\ 2e$$

was stressed.

Important reactions involving excited atomic and molecular species in the emission of auroral and airglow emissions as well as their role in the chemistry of the mesosphere was reviewed.

Mars and Venus

Ultraviolet Airglow measurements (Barth) were conducted on Mariner VI by means of an Ebert-Fastie spectrometer operating with a 3 second scan and a resolution of 10 Å between 1100 and 1900 Å and 20 Å between 1900 and 4300 Å. The first observations occured when the solar zenith angle was 27° and the tangential point was about 130 km above the surface of the planet. By comparison of a synthetic spectrum obtained by bombarding CO_2 with 20 eV electrons, the strong $CO_2{}^+$ emission feature at 2890 Å was identified. Also identified was the 2160 Å emission of neutral CO. The Lyman alpha line of atomic hydrogen at 1216 Å was identified. Atomic oxygen was identified from emission in the 1304, 1356, and 2972 Å lines. Nitrogen and its oxides were not detected so that there appears to be very little N_2 in the atmosphere of Mars. Preliminary information from the height distribution of the emission seems to favor a low temperature of 400°K.

Reviews of the different hypotheses of the structure of the atmospheres of Mars and Venus were presented. It was pointed out that for Mars, while an F – 1 type ionosphere is favored of all the models presented, there are still discrepencies in the scale height for the neutral temperature of 700°K. Calculations of the interaction of the solar wind with the atmosphere and ionosphere show that a shock wave will form which compresses the ionosphere, such that the scale height is a factor of two less than would be expected on the basis of either photochemical equilibrium or diffusion theory. This reduction will give agreement with the observed ionospheric scale height. The 700°K temperature will have to be modified if the 400°K preliminary results from Mariner VI are confirmed.

The formation of the atmosphere of Venus was also discussed. A model was presented which included an estimate of the $O(^1D)$ population in the atmosphere utilizing recent laboratory measurements of the quenching of $O(^1D)$ by CO_2 wherein the intermediate CO_3 is produced.

WORKING GROUP VIII–1, COMPOSITION AND DENSITY VARIATIONS
M. Marov – Reporter

Since the last assembly of IAGA in Switzerland in 1967, the main efforts in the study of the structure of the upper atmosphere have been on the problem of obtaining a more accurate quantitative estimation of the atmospheric composition, density, and temperature variations discovered earlier.

The period covers the maximum of the 20th eleven-year cycle of solar activity, which had an intensity equal to approximately 0.6 of the maximum of the 19th cycle. The results obtained confirm that the principal response of the thermosphere to changes in the solar electromagnetic and corpuscular radiations, can be accounted for as solar and geomagnetic activity variations, diurnal and semiannual variations, and less well established seasonal – latitudinal variations.

The number of composition measurements by mass spectrometers and monochromators, unfortunately, continues to be very low and rather randomly distributed in both space and time. This situation prevents an accurate quantitative determination of the real height distributions of the major and minor constituents and their variations.

The number density profiles of the CIRA–1965 and Jacchia 1965 models that summarized our knowledge of thermospheric structure until 1964, can be reconciled quite reasonably with measured distributions of N_2 and O_2 above 120 km (the discrepancies are less than about a factor 1.5), but are quite in disagreement with measurements of atomic oxygen made by mass-spectrometers. There are indications that this is due to errors in the mass-spectrometer technique rather than real variations in the thermosphere. This conclusion is supported by the results of EUV absorption measurements that are closer to the model distributions of 0.

As far as diurnal composition variations are concerned, the latest mass-spectrometer measurements indicates that the day-time concentrations exceed the nighttime ones approximately by a factor of 1.5 for N_2 and O_2 and by a factor of about 3 for 0, while earlier an opposite result had been found. The He and 0 variations during the solar activity cycle result in quite prominent seasonal density variations at heights above about 500 km (depending on what gas predominates at these heights). The winter helium bulge was considered to be diminished in 1968–69 because of the increasing influence of the atomic oxygen bulge.

The relationship between the density response to solar activity variations and the index of decimetric flux was found to be quite satisfactory for the long period variations at least. It seems most reasonable now, for development of more accurate representations of solar activity effects, to reflect the intrinsic connection of the thermosphere variations with individual EUV radiations. In geomagnetic density variations, the detailed correlation between density and Kp index has been found by satellite drag to be present in the height range 125–180 km, and has been confirmed by accelerometer measurements. Some new proposals concerning the using of geomagnetic activity indexes other than Kp and Ap (Dst, AE) have been advanced, but it seems they are not well founded at this stage. The seasonal variations in Kp and Ap indices should, however, be taken into account when analyzing long period variations in the thermosphere.

The diurnal density variations are found to confuse the semiannual variations, nevertheless substantial progress has been achieved in the study of the latter. The semiannual variations are exhibited quite clearly in the whole altitude range from about 90–110 km, (as deduced from grenade and meteor trail methods) up to 1100 km, as deduced from satellite orbit decay studies. This appears to reflect a property of the source of such density variations, but of its real nature there are only speculations now. The amplitude of semiannual variations depends on solar activity and varies on average from 1.5 at 150–200 km up to a factor of 3 at 600 and 1000 km. At 210 km, the intensity of semiannual variation was found to exceed the diurnal one by a factor of 1.3.

Intensive theoretical study of the thermospheric structure has been carried out since 1967 as well. The simulation of the processes responsible for the observed variations, along with the new, more complete experimental results, undoubtedly will provide a better understanding of the thermospheric structure and give rise to construction of more representative models of the upper atmosphere.

WORKING GROUP VIII–2, WINDS, GRAVITY AND INFRASONIC WAVES

G. V. Groves – Reporter

During the last two years, upper atmosphere wind measurements by ground-based and rocket techniques have continued in support of various objectives, such as synoptic studies, the general circulation, tidal components, wave-like components, and the investigation of special events and atmospheric phenomena in which atmospheric motion may play a part. There has been an improvement in the distribution of data by latitudes with observations now being undertaken at high and low latitudes but the Southern Hemisphere is still poorly covered in comparison with the Northern Hemisphere and the Eastern Hemisphere in comparison with the Western Hemisphere.

Ground-based observations relate to the 80 –110 km region and to the radio-meteor and ionospheric drift methods of measurement. An advantage of these methods in comparison with rocket techniques is their continuous sampling in time, leading to the resolution of tidal and prevailing components. For investigating short-period variations, such as turbulence and gravity waves, statistical information can be obtained in the form of power spectra but with present single-station systems, adequate height resolution and sampling rates are not available for studying individual turbulent and gravity-wave phenomena. Considerable data handling and analysis is involved with ground-based wind-measuring methods and recent developments in these methods owe much to the improved computing and data handling facilities that are now available in comparison with five years ago.

Above about 75 km, short-term and small-scale variations become a major component of wind variability, and most discussions of these variations have been in terms of "wave" concepts, although the correctness of this representation has yet to be proved by observation. For the detection and description of gravity waves in the upper atmosphere, data are needed, according to Luidzen (1), with a time resolution of the order of 20 minutes, a vertical resolution of the order of 1 km and a horizontal resolution of the order of 10 to 100 km. No such coverage is possible at the present time. Ionospheric observations have nevertheless provided indirect evidence of gravity waves in various ways. Horizontally moving irregularities have been interpreted by Goodwin as gravity waves originating at high latitude (2), and the vertical stratification of E – region ionization (3) has been reported by Rao to be consistent with the gravity wave mechanism. Also, Müller finds, with the radio-meteor technique, that short-term variations have periodicities that are consistent with being gravity waves (4). The complicated pattern of winds between 80 and 110 km has been graphically revealed by the results from the Garchy radar (5). A general downwards propagation of phase is shown by these results and by similar time cross sections from luminous trail releases and is evidence of an upwards propagation of energy. Significant variability from day-to-day has been shown by the Adelaide meteor results, and according to Elford the extent to which this variability is due to turbulence, gravity waves or large scale "weather systems" is not at present known (6). Statistical results indicate the presence of all three, and it is possible that they are inter-related and of comparable importance. Above 80 km, both radio-meteor and chemical trail releases have shown a structure function (i.e. an r.m.s. transverse velocity difference between two points separated by a certain distance) which, in the horizontal, corresponds to an isotropic and inertial region of turbulence, whereas in the vertical, the structure function is probably related to the gravity wave spectrum, other motions being damped by buoyancy forces. An inter-relating mechanism that has been suggested by Ishimine, is that changes in local potential temperature due to gravity waves are responsible for the production of turbulence (7).

A long series of wind data has now been obtained at Kühlungsborn (54°N, 12°E) and Collin (57°N, 13°E) by ionospheric drift measurements at low frequencies referring to the 95 km level. An interesting result from data over ten years is a relationship between wind velocities and the solar cycle (8). Other locations where E–region ionosphere drifts are being observed are Aberystwyth (52°N, 4°W), Barbados (13°N 60°W), Canterbury, New Zealand (44°S, 173°E) and Puerto Rico.

The measurements of winds in the mesosphere and ionosphere by research rockets employing for example the grenade, falling sphere, and chemical release techniques, has continued and more emphasis has recently been given to the investigation of special events. Table I summarizes some of the investigations of mesospheric and ionospheric winds undertaken in connection with special events and other problems during the last few years. As shown in the table, the structure of a sudden warming in the mesosphere has been investigated at three North American sites, and, in 1969, launchings at the Kiruna site were also coordinated with these. Although temperature is the primary parameter in this case, wind variations occur and are related. Another problem of current interest is the effect of metereological parameters on D–region ionization in winter time when over groups of a few days, the high-frequency radio absorption is above the level appropriate to the solar zenith angle. Since the IQSY, ionospheric winds have been investigated at low latitudes and gun-launched probes at Barbados (13°N, 60°W) have continued to be an important source of low-latitude wind data between 90 and 140 km. A similar gun facility was brought into operation at Yuma, Arizona (33°N, 114°W) in June, 1966. Comparisons between the meteor and luminous trail methods and the ionospheric drifts indicate that in the D and E–regions the latter represent neutral winds rather than traveling waves (22).

At lower heights, small (metereological) rockets, employing chaff or a parachute and temperature sonde, have continued to be launched and at many sites launchings have continued throughout the year on a regular basis, often once a week, as an upwards extension of synoptic studies with balloons. Launching programs have also been undertaken for special studies for example in wintertime during stratospheric warmings. With chaff payloads, altitudes of 80 km or more have been achieved with these smaller rockets, but temperature measurement is then sacrified. It is now 10 years since meteorological rockets were first introduced and for some sites, many hundred of wind profiles are available, enabling the upper atmosphere climatology of these sites to be derived in terms of monthly means, standard deviations and other statistics. An interesting and somewhat surprising development has been the resolution of diurnal and semidiurnal components below 60 km altitude where they amount to only a few metres per second in amplitude. With the accumulation of observations the quasi-biennial component has also been resolved at a number of sites, particularly at Ascension where it is a significant part of the zonal component and data now extend over two cycles. Within the last two years, low-latitude and Southern Hemisphere rocket launching sites have been brought into operation within the organization of either the MRN (Meteorological Rocket Network) or EXAMETNET (Experimental Inter American Meteorological Rocket Network). This is a welcome improvement in the latitudinal distribution of meteorological rocket launching sites, although the data sampling is still biased to latitudes near 30°. At eastern longitude sites such as those in Pakistan (23), India and Australia, sufficient data are now available for studying seasonal variations and, in time, longitudinal and N–S hemisphere differences may become apparent but not at present. At mid-and high-latitudes (now augmented with a new MRN site at Thule, Greenland (77°N, 69°W) observations are particularly valuable in wintertime when large disturbances to the polar vertex occur often in conjunction with stratospheric warmings. Such observations have been made at Heiss Is, (81°N, 58°E), West Geirinish in Scotland (57°N 7°W), at various North American sites and in the Antarctic (78°S).

With regard to conventional balloons, one aspect of note is the improved ceiling altitudes that have recently been obtained. Studies of radioactive fallout and of meteorological interest have stimulated high-level flights and a 30 km altitude is now regularly attained over certain areas, notably North America and Australia. The development of high-altitude balloons at the University of Melbourne, Australia, by Laby and Unthank, has led to flights exceeding 130,000 ft (39 km) on 20–30 occasions using small neoprene balloons of the order of 1000 gm with gas-valving. These flights have shown large day-to-day fluctuations in the east-west component of stratospheric winds (24).

The latitudinal transport of energy is of interest in studies of the energy balance of the stratosphere. Eddy fluxes have been evaluated from balloon data to 24 km altitude, but at greater heights coverage is limited to the Western Hemisphere and therefore zonal averages and standing eddy components cannot be evaluated. Transient eddies, which are the time averages for individual sites, can however be evaluated and have been found by Newell, Wallace and Mahoney to increase from a minimum at 24 km to a possible maximum at 55 km (25). The velocity of standing eddies may also be expected to increase at greater heights, but a more global distribution of observations is needed in order to find out.

In the mesosphere, little reliable information is available on eddy fluxes and circulation cells. In this region of the atmosphere, solar energy is being absorbed at the 50 km level and, by analogy with the troposphere which has a main heat source at the ground, it is a dynamical region controlled by this heating up to a level, which Faust puts at 70 km (26, 27). In the lower ionosphere, the question of circulation is still largely unexplored, but above 200 km, the apparent eastwards rotation of the upper atmosphere, as indicated by satellite orbits, has lead to theoretical considerations of F–region winds in terms of ion drag and neutral air pressure gradients (28, 29). The results obtained have been generally consistent with the satellite findings although the global wind patterns involve meridianal as well as zonal components. Only very few rocket wind measurements are available for 200 km or above.

In recent years there has been increasing interest in infrasonic waves and their association with other geophysical phenomena. Infrasonic bursts lasting about 1 hour and having dominant periods between 1 and 15 minutes have been found by Challinor to be highly correlated with the approach of cold fronts (30). Most observations to date have been made at periods of less than 2 minutes. At College, Alaska, an infrasonic observatory was established in January, 1966 for observing auroral infrasonic waves. The propagation of the waves has been found by Wilson (31) to be highly directional and to arise from supersonically moving sources of auroral ionization. The questions to be considered here are the possible basic mechanism for generating the pressure pulse and future work is concerned with investigating the processes involved. Finally, I would like to record my thanks to members of Working Group 2, for their help in supplying information relevant to this review.

Table I. Special Events and Other Problems Involving Mesopheric and Ionospheric Wind Measurements

Topic	Sites	Sponsors and Groups Involved	References
Structure of a sudden warming in the mesosphere	Point Barrow	NASA	(9)
	Fort Churchill Wallops Island		
	Kiruna	Sweden/UK/NASA	
D-region winter anomaly	Wallops Island	NASA/University of Illinois	(10)
Low-latitude ionospheric winds	Thumba	INCOSPAR/NASA/CNES	(11)
	Barbados	US Army/Canadian Department of Defence Production	(12)
Seasonal variations	Sonmiami	SOPARCO/CNES and	(13)
		SUPARCO/UK/NASA	(14)
Arctic Summer Mesosphere	Fort Greely and Thule	US Army Atmospheric Science, Lab, WSMR	(15)
Mesospheric wind structure	Arenosillo	INTA, Spain	(16)
		Max Planck Institut für Aeronomie	
Eastwards atmospheric rotation above 200 km	Woomera	University College, London	(17)
Wind shear and sporadic E	Eglin AFB, Florida	Air Force Cambridge Research Laboratory	
Three dimensional wind observations	Puerto Rico Eglin AFB	Air Force Cambridge Research Laboratory	(18)
Comparisons between meteor winds and ionospheric drifts	Sheffield Aberystwyth Kühlungsborn	Univ. of Sheffield Univ. of Aberystwyth Observatory for Ionospheric Research	(19)
	Collin	Geophys. Observatory	
Comparisons between luminous trail movements and ionospheric drifts	Barbados Eglin AFB	Univ. of West Indies	(20)
Circulation in the meteor zone	Kharkov	Kharkov Polytechnical Institute	(21)
	Obminsk Sheffield	Inst. of Geophys., Moscow Univ. of Sheffield	

References

(1) R. S. Lindzen Data necessary for detection and description of tides and gravity waves in the upper atmosphere, COSPAR WG 2 report, Feb. 1968.

(2) G. L. Goodwin Planet Space Sci. 16, 273 (1968)

(3) U.R. Rao et al. Measurement of E–layer electron densities at Thunba with high-frequency capacitance probe, Physical Research Lab. Ahmedabad

(4) H. G. Müller Planet Space Sci. **14**, 1253 (1966)
(5) I. Revah and A. Spizzichino A continuous wave radar for ionospheric wind measurements, Special Report No. 75, AFCRL – 68 – 0228, Air Force Cambridge Research Laboratories, Bedford, Mass.
(6) W. G. Elford Upper atmospheric wind observations at Adelaide, Department of Physics, University of Adelaide Report, July 1966
(7) T. Ishimine J. Radio Res. Lab. **15**, 23 (1968)
(8) K. Sprenger and R. Schminder J. Atmos. Terr. Phys. **31**, 217, (1969)
(9) J. S. Theon, W. Nordberg, L. B. Katchen and J. J. Horvath J. Atmos. Sci. **24**, 428 (1967)
(10) C. F. Sechrist, Jr. E. A. Mechtly, J. S. Schirke, and J. S. Theon J. Atmos. Terr. Phys. **31**, 145 (1969)
(11) P. D. Bhavsar and K. Ramanujaro, Space Research **8**, 655, (1968)
(12) C. H. Murphy J. Geophys. Res. **74**, 339 (1969)
(13) M. Shafi Ahmad Sodium vapour release measurements of winds and diffusion in the upper atmosphere, presented at COSPAR Symposium, Prague, May 1969
(14) M. Rahmatullah, M. S. Ahmad, G. V. Groves, and D. P. McDermott Measurement of upper atmosphere winds and temperature from rocket-grenade-TMA experiments conducted from Sonmiani in Spring and Autumn of 1966–67, presented at COSPAR Symposium, Prague, May 1969
(15) J. E. Morris and M. D. Kays J. Geophys. Res. **74**, 427, (1969)
(16) A. Azcárraga, L. Sánchez and H. V. Widdel On the structure of mesospheric winds, presented at COSPAR Symposium, Prague, May 1969
(17) D. Rees, R. W. Roper, K. H. Lloyd, and C. Low High altitude profiles of wind velocity, temperature and density, presented at COSPAR Symposium, Prague, May 1969
(18) M. A. Macleod Space Research **9**, 363 (1969)
(19) H. G. Müller J. Atmos. Terr. Phys. **30**, 701, (1968)
(20) J. W. Wright and L. S. Fedor Space Research **7**, 67, (1967)
(21) B. L. Kashcheyev and I. A. Lysenko, J. Atmos. Terr. Phys. **30**, 903, (1968)
(22) G. S. Kent and R. W. H. Wright J. Atmos. Terr. Phys. **30**, 657, (1968)
(23) M. Rahmatullah and S. A. Jafri Space Research **8**, (1969)
(24) J. E. Laby and E. L. Unthank J. Atmos. Sci **24**, 98 (1967)
(25) R. E. Newell, J. M. Wallace and J. R. Mahoney Tellus, **18**, 363, (1966)
(26) H. Faust Energie transport zur mesosphäre Meteor Rdsch. **20**, 153, (1967)
(27) H. Faust Die Höhe der Oberganze des 2. dynamischen systems, Meteor. Rdsch. (in press)
(28) N. Matuura J. Atmos. Terr. Phys. **30**, 763, (1968)
(29) R. A. Challinor, Planet Space Sci. **16**, 557 (1968)
(30) R. A. Challinor J. Atmos. Terr. Phys. **30**, 1917 (1968)
(31) C. A. Wilson J. Geophys. Res. **74** 1812, (1969)

WORKING GROUP VIII–3, EXOSPHERIC PROBLEMS

Brian A. Tinsley – Reporter

Since the last General Assembly of IAGA in St. Gall in 1967, there has been progress in a number of fields of Exospheric Studies, and of course, new problems have arisen to replace the old problems being solved. The subject of exospheric studies has broadened to include the exospheres of Venus and Mars and there are now problems in interpreting observations for both these planets.

Since these are discussed in Hunten's report it is not necessary to discuss them further.

Turning now to the terrestrial exosphere, there have been a number of satellite measurements made of Lyman α from the hydrogen in the exosphere. For example, M. A. Clark has obtained data from his experiment on OV1-14, where angular scans across the geocorona are made at 10,000 Km, with results looking much like the Barth measurement and Mariner 4 of Venus, only of course with much more extensive coverage.

Meier has analyzed the data of several satellites and can get quite good agreement between his theoretical calculations and the observations, providing some satellite orbiting component is assured.

Meier has also found a 27 day variability of about 30% in the Lyman α flux, which he attributes to changes in solar Lyman α, which needs to be taken into account. A similar variability in solar Lyman α has been reported by Fossi and others from data obtained from the Solrad 8 satellite. Other effects which have come to light and which need to be taken into account in interpreting Lyman α data, are the fact that the altitude profiles previously used need to be modified in a way consistent with the presence of appreciable molecular hydrogen at 100 km, and also that the extraterrestrial Lyman α background is not uniform over the celestial sphere.

Ground based Balmer α observations have also been analyzed by Meier, and he postulated an extraterrestrial component of 3–4 Rayleighs in addition to that from geocoronal scattering. This component has now been 'found' by Tinsley.

Tinsley has examined his data for any effect dependent upon galactic latitude (after exclusion of the bright gaseous nebulae, sources) and finds differences between low, middle and high galactic latitudes consistent with an intensity varying as the cosecant of the galactic latitude, which averages about two Rayleighs. In addition, he has calculated in detail the tropospheric scattering of bright gaseous nebulae sources, and finds that there is about one half Rayleigh from such scattering in the zenith, and up to 3R at 80° zenith distance. He has also applied a more exact scattering and extinction correction than the earlier plane-parallel treatment, and finds more contrast between the sunward and antisolar directions than found in earlier work.

The problem of the apparently high Balmer α intensitites, an order of magnitude greater than expected relative to Lyman α, referred to by Donahue of the IAGA meeting in Boston in 1965, has been solved. The solution is found partly by taking account of the galactic and tropospheric scattered components as just discussed. This is important for large depression angles. The discrepancy at small depression angles is partly resolved by the discovery of a numerical error in the original radiative transfer treatment, and partly by the reasonable assumption of a 3–4 times increase in line center solar Lyman β over the 1962 measurements by Tousey.

There has been recent work on lateral flow calculation by Patterson and Joseph which support the earlier conclusions of a diurnal variation by less than a factor of 2.

The hydrogen density maximum could be as late as 6 a.m., at least between 4 a.m. and 6 a.m. Balmer α observations demonstrating this have been made by Tinsley and are consistent with about a 2:1 diurnal variation.

Further studies on the winter helium bulge have been made using satellite drag data, rocket & satellite mass spectometer data, and ground based helium 10830 Å data.

A surprising feature of these results is the very large amplitude of the seasonal-latitude variation. The winter/summer variation at latitude 34° is a factor of 10 at 120 km, a factor of 4 at 600 km, and this requires a strong driving force to counteract the smoothing effects of lateral flow.

Some possible mechanisms for producing the winter bulge were discussed by F. S. Johnson in his review to IAGA in St. Gall in 1967. He found charges in the turbopause level to be inadequate in that they failed to provide the necessary flux to support lateral flow. He favored the effects of large scale circulation carrying helium to the winter pole region.

A new mechanism suggested by Krassovsky is that helium ions produced in the summer hemisphere migrate to the winter hemisphere, and are there neutralized, providing the buildup in neutral helium there.

Also, it should be remembered, the most important mechanism for loss of He^4 from the earth is believed to be the loss of ions along open polar field lines, according to the models of Banks and Axford. This loss would also contribute significantly to the summer polar regions being deficient with respect to the winter polar region.

There is no reason at present to exclude any of these from making some contributions to the winter buildup, although ion transport in itself would not be sufficient, as it would not produce the larger enhancement at lower levels.

Further observations of helium 10,830 Å and H Balmer α made at widely distributed points around the globe should be of great value for our understanding of helium and hydrogen transport in the exosphere and would be valuable supplements to the shorter term observations of rockets and satellites.

A new series of measurements of Balmer α is beginning in Camden, Australia; in South West Africa; and in Israel. The Australian work is with a scanning spectrometer, and the South-West African and Israeli work is with further instruments. A more detailed account of theoretical and experimental work in Israel follows, supplied by J. H. Joseph of Tel Aviv University.

At Tel Aviv University, studies of the hydrogen distribution in the upper atmosphere are concentrated in three directions.

I) The time-dependent diffusion equations for atomic and molecular hydrogen have been solved numerically for the thermosphere between 100 km and the exobase. The results show the thermosphere below 200 km lags up to six hours behind that in the region above, and the diurnal variation is reduced. The lag in optical depth is less severe, being one or two hours behind the ambient atmosphere. The effect of adding H_2 has been calculated and a reduction in the diurnal variation is found.

II) A tilting-filter scanning photometer using a photon counter is being constructed for long term studies of Balmer α in the night sky.

III) The line-dependent photochemical equations in a moist mesosphere are in the process of being solved numerically including both eddy motions and winds.

WORKING GROUP VIII–6, METEORS

T. R. Kaiser – Reporter

Recent developments in meteor science relevant to the interests of IAGA can be summarized under three headings which, however, cannot be regarded as exclusive. They are, respectively: (i) the use of meteors as tracers for the study of upper atmospheric parameters, particularly winds; (ii) the physical processes accompanying and immediately following the entry of a meteoroid into the earth's atmosphere; (iii) the longer term effects of meteoric debris deposited in the atmosphere (particularly ionospheric phenomena). The following report has therefore been divided roughly under these three headings.

Atmospheric Data from Meteors

It is gratifying that, following IAGA resolution 23 of the St. Gall meeting, there has been an extension in the application of the radio-meteor technique for wind measurements and that progress has been made in extending these studies to lower latitudes. There is still, however, a relative lack of such measurements at high latitudes, and particularly in the polar regions.

Meteor wind observations are essentially confined to the altitude range 80 – 105 km and much of the work to date has dealt with average parameters over this interval. It is therefore noted with means of determining heights with accuracy between ±5 and ±2 km, depending on the technique used. Wind shears are also being resolved by both spaced receiver measurements and by the differential doppler method. The data are being utilized in the study of tides, turbulence and internal gravity waves and in comparisons between neutral winds and ionospheric drifts. There is yet considerable scope for cooperative observing programs; attention here also should be drawn to the need for simultaneous observations at widely spaced sites over extended periods of at least several days.

The following table gives a list of existing and projected meteor wind stations with brief details, where available, of the technique used.

Meteor Wind Stations

	Geographical Location		Freq. MHz	Mode	Height Accuracy, km.	Status
Heiss	80 N	55 E	33	pulse	± 2	existing
Fairbanks	65 N	48 W	41	pulse	–	projected
Tomsk	57 N	85 E	30	pulse	± 5	existing
Obninsk	56 N	38 E	24	pulse	± 2	existing
Kazan	56 N	49 E	30	pulse	± 5	existing
Sheffield	53 N	1 W	24.8 36.3	pulse pulse	± 2	existing
Bracknell	51 N	1 W	36.3	pulse	± 5	projected
Kiev	50 N	31 E	34	pulse	± 5	existing
Kharkov	50 N	36 E	37	pulse	± 2	existing
Garchy	47 N	3 E	30	CW	± 3	existing
Durham	43 N	71 W	36.8 73.6	pulse pulse	± 5	existing
London	43 N	81 W	40	CW	± 1	projected
Frunze	43 N	75 E	36	pulse	± 5	existing
Havana	40 N	90 W	41	pulse	± 3	existing
Dushanbe	38 N	69 E	36	pulse	± 2	existing
Stanford	37 N	122 W	30.1	pulse	± 2.5	existing
White Sands	33 N	106 W	33	pulse	–	projected
Kingston	18 N	77 W	36	pulse	± 5	projected
Mogadishu	2 N	18 E	37	pulse	± 2	1968-69
Gan	0	73 E	36.3	pulse	± 5	projected
Newcastle	33 S	151 E	–	–	–	projected
Adelaide	35 S	130 E	26.8 27.5	CW pulse	± 2	existing
Christchurch	44 S	173 E	27	pulse	–	projected

References 1 – 7 in the bibliography refer to recent work on meteor wind studies.

Atmospheric temperature and density data, in the meteor zone, have been obtained from radio-meteor observations at Havana (Illinois) by Verniani (8).

Meteor Physics

Knowledge of the physics of meteor flight in the atmosphere is of primary importance in understanding the role played by meteors in the upper atmosphere. Recent work on the theory of meteor ablation is described in references 9 – 11. Lebedinets and Shuskova (11) present numerical solutions of the ablation profile for solid meteoroids, while the effects of fragmentation have been discussed by Simonenko (12). There is general agreement on the importance of fragmentation for the brighter photographic meteors, but its role for fainter ones is still a subject of controversy. Poole and Kaiser (13) have deduced the dependence of height of ablation on meteor mass from observations of faint radio-meteors and find it to support the view that these are due to compact meteoroids.

From theoretical studies (14, 15) of the diffusion of an ionized column in the presence of the geomagnetic field it is concluded that diffusion transverse to the field lines will not be severely inhibited unless the axis of a meteor train is within 1° of the field line. Experimental investigations (15, 16) of the effect of the magnetic field on diffusion in meteor trains support this view but also suggest that field aligned irregularities may develop in the trains of bright meteors. The effects of neutral winds and electric fields have also been the subjects of theoretical study (15). It is concluded that a meteor train will move with the neutral wind unless it is aligned with the magnetic field to within 1°; this is clearly of importance in relation to the meteor wind measurements.

The role of electron attachment in meteor trains has been studied by Glöde (17) and Rajchl (18). Rajchl (18, 19) disputes a previous suggestion, that enduring train luminosity derives from mutual neutralization of positive and negative ions, and proposes the radiative association reaction $O + NO \rightarrow NO_2 + h\nu$.

Jenkins and du Vall (20) have estimated the magnetic disturbance which might be produced by the formation of an ionized meteor train. They predict a maximum effect of the order of 25γ for an infinitely conducting and horizontal meteor train which is parallel to the local current. An attempt to associate micropulsations with meteors from the Geminid meteor shower has proved inconclusive (21).

Meteoric Constituents in the Atmosphere

The most important development under this heading is the accumulating evidence supporting the view that metal ions of meteoric origin are important in the formation of sporadic E layers. The production of narrow E_S layers by the wind shear mechanism requires an ionic component with a much longer life-time than the atmospheric ions (22, 23) and it is predicted that there should be a minimum in the density of the latter at the maximum of an E_S layer. Rocket-borne mass spectrometer studies (24 – 29) reveal that the meteoric ions are at two levels; one broad layer (~10 km thick, $n_e \sim 10^4$ cm^{-3}) is centered at about 93 km and other narrower layers are observed above 100 km. Narcisi (25) has also confirmed the predicted minima in the atmospheric ion density. Mg^+ and Fe^+ are observed at both levels and, while photo-ionization may be invoked above 100 km, other processes such as charge exchange are required at the lower level since solar radiation capable of ionizing Mg and Fe cannot reach 93 km altitude. Si^+, Ca^+ and, Na^+ and Al^+ are among other metallic constituents; the latter three could be produced by solar ultraviolet at the 93 km level.

Collisional ionization may be important at 110 km or so, where ionization from many faint meteor trains may coalesce to form a layer, but not at 93 km (where the ionization is produced in fewer dense trains in which the life-time of the ions is not likely to be sufficient to allow the trains to coalesce). The metal ion chemistry of the atmosphere, including the role of metal oxides, has been treated in references 30 and 31. Gadsden (32) concludes, from the profile of the twilight sodium layer, that it is meteoric in origin. Sida (33) has determined the probability coefficients for collisional ionization of various meteoric constitutents as a function of meteoroid velocity and concludes that this could be an important source of the nighttime E–region. His estimate of the equilibrium density (3×10^3 cm^{-3}) is reasonable, however it is based on a high value for both meteoroid influx ($3 \times 10^9 g$ day^{-1}) and recombination coefficient ($10^{-8} cm^3 sec^{-1}$). If this latter were nearer the radiative value ($3 \times 10^{-12} cm^3 sec^{-1}$) a much lower mass influx would be indicated.

Attempts to correlate E_s occurrence with meteoric activity have not been very successful (34, 35, 36). This is perhaps not surprising since the small particles which make the major contribution to the mass influx are more abundant in the sporadic background than in the major meteor showers. Also, the E_s pattern will depend on the occurrence of wind shears.

Meteoric dust has frequently been invoked as the source of condensation nuclei for noctilucent clouds. Recent work (37, 38, 39) makes this appear less likely, as rocket flights through noctilucent clouds have failed to reveal such particles in sufficient numbers. Witt (37) has proposed a mechanism of hydration of ion clusters by sublimation which could involve ions of meteoric origin (such as Fe^+). Scattering of solar radiation by meteoric dust has been invoked by Carrara et al. (40) to explain its possible influence on VLF propagation (i.e. on the properties of the D–region).

Bibliography

1. Proceedings of the workshop on methods of obtaining winds and densities from radar meteor trail returns (ed. A. A. Barnes and J. J. Pazniokas). Office of Aerospace Research (U. S. Air Force), 1968.
2. H. G. Müller. Wind shears in the meteor zone. Planet. Space Sci. **16**, 61–90, 1968.
3. H. G. Müller. Simultaneous observations of meteor winds and ionospheric drifts. J. Atmos. Terr. Phys., **30**, 701–706, 1968.
4. A. A. Barnes. Winds and densities from meteor trail returns. Bull. Amer. Met. Soc., **48**, 1967.
5. L. Kashaheyev and I. A. Lysenko. Atmospheric circulation in the meteor zone. J. Atmos. Terr. Phys., **30**, 903–905, 1968.
6. R. E. Newell and R. E. Dickinson. On the application of a proposed global system for measuring meteor winds. Pure and Appl. Geophy., **68**, 162–172, 1967.
7. E. Phillips. Wind structure from the amplitude fluctuations in persistent radio-meteor echoes. Planet. Space Sci., **17**, 553–560, 1969.
8. F. Verniani. Profili di densita atmosferica tra 70 e 100 km di quota. Atti del XVII Convegno AGI, 263–280, 1968.
9. A. F. Cook. The physical theory of meteors. Physics and Dynamics of Meteors (ed. L. Kresak and P. M. Millman), pp 149–160: D. Reidel (Dordrecht–Holland), 1968.
10. E. Opik. Interaction of meteoric bodies with the terrestrial atmosphere. The Irish Astronomical Journal, **8**, 53–62, 1967.
11. V. N. Lebedinets and V. B. Shuskova. Vaporization and deceleration of small meteoroids. Solar System Research, **2**, 30–35, 1968.
12. A. N. Simonenko. The behaviour of small particles detached from a meteoroid. Soviet Astron. – AJ, **12**, 341–348, 1968.

13. L. M. G. Poole and T. R. Kaiser. The duration distribution of radio-meteors from underdense shower meteor trains. Planet. Space Sci., **15**, 1131–1149, 1967.
14. T. R. Kaiser. Diffusion of meteor trains in the geomagnetic field. Physics and Dynamics of Meteors (ed. L. Kresak and P. M. Millman), pp 161–168: D. Reidel (Dordrecht–Holland), 1968.
15. T. R. Kaiser, W. M. Pickering and C. D. Watkins. Ambipolar diffusion and motion of ion clouds in the Earth's magnetic field. Planet. Space Sci. **17**, 519–552, 1969.
16. C. D. Watkins. Height dependence of the effect of the geomagnetic field on meteor trains. J. Atmos. Terr. Phys., **30**, 1827–1832, 1968.
17. P. Glöde. Estimation of attachment rate from the different echo duration of night and daytime meteors. Physics and Dynamics of Meteors (ed. L. Kresak and P. M. Millman), pp 175–186: D. Reidel (Dordrecht–Holland), 1968.
18. J. Rajchl. About turbulence and attachment in meteor trains. Bull. Astr. Inst. Czech., **20**, 10–13, 1969.
19. J. Rajchl. On the origin of meteor long-duration train luminescence. Bull. Astr. Inst. Czech., **19**, 323–325, 1968.
20. A. W. Jenkins and B. W. du Vall. A theory of meteor induced micropulsations. J. Geophys. Res., **72**, 2301–2307, 1967.
21. R. G. Green. An analysis of the magnetic effect from shower meteors. J. Geophys. Res., **72**, 2309–2313, 1967.
22. J. D. Whitehead. Survey of sporadic E processes. Space Research VII, pp 89–99: North Holland (Amsterdam–Holland), 1967.
23. L. J. Gleeson. Positive ion layers in the E–region of the ionosphere. Planet. Space Sci., **15**, 27–37, 1967.
24. R. S. Narcisi. Ion composition of the mesosphere. Space Research VII, pp 186–196: North Holland (Amsterdam–Holland), 1967.
25. R. S. Narcisi. Processes associated with metal-ion layers in the E region of the ionosphere. Space Research VIII, pp 360–369: North Holland (Amsterdam–Holland), 1968.
26. C. R. Smith, H. C. Brinton, M. W. Pharo and H. A. Taylor. Lower E–region ion concentrations measured at a time of declining solar activity. J. Geophys. Res., **72**, 2357–2363, 1967.
27. A. D. Zhludko. Ion composition of the night-time ionosphere. Geomag. and Aeron., **8**, 762–765, 1968.
28. J. M. Young, C. Y. Johnson and J. C. Holmes. Positive ion composition of a temperate latitude E_s layer as observed during a rocket flight. J. Geophys. Res., **72**, 1473–1479, 1967.
29. F. Arnold, W. Berthold, B. Betz, P. Lammerzahl, J. Zahringer. Mass spectrometer measurements of positive ions and neutral gas between 100 and 223 km above Andoya, Norway. Space Research IX, pp 256–261: North Holland (Amsterdam–Holland), 1969.
30. E. E. Ferguson and F. C. Fehsenfeld. Some aspects of the metal ion chemistry of the Earth's atmosphere. J. Geophys. Res., **73**, 6215–6223, 1968.
31. E. Swider. Processes for meteoric elements in the E region. Planet. Space Sci., 17, 1233–1246, 1969.
32. M. Gadsden. Sodium in the Upper Atmosphere: meteoric origin. J. Atmos. Terr. Phys., **30**, 151–161, 1968.
33. D. W. Sida. The production of ions and electrons by meteoritic processes. Mon. Not. Roy. Astr. Soc., **143**, 37–47, 1969.

34. K. M. Kotadia and K. G. Jani. Sporadic E ionization and anomalous increase in the rate of radar meteor counts during 1963. J. Atmos. Terr. Phys., **29**, 221–223, 1967.
35. R. Godzhova. Effect of meteor showers on the sporadic E layer. Bogarskata Akad. Nank, Doklady, **20**, 787–790, 1967.
36. J. W. Wright. Sporadic E as an indicator of wind structure in the lower ionosphere and the influx of meteors. J. Geophys. Res., **72**, 4821–4829, 1967.
37. G. Witt. The nature of noctilucent clouds. Space Research IX, pp 157–169: North Holland (Amsterdam–Holland), 1969.
38. E. Hesstvedt. Nucleation and growth of noctilucent cloud particles. Space Research IX, pp 170–174: North Holland (Amsterdam–Holland), 1969.
39. R. K. Soberman. Extraterrestrial origin of noctilucent clouds. Space Research IX. pp 183–189: North Holland (Amsterdam–Holland,, 1969.
40. N. Carrara, A. Cionini and L. Ronchi. Possible influence of meteoric dust on VLF signal propagation. II Nuovo Cimento, **53B**, 222-255, 1968.

WORKING GROUP VIII–7, PLANETARY ATMOSPHERES

D. M. Hunten – Reporter

A wealth of data on the upper atmospheres of Mars and Venus has become available from the planetary probes Mariner IV and V, and Venera 4 (confirmed by Venera 5 and 6) (refs. B1–B3). Many of these results have been discussed in detail at the first two Arizona Conferences (refs. A1, A2), and further references may be found in their proceedings.

The Mariner occultation experiments gave electrondensity profiles for Mars and Venus. At first, the Mars profile resisted all attempts to explain, except those based on an exospheric temperature so low that few were prepared to accept it (ref. A1, papers by Donahue, Hunten, and Johnson). The Venus profile, however, can be explained without difficulty by photoionization of CO_2 and recombination of CO_2^+ (McElroy 1969). Several authors have suggested that the Martian ionosphere is drastically modified by solar-wind pressure, and a quantitative model has been worked out by Cloutier *et al.* (1969). The solar-wind gas, after passing through a shock, flows through the topside ionosphere at about 1 km/sec. Its magnetic field picks up CO_2^+ ions as soon as they are formed, and sweeps them downwards. The topside scale height of the ionosphere should then be equal to that of neutral CO_2, and the profile is therefore consistent with a reasonable exospheric temperature. On Venus, the observations seem to show that the solar-wind plasma is stopped at about 500 km. Cloutier *et al.* offer no explanation of this difference, but speculate that it may be related to the presence of light gases, particularly He.

The nighttime ionosphere observed by Mariner V requires a special source, because of the very slow rotation of Venus. McElroy and Strobel (1969) suggest the transport of He^+ (or possibly H_2^+) at very high altitudes from the dayside. As the light ion diffuses downward, it will eventually react and produce CO_2^+, which will then recombine. The observed electron-density profile is well reproduced by the model. The availability of H_2^+ from the dayside is rendered unlikely by the recent work of McElroy and Hunten (1969b), who point out that H_2 is rapidly dissociated in the presence of CO_2^+.

These models require the Venus and Mars thermospheres to be mainly undissociated CO_2, and indeed atomic oxygen is inferred to be rare on Venus from the negative result of Venera 4, which searched for resonance scattering at 1304 Å. The necessary rapid association of CO and O may be provided by a relatively stable CO_3 complex formed from CO_2 and $O(^1D)$. This mechanism was discussed in some detail at the 1968 IAGA symposium (ref. A4), and has been applied to the Mars atmosphere by McElroy and Hunten (1970). Many excellent review papers appear in ref. A4, but more laboratory attention is needed to the problems posed by CO_2 and H_2 atmospheres.

Venera 4 and Mariner V observed extensive Lyman α coronas around Venus. The Mariner data have been analyzed in detail (Wallace 1969), and seem to suggest an exospheric temperature of around 640°K. But at lower altitudes, an additional component is present, which can be fitted with a mass of 2. Barth *et al.* (1968) suggested that this component is due to H_2, but the required amounts are so large as to raise a number of serious difficulties (Donahue, ref. A2, and 1969; McElroy and Hunten, 1969a). The most attractive alternative is a large abundance of deuterium; there is a great enhancement of the D/H ratio in the exosphere by the combined effects of diffusion and escape. Donahue suggests that the ratio may even have the terrestrial value in the lower atmosphere; McElroy and Hunten favor a considerable enrichment.

The Third Arizona Conference was devoted to the atmosphere of Jupiter; its proceedings, (ref. A3) contain a paper by Hunten on the upper atmosphere, and one by Strobel on methane photochemistry; the latter topic is also discussed by McNesby (1969). The Lyman α albedo of Jupiter has been observed by Moos *et al.* (1969), and from this can be derived the column abundance of H in the thermosphere (see also Carlson and Judge, 1969). The H atoms are produced in the ionosphere, and diffuse downwards; a model of this system agrees with observation if the eddy diffusion coefficient has the same value as for Earth. An ionospheric model can be derived, but is very uncertain because several potentially important rate coefficients are unknown. For methane the situation is not as bad, but further laboratory work is needed.

References

A: Conference Proceedings, including the three Arizona Conferences on Planetary Atmospheres.

A1: *The Atmospheres of Mars and Venus,* eds. J. C. Brandt and M. B. McElroy (New York, Gordon & Breach) 1968.

A2: *The Atmosphere of Venus,* J. Atmos. Sci., **25**, No. 4, 533–671 (1968).

A3: *The Atmospheres of the Major Planets,* J. Atmos. Sci., **26** (September 1969).

A4: *Symposium on Laboratory Measurements of Aeronomic Interest,* ed. H. I. Schiff, IAGA Symposium No. 8, Can. J. Chem., **47**, 1711–1941 (1959).

B: Mariner and Venera announcements.

B1: Mariner IV (Mars), Science, **149**, 1226–1248 (1965).

B2: Mariner V (Venus), Science, **158**, 1665–1690 (1967).

B3. Venera 4, Trans. Am. Geophys. Union, **48**, 931 (1967) (translation of a TASS report).

C: Individual papers.

Barth, C. A., L. Wallace and J. B. Pearce, Mariner 5 measurement of Lyman-alpha radiation near Venus, *J. Geophys. Res., 73,* 2541, 1968.

Carlson, R. W. and D. L. Judge, The extreme ultraviolet dayglow of Jupiter, *Planet. Space Sci., 17,* in press 1969.

Cloutier, P. A., M. B. McElroy, and F. C. Michel, Modification of the Martian ionosphere by the solar wind, *J. Geophys. Res., Dec. 1, 1969.*

Donahue, T. M., Deuterium in the upper atmospheres of Venus and Earth, *J. Geophys. Res., 74,* 1128, 1969.

Fjeldbo, G. and V. R. Eshleman, The atmosphere of Mars analyzed by integral inversion of the Mariner IV occultation data, *Planet. Space Sci., 16,* 1035, 1968.

Hunten, D. M. and M. B. McElroy, The upper atmosphere of Venus: The Regulus occultation reconsidered, *J. Geophys. Res., 73,* 4446, 1968.

McElroy, M. B., The upper atmosphere of Mars, *Astrophys. J., 150,* 1125, 1967.

McElroy, M. B., The upper atmosphere of Venus, J. *Geophys. Res., 73,* 1513, 1968.

McElroy, M. B., Structure of the Venus and Mars atmospheres, *J. Geophys. Res., 74,* 29, 1969.

McElroy, M. B. and D. M. Hunten, The ratio of deuterium to hydrogen in the Venus atmosphere, *J. Geophys. Res., 74,* 1720, 1969a.

McElroy, M. B. and D. M. Hunten, Photochemistry of CO_2 in the atmosphere of Mars, submitted to *J. Geophys. Res.,* 1970.

McElroy, M. B. and D. M. Hunten, Molecular Hydrogen in the atmosphere of Mars, *J. Geophys. Res., 74,* 5807, 1969b.

McElroy, M. B and D. F. Strobel, Models for the nighttime Venus ionosphere, *J. Geophys. Res., 74,* 1118, 1969.

McNesby, J. R., The photochemistry of Jupiter above 1000 Å, *J. Atmos. Sci., 26, 594, 1969.*

Moos, H. W., W. G. Fastie, and M. Bottema, Rocket measurement of ultraviolet spectra of Venus and Jupiter between 1200 and 1800 Å. *Astrophys. J., 155,* 887, 1969.

Wallace, L., Analysis of the Lyman-alpha observations of Venus made from Mariner 5, *J. Geophys. Res., 74,* 115, 1969.

COMMISSION IX
HISTORY
N. V. Pushkof – Chairman

E. J. Chernosky – Acting Reporter

The scheduled meeting was held on Wednesday 10th September at 16:00 hours with about 15 persons attending. In the absence of Professor Pushkov, E. J. Chernosky acted as chairman at the request of Father Romaña.

A very interesting invited paper was presented by Father Romaña on early magnetic observations made by the Jesuits. The teachers in Jesuit Colleges were followers of Gilbert and continued his work in magnetics. These followers were Grandamy, Boneo, Kircher, Fabry, Des Challes and others. Kircher's "Geographica Magnetica" shows more than 580 values of D observed before 1640, obtained mostly by missionaries in their travels to the Far East and America.

Observations of the variation of D by Father LanaZerzi before 1686 in Italy and of Father de la Charme in China during 1728 are noted. Observations of the aurora were made in the 17th and 18th centuries.

More recent work including the establishment of 14 magnetic observatories around the world was noted by Father Romaña.

Professor Chapman suggested that the old records formed by Father Romaña be xeroxed so that calligraphers could decipher them. These data were also of interest to Dr. Fournier in his studies. He commented that some magnetic data was coming from the mainlaind of China.

The possible application of his method of study of the magnetic pole locations to the resolution of earlier data was noted by Dr. Knapp.

The members of Commission IX were urged to take an active interest in the work of the World Magnetic Archives group because of its very similar goals.

As observations of the aurora were possible long before magnetic observations, further research for historical records of auroral sightings were recommended, a paper on Chinese observations has been published in the Journal of Geophysical Research.

French Proposal

We recognize the necessity of the reorganization and in general we are in accord with the French proposition, but we are not in accord with the method of putting it in practice. If one assigns a certain number of Commissions of an Association to such a Union and another portion to another Union, one creates fractures which for certain Associations represents a sort of death for that Association; for example, for IAGA. Moreover these new Unions formed with the pieces provided by the old ones risk being an artificial edifice in which the connections will not stand the effect of time. It would be better that one take a strictly scientific point of view concerning what is necessary to set the earth sciences in order and having once found the new disposition suitable proceed to the dissolution of the former Unions or Associations and the creation of new ones (or vice versa).

JOINT IAGA – IAMAP COMMITTEE ON ATMOSPHERIC ELECTRICITY

L. Koenigsfeld – Chairman
H. Dolezalek – Secretary

SYMPOSIUM ON ELECTRICAL PROCESSES AND PROBLEMS IN THE STRATOSPHERE AND MESOPHERE

H. Dolezalek – Convener
W. A. Hoppel and V. A. Mohnen – Reporters

Two sessions of this symposium were held. One, on 4 September, was chaired by C. G. Fälthammar, and one, on 5 September, was chaired by H. Dolezalek.

In the opening paper, H. Dolezalek summarized briefly the "Classical Picture of Atmospheric Electricity", placing special emphasis on discrepancies and alternatives. In spite of its deficiencies, the classical picture represents (up to now) the only existing full qualitative descriptions of long term averages; but there is no quantitative proof. By incorporating extraterrestrial and new atmospheric processes the classical picture will continue to evolve, because the most economic way to arrive at an acceptable solution of the fundamental problem of atmospheric electricity is the attempt to test the classical picture down to daily and hourly means.

Bhartendu described correlation coefficients for electric fields data taken from twenty land stations around the globe. From the low values of the correlation coefficient, he questioned the effectiveness of the mechanism of thunderstorm activity as being responsible for effecting the field variation at land stations. In discussion, L. Koenigsfeld pointed out that correlation coefficients calculated for four stations in Belgium showed relatively good correlation between the three inland stations. He enumerated basic difficulties in correlating various stations separated by great distances.

Three papers dealt with the electric fields in the stratosphere. Horizontal fields at 10 to 50 mV/m associated with auroral and magnetic disturbances were measured by F. Mozer. Generally these fields originate in the magnetosphere and are mapped down to balloon height with little attenuation. In some cases, there is evidence that nearby weather processes produce large horizontal electric fields at balloon altitudes in the stratosphere. U. Fahleson presented the results of an analytical and numerical study at the two-dimensional atmosphere with exponentailly increasing conductivity taking into account electric fields of tropospheric origin. A similar problem was also treated by W. A. Hoppel who gave numerical solutions to the perturbation in the equipotential surfaces caused by orographic features. The results of these studies show that the horizontal and vertical fields in the stratosphere may be effected by tropospheric fields.

Some papers of the first session were more of a speculative nature. H. W. Kasemir pictured a fair-weather electric current as penetrating the ionosphere where it interacts with the magnetic field. An essential feature of this picture is an electric ring current which at the equator flows across the magnetic field lines with the components along the lines being zero. Qualitative results of the strength and distribution of the ring current together with field and current flow lines were given, resulting in basically greater air-earth current density at higher latitude.

R. D. Hill suggested that the earth-ionosphere fair-weather field arises from the lowest order resonant excitation of the cavity by lightning, and proved that the same field is generated by electrostatic induction from equivalent thundercloud-charge dipoles.

W. L. Webb (paper read by H. Dolezalek) postulated that the atmospheric electric structure of the earth is controlled by an electromotive force in the lower ionosphere which is produced by the interaction between the neutral atmosphere tidal circulations and ionospheric magnetic field. The thunderstorms are then low-resistance links between ionosphere and earth. In the discussion, considerable doubt was expressed regarding, in particular, the extremely large horizontal potential differences in the ionosphere as postulated by Webb.

Imyanitov and Chubarina, in a turned-in short contribution, suggest a solution of the fundamental problem which is about pointing into the opposite direction: low altitude effects of a complex meteorological nature (including turbulence) are held to be responsible for the effects they measured on numerous flights. They postulate that these results do not fit into the spherical capacitor hypothesis (which is a part of the classical picture).

In the second session, R. Muhleisen reported on new results of measurements over the ocean (Atlantic Expedition of the research vessel "Meteor"). The electrode effect could be detected in full magnitude on the Atlantic. The average value of the electric field above the sea surface was about 125 V/m, in 10 to 100 m above the surface it dropped to about 60 V/m. This phenomena as well as the results of small ion counts lead to a value of 0.9×10^{-12} A/m^2 for the air-earth current density, which is only one quarter of the value accepted up to now (Carnegie expedition). The total current of the global air electric circuit needs now also to be corrected and then amounts to 665 Amperes instead of 1500 to 1800 A. However, these low values have been questioned by Kasemir, who found at the same time on the vessel "Discoverer" current values of about 2×10^{-12} A/m^2.

D. E. Olson investigated the possibility of atmospheric electrical effects due to the aurora. His measurements showed, for example, large negative excursions of the electric field at ground level during strict fair-weather conditions and peculiar increase in negative ion densities as well as variations in air-earth current densities (both at the 100 mb level) being associated with auroral activity. A high influx of negative space charge, auroral bremsstrahlung flux driving electrons down generating a potential gradient or plasma instabilities in the auroral electrojet could be responsible for the observed effects.

R. Markson speculated in his paper that certain solar initiated geophysical parameters (Polar cap absorption, magnetic index, etc.) are associated with lunar position, the earth's electric field and thunderstorms. The question remains: Is solar activity, presumably modulated by the moon, influencing thunderstorm activity? If the answer turns out to be yes, one will have an important clue in solving the problem of thunderstorm electrification.

Increasing attention is being devoted to aerosol particles in the stratosphere or mesosphere. B. G. Shuster reported on measurements of stratospheric aerosol (11-48km) using the NCAR Lidar System (100 Megawatts peak power, no pulse counting). He could confirm the existence of an aerosol layer at 20 km height and furthermore demonstrate its variation with time by producing a time sequence movie from the return signal (15 sec. interval). Two more weak aerosol layers were detected at about 11 km and above 35 km. The temperature profile of the tropopause was also recorded for correlation purposes.

V. A. Mohnen discussed the possible nature of positive and negative ions in the stratosphere and mesosphere, i.e., at altitudes not yet accessible to direct mass spectrometric measurements. It is anticipated that the major positive ions are $H^+(H_2O)_n$ at any level up to 75 km, however, the mean number of attached water molecules is a function of altitude (i.e. temperature and water concentration). The negative ion scheme is expected to change drastically with altitude. The formation of aerosol by gas to particle conversion, (responsible for the aerosol layer at 20 km height) is postulated to take place throughout the atmosphere up to around 85 km (even noctilucent clouds could have their cause to some extent due to gas to particle conversions).

Closely related to the last two papers was the short contribution by Widdel (read by H. Dolezalek), who measured with a mobility spectrometer, the vertical profile of positive and negative ions from more than 70 km down. The electron density was also computed.

In general, all papers reflected in one way or another the search for a broader base of, and a more quantitative approach to atmospheric electricity. Problems previously only discussed in Aeronomy or Extraterrestrial Physics now continue to become of increasing importance to explain atmospheric electrical effects.

The papers of the symposium will be published in a special issue of "Pure and Applied Geophysics".

Business Conducted for the Joint Committee

No formal business meeting of the joint committee was held, but the Chairman, Secretary and a few other members held informal disucussions about topics which should be discussed in Moscow in 1971. Tentative plans were laid to cover the following topics:

(1) First results and problems of the Ten-Year Program in Atmospheric Electricity

(2) The measurement of air-earth current density and electrode effect

(3) The variations in the nature of positive and negative ions in the layers 0 . . . 8 km, 8 . . . 16 km, 16 . . . 33 km, 33 . . . 62 km, 62 . . . 80 km of the atmosphere

(3a) Concept and measurement of ion mobility

(4) Thunderstorm monitoring

(5) Thunderstorm electrification and structure

(5a) Electric processes in the generation of precipitation

(6) Initiation and propagation of lightning

(7) Modern measuring techniques in atmospheric electricity

(8) Extraterrestrial effects, including measurements on planets

(9) Meteorological applications of atmospheric electricity

(10) Business Meetings

JOINT IAGA – IAMAP COMMITTEE ON LUNAR VARIATIONS

O. Schneider – Chairman
S. R. C. Malin – Acting Reporter

A description of the origin, purpose and history of the Joint IAGA – IAMAP Committee on Lunar Variations is given in the Transactions of the XIV General Assembly of IUGG, St. Gall, Switzerland, 1967 (IAGA Bulletin No. 25, p. 135). In the same Bulletin (p. 138) is a bibliography of relevant papers, which forms a supplement to the "Annotated Bibliography of Lunar Influences on Atmospheric and Geophysical Phenomena" by W. Nupen and G. Thuronyi (Meteorological and Geoastrophysical Abstracts, 14, No. 12, 3958-4019, 1963). The bibliography presented here lists further papers which do not appear in the above publications.

Because one of the joint sponsors of the Lunar Committee (IAMAP) was not represented at Madrid, it was not possible to hold a full-scale business meeting; however, the General Secretary of IAMAP agreed that a business meeting could be held, but that it was not appropriate to make formal resolutions or to change the constitution of the committee and its working groups.

PROGRESS REPORT

The meeting which was held at 09:00 on 9 September, was attended by 17 delegates, including the following members of the committee: S. Chapman, J. O. Cardus, S. R. Malin, S. Matsushita, R. G. Rastogi, A. T. Price, E. J. Chernosky, and O. Schneider.

A report on progress since the St. Gall meeting was presented by the chairman. He reviewed the literature, both published and in the process under a number of headings. The theoretical study of atmospheric oscillations was considered in only three papers (Blamont and Teitelbaum, 1968a, 1968b,; Burkard, 1968). Theoretical aspects of geomagnetic field variations and the associated current systems had been more widely discussed. Maeda and Fujiwara (1967) and Matsushita (1967, 1969a, 1969b) had considered the whole lunar dynamo problem, while Price and Stone (1969) were developing a current system model based solely on geomagnetic data. Gupta (1967) discussed the relative importance of the sun's radiation and gravitational tide on geomagnetic daily variations. The influence of the oceans and conductivity of the mantle were examined by Chapman and Kendall (1969), Larsen (1969), Malin (1969a) and Malin and Winch (1968).

As in the past, the majority of papers concerned methods of analysis and the presentation of new results. The former group included a new description of the Chapman-Miller method (Malin and Chapman, 1969b), in response to a suggestion made at St. Gall. Extension of the method to include further tidal harmonics was considered by Winch (1969) and Malin and Chapman (1969a). Deviations of lunar terms from incomplete daily sequences was discussed by Haurwitz and Cowley (1967) and Gupta (1968a). Affolter and Schneider (1969), Machado and Schneider (1969) and Schneider (1969) considered the effect of lunar daily variations on solar daily variations derived from the five International Quiet Days of each month. Maksimov, Vorobyov and Gindysh (1969) and Malin and Leaton (1969) discussed spurious effect likely to be found in the results of lunar analyses.

New determinations of lunar daily variations in the atmospheric pressure were made by Haurwitz and Cowley (1967, 1968b), Palumbo (1960, 1961, 1962, 1966) and Van Wijk (1969). A paper by Malin and Chapman (1969z) contains the first determination of the 0_1 tide in atmospheric pressure. In an important paper, Haurwitz and Cowley (1969) collected $\ell_2(p)$ data for over 100 stations, and subjected these to spherical harmonic analysis. In another important study, Gupta (1968b) and Gupta and Chapman (1968a, 1968b), collected and analyzed geomagnetic data from 100 stations operating during the IGY/C. In addition, they analyzed data for 16 stations for the preceding sunspot minimum period, and included some previously unpublished results for longer series of data. Other geomagnetic results were presented by Cardus (1969), Malin (1967, 1969b), Malin and Winch (1968) and Palumbo (1968). Lunar variations had also been investigated in earth currents (Esponda, 1969), cosmic radiation (Bussion and Gupta, 1968). Aurora (Stoffregen, 1967), wind velocity (Haurwitz and Cowley (1968a; 1968b), and ionospheric parameters (Fatkullin and Zayulyaeva, 1969; Chakravarty and Rastogi, 1969; Rastogi 1968a, 1968b, 1968c; Rastogi and Chakravarty 1969; Rastogi and Sharma 1969a, 1969b; Rastogi and Trivedi 1969; Sharma and Rastogi 1968; Sharma and Rastogi 1969a, 1969b; Trivedi and Rastogi 1969).

References which relate to the above report are listed below:

Reference list of papers dealing with Lunar Variations in Geomagnetism, Aeronomy, and the terrestrial atmosphere at large, mainly covering the period July 1967 to June 1969, but also including some titles not listed in the Chairman's Report, St. Gall (Schneider 1968).

(Not included are papers on those aspects of the interaction of the Moon with the circumterrestrial environment that have no direct bearing on geophysical phenomena. Thus, the rather copious literature on solar wind flow past the Moon, shadowing effects of the Moon and similar subjects are not included).

Affolter, H. R. and Schneider, O, (1969): Sistemas Ternarios de las Variaciones Geomagnéticas Diarias. Presented at the 5th Meeting of the Asociación Argentina de Geofísicos y Geodestas, Córdoba, May 1969.

Blamont, J.-E. and Teitelbaum, H. (1968a): La marée diurne antisymétrique. *Annales de Géophysique,* tome 24.

Blamont, J.-E. and Teitelbaum, H. (1968b): La rotation du vecteur vitesse horizontal dans les mareés atmosphériques. *Annales de Géophysique,* tome 24.

Burkard, O. M. (1968): Ein neur Lösungsansatz zum Gezeitenproblem in der Atmoshäre. *Acta Physica Austriaca, 27,* p. 186–194.

Bussian, A. E. and Gupta, J. C. (1968): A Search for Lunar Effect on Cosmic Rays. *Journal of Geophysical Research,* vol. 73, No 13, p. 4404–4408.

Cardus, J. O. (1969): Determination of the Moon's Influence on the Declination at Fernando Poo. Presented at Madrid Assembly.

Chapman, S. and Gupta, J. C. (1969): Note on the Computation of the Solar and Lunar Geomagnetic Variations. *Gerlands Beitrage Zur Geophysik,* 78 2.

Chapman, S. and Gupta, J. C. and Malin, S. R. C. (1969): Note (2) on the Computation of the Solar and Lunar Geomagnetic Variations. *Gerlands Beitrage zur Geophysik,* in the press.

Chakravarty, S. C. and Rastogi, R. G. (1969): Lunar Oscillations in the D-Region Absorption at Singapore. *Nature* (in the press).

Chapman, S. and Kendall, P. C.: Theoretical Effects of Sea and Ocean Tides on the Geomagnetic L_2 Variations. Presented at Madrid Assembly.

Esponda, C. A. (1969): Calculation of Solar and Luni-Solar Harmonic Coefficients of the Earth Currents Daily Variations at San Miguel, Argentina, 1950–1958. Presented at Madrid Assembly.

Fatkullin, M. and Zaguliaeva, V. (1969): Personal communication (to be published in *Geomagnetizm i Aeronomiya,* 1969 and 1970).

Frazer-Smith, A. C. (1969): A Possible Full-Moon Enhancement of Hydromagnetic Emission Activity. *Journal of Geophysical Research,* vol. **74,** No 11, p. 2987–2995.

Gupta, J. C. (1967): Relative Importance of Solar Radiation and Gravitational Tide in Causing Geomagnetic Variations. *Journal of Geophysical Research,* vol. **72,** No 5, p. 1583–1590.

Gupta, J. C. (1968a): Computation of the Semidiurnal Lunar Harmonic Term L_2 in Meteorological Data Using Only Three Values on Each Day. *Journal of Geophysical Research,* vol. **73,** No 15, p. 5004–5007.

Gupta, J. C. (1968b): Information on the Geomagnetic Data Collected for the Lunar Current System Project. *NCAR Manuscript* No 68–109.

Gupta, J. C. and Chapman, S. (1968a): Manual of the Coefficients of the First Four Harmonics of the Solar and Lunar Daily Geomagnetic Variations Computed from IGY/C and Certain Other Data. *NCAR Pub.* No MS68–110.

Gupta, J. C. and Chapman, S. (1968b): Range and Daily Movement of the Solar and Lunar Daily Geomagnetic Variations S and L in X, Y, and Z at 100 Stations. *NCAR Pub.* No MS68–132.

Haurwitz, B. and Cowley, A. (1967): New Determinations of the Lunar Barometric Tide. *Beiträge zur Physik der Atmosphäre,* vol. **40,** p. 243–261.

Haurwitz, B. and Cowley, A. (1968a): Lunar Tidal Winds at Four American Stations. *Geophysical Journal of the Royal Astronomical Society,* vol. **15,** p. 103–107.

Haurwitz, B. and Cowley, A. (1968b): Lunar and Solar Barometric Tides in Australia. *Monthly Weather Review,* vol. **96,** No 9, p. 601–605.

Haurwitz, B. and Cowley, A. (1969a): The Lunar Barometric Tide, its Global Distribution and Annual Variation. *Pure and Applied Geophysics* (1969 or 1970).

Haurwitz, B. and Cowley, A. (1969b): The Lunar Semidiurnal Wind Variation at Uppsala and at Hong Kong (To appear in the *Quarterly Journal of the Royal Meteorological Society,* 1969 or 1970).

Larsen, J. C. (1969): Electric and Magnetic Fields Induced by Deep-Sea Tides. Presented at the Madrid Assembly (Abstract in: IAGA Bull. No 26, p. 194).

Machado, E. A. and Schneider, O.: A Table for Determining Lunar Residues in Five-Day Means of Daily Variations. Presented at Madrid Assembly.

Maeda, H. and Fujiwara, M. (1967): Lunar Ionospheric Winds Deduced from the Dynamo Theory of Geomagnetic Variations. *Journal of Atmospheric and Terrestrial Physics,* vol. **29,** p. 917–936.

Maksimov, I. V., Vorobyov, V. N. and Gindysh, B. N.: On the Quasi–periodic Character of the Long-Period Variations of the Solar and Lunar Tide-Generating Force. Presented at Madrid Assembly.

Malin, S. R. C. (1967): Luni-Solar Daily Variations of the Geomagnetic Field at Tananarive during the International Geophysical Year. *Nature,* vol. **215,** No 5102, p. 719–720.

Malin, S. R. C. (1969a): The Effect of the Sea on Lunar Variations of the Vertical Component of the Geomagnetic Field. *Planetary and Space Science,* vol. 17 p. 487–490.

Malin, S. R. C. (1969b): Lunno–sutochnye variazii geomagnitnogo polya v Irkutske b period MGG. *Geomagnetism i Aeronomiya,* Tom IX, No 1, pl 127–128. (Lunar variations of the geomagnetic field at Irkutsk during the period of the IGY).

Malin, S. R. C. and Chapman, S. (1969a): Lunar Tidal Components O_1 and N_2 in the Atmospheric Pressure. Presented at Madrid Assembly. (Pure and Applied Geophysics, perhaps end of 1969, or 1970).

Malin, S. R. C. and Chapman, S. (1969b): The Determination of Lunar Daily Geophysical Variations by the Chapman-Miller Method. (To be published in Geophysical Journal of the Royal Astronomical Society, probably 1970).

Malin, S. R. C. and Leaton, B. R. (1969): Amplitude Error in the L Vector from Noisy Data. *Planetary and Space Science,* vol. **17**, p. 483–486.

Malin, S. R. C. and Winch, D. (1968): Anomalous Luni–Solar Daily Variation in the Geomagnetic Field at Watheroo, Western Australia. *Nature,* vol. **218**, No 5145, p. 941–942.

Matsushita, S. (1967): Sq and L Current Systems. *Geophysical Journal of the Royal Astronomical Society,* London, Commemorative Volume for Dr. Sydney Chapman's 80th Birthday.

Matsushita, S. (1969a): Lunar Dynamo Currents, Winds, and Electric Fields. Presented at Madrid Assembly.

Matsushita, S. (1969b): Review on Dynamo Currents and Electric Fields in the Equatorial Region. *Third International Symposium of Equatorial Aeronomy, Ahmedabad.*

Michel, F. C. (1968): Lunar Wake at Large Distances. *Journal of Geophysical Research,* vol. **73**, No 23, p. 7277–7283.

Palumbo, A. (1960): La marea atmosferica a Catania. Atti della Associazione Geofisica Italianan, X Convegno, Roma; p. 53–68.

Palumbo, A. (1961): Dati sulla marea atmosferica lunare a Catania. *Atti della Associazione Geofisica Italiana,* XI Convegno, Roma; p. 209–215.

Palumbo, A. (1962): La marea atmosferica lunare a Napoli. *Atti della Associazione Geofisica Italiana,* XII Convegno, Roma; p. 1–5.

Palumbo, A. (1966): Sulle maree atmosferiche. *Atti della Associazione Geofisica Italiana,* XV Convegno, Roma; p. 235–371.

Palumbo, A. (1968): Dati sullcampo geomagnetico L all'Osservatorio Vesuviano. *Bolletino della Societa dei Naturalisti in Napoli,* vol. LXXVII, p. 1–13.

Price, A. T. and Stone, D. J.: The Determination of the Lunar Current Systems from IGY/IGC Geomagnetic Data. Presented at Madrid Assembly.

Rastogi, R. G. (1968a): Lunar–Solar Tidal Oscillations in Horizontal Magnetic Intensity H and in foF2 at Huancayo during Low Solar Activity Period. *Journal of Atmospheric and Terrestrial Physics, 30,* (4), p.497–512.

Rastogi, R. G. (1968b): Lunar Tidal Variations in H at Buancayo during IGY/IGC. *Annales de Geophysique,* **24** (3), p. 779–788.

Rastogi, R. G. (1968c): Lunar Tidal Variations in foF2 in the American Zone during the Years of Low Solar Activity at Huancayo, Panama and Buenos Aires – A Geomagnetic Anomaly Effect. *Proceedings of the Indian Academy of Sciences, 68,* p. 23–39.

Rastogi, R. G. (1969a): Lunar Tidal Variations in foF2 in the American Zone during Periods of Low Solar Activity, III. Middle Latitude Stations: Puerto Rico and Falkland. *Proceedings of the Indian Academy of Sciences, 69,* p. 250.

Rastogi, R. G. (1969b): Lunar Tidal Oscillations in foF2 and h'F at Huancayo during IGY/IGC. *Annales de Geophysique,* **25** (1), p. 73–84.

Rastogi, R. G. (1969c): Lunar Tidal Oscillations in Ionospheric Absorption at Colombo. *Journal of Terrestrial and Atmospheric Physics* (in the press).

Rastogi, R. G. and Chakravarty, S. C. (1969): Lunar Tides in the Lower Regions of the Equatorial Ionosphere. *Proceedings of the 3rd International Symposium on Equatorial Aeronomy, February 1969, Ahmedabad.*

Rastogi, R. G. and Sharma, R. P. (1969a): Lunar Tides in Electron Density at Different Heights of the Ionosphere (Presented at the Madrid Assembly).

Rastogi, R. G. and Sharma, R. P. (1969b): Ionospheric Lunar Tides over the Magnetic Equator. *Proceedings of the 3rd International Symposium on Equatorial Aeronomy, February 1969, Ahmedabad.*

Rastogi, R. G. and Trivedi, N. B. (1969): Lunar Tides in H at Stations within the Equatorial Electrojet Belt. (Presented at the Madrid Assembly).

Schneider, Q. (1968): Joint IAGA – IAMAP Committee on Lunar Variations; Report on Activities for the Period August 27, 1963 to May 31, 1967. *IAGA Bulletin No. 25.*

Schneider, O. (1969): Lunare Reste in mittleren Sq. *Gerlands Beitrage zur Geophysik,* Bd. **78**, No. 2, p. 115–119.

Sharma, R. P. and Rastogi, R. G. (1968): Lunar Tides in Noon Electron Density at Fixed Real Heights in the Ionosphere over Purerto Rico and Huancayo. *Journal of Atmospheric and Terrestrial Physics, 30* (3), p. 453–485.

Sharma, R. P. and Rastogi, R. G. (1969a): Some Studies of the Phase Reversal of Lunar Semi-Monthly Oscillations in Midday foF2. *Journal of the Institute of Telecommunication Engineers* (in the press).

Sharma, R. P. and Rastogi, R. G. (1969b): Lunar Perturbations in the Geomagnetic Field and in the Characteristics of the F–Region over Huancayo. *Journal of Pure and Applied Geophysics* (in the press).

Stoffregen, S. (1967): On the Moon's Influence on the Auroral Activity. *Birkeland Symposium on Auroral and Magnetic Storms, Sandefjord.*

Trivedi, N. B. and Rastogi, R. G. (1969): Lunar Tidal Oscillations in Horizontal Magnetic Intensity at Kodaikanal during Periods of Low and High Sunspots. *Indian Journal of Meteorology and Geophysics,* **20** (3).

Van Wijk, A. M. (1969): Personal Communciation.

Winch, D. E. (1969): Geomagnetic Lunar Partial Tides.

BUSINESS MEETING

Among the items considered in the business meeting were the following:

Study Groups Within the Lunar Committee – (O. Schneider)

This suggestion was approved by the committee, and the following study groups were tentatively established, with a view to assessing their value before the Moscow meeting, when the conversion of such study groups to full working groups may be considered.

i) Theoretical aspects of atmospheric oscillations (Haurwitz, Kertz, Lindzen, Sawada, Siebert, Teitelbaum)

ii) Internal (lithospheric and hydrospheric) sources of lunar variations, (Kendall, Larsen, Malin, Price)

iii) Solar and Interplanetary effects (Gupta, Matsushita, Price)

iv) Data Compilation (Gupta, Malin, Schneider (or his nominee Sharma)

v) Hydromagnetic aspects of lunar variations (Dunford, Kato, Matsushita, Rastogi, Redding)

Nomenclature – (Chapman, Winch)

A comprehensive system of lunar nomenclature was presented by Chapman and Malin (see later section), and some suggestions of Winch were also considered, who proposed the terms "positive phase low tides," and "negative phase low tides," respectively, according to the phase change with lunar age.

Spectral Analysis for Lunar Terms – (Cardus)

The committee recognized the value of spectral analysis as a complement to the analysis of specific frequencies. It was considered that methods of spectral analysis should be examined by the Working Group on Procedures, and to this end J. C. Larsen was invited to assist the Working Group and Sir Edward Bullard will be invited to nominate an additional adviser.

Symposium on Lunar Variations – (Malin)

The committee favored the idea of such a symposium, and requested the chairman to take the necessary action to incorporate such a symposium in the program of the Moscow meeting in 1971. Note was taken of a Symposium on Upper Atmospheric Currents and Electric Fields to be held in Boulder, August 17–21, 1970.

French Proposal for a Federation of three International Unions.

At the request of the General Secretary of IAGA, Dr. Alldredge, the French proposal was put on the agenda of the Committee's business meeting, and has been carefully analyzed and discussed on Monday, September 8. A group of three participants, consisting of Prof. Benkova, Prof. Price and Dr. Wienert, with the Committee Chairman as Convenor, was charged with the task of summarizing the Committee's views, and has produced the following statement:

(1) The lunar variations coming within the terms of reference of this Committee, while not including ocean and solid earth slides, do comprise phenomena seated in the Earth's interior and partly in the Oceans (through electromagnetic induction effects), along with others in the far and near upper atmosphere, and in the troposphere. They occur in any of these domains, but mainly on the atmosphere-ground, and atmosphere-hydrosphere interfaces. They share this dual character with most of the other transient variations of the geomagnetic field. Tidal potential theory, – generally considered as a chapter of Geodesy – though not a part of the Lunar Committee's responsibilities, is an important tool in its work, and references to it are therefore frequently made.

(2) While it is not the responsibility of those doing research on transient geomagnetic variations, to secure the quality, uniformity and significance of the observational data, as users they are vitally interested in these aspects. The Lunar Committee is much concerned as to which of the proposed Unions will have the task of coordinating and standardizing the current magnetic observatory work, including the storing and processing of data. This coordination and standardization has been one of the important, and satisfactorily handled, responsibilities of IAGA in the past, but the Lunar Committee is doubtful if a similar success could be guaranteed by any arrangement whatsoever, of "Interunion" Commissions that would now have to be set up between such bodies as, for instance, the proposed Internal and External Geophysics Unions. The time variations of the Geomagnetic field are typical interface phenomena, and the technical implications of magnetic observatory work are so diverse that it seems dangerous or impractical to split them up or bring them under regulations emanating from joint commissions.

(3) Being itself a joint body, the Lunar Committee can testify to the fact that it is not always easy to comply with the requests of both parent organizations. The proposed new arrangement would render this situation still more difficult, since the Committee would then have to come under a three-fold, rather than the present two-fold, affiliation.

(4) The Lunar Committee shares the desire of the authors of the proposal, to get a closer contact with some of the work presently done by URSI, and would welcome measures to secure a better arrangement for exchanging information.

(5) The Lunar Committee suggests that no decision should be adopted without a further careful analysis of all implications such as those here discussed.

Tidal Nomenclature (some suggestions for the consideration of the Joint IAGA/IAMAP Lunar Committee)

S. Chapman and S. R. C. Malin

The tidal potential over the earth.

The tide-generating potential of the sun and moon is developed (e.g. by Doodson, 1922) as a series of purely harmonic components with time arguments that involve t, the mean solar time: h, the longitude of the mean sun: s, the longitude of the mean moon: p, the longitude of the moon's perigee; and p_S, the longitude of the sun's perigee. Here we consider only the few major terms with daily and subdaily periods, ignoring a multitude that are of trivial amplitude. These major terms are known by letter-symbols. The principal term is lunar, M_2, with time argument $2t - 2s + 2h$ or 2τ, where τ denotes the mean lunar time; the corresponding solar term is S_2, with argument 2t; there are important lunar terms O_1, with argument $t - 2s + h$, and N_2, with argument $2t - 3s + 2h + p$. There are also terms K_1 and K_2 with considerable amplitudes, whose arguments are $t + h$ and $2(t+h)$; $t + h$ represents sidereal time; there are independent lunar and solar contributions, with the same geographical distribution, to each of K_1 and K_2.

We propose that the lunar harmonics M_2, O_1, N_2 be called *lunar tidal (potential) harmonics,* and the solar term S_2 the *solar tidal (potential) harmonic;* and that the terms K_1 and K_2, of combined lunar and solar origin, be called the *sidereal-time tidal (potential) harmonics.*

Tidal Variations in the Atmosphere.

The movements of the atmosphere and the associated changes of mass distribution and barometric pressure, induced by the tidal influence of the sun and moon, have harmonic components with the same time arguments as all those in the tidal potential. These may be called *lunar, solar* or *sidereal-time tidal atmospheric harmonics.* (Because the lunar sidereal and solar sidereal tidal harmonics in the potential and in the atmosphere have the same period, and the same geographical distribution of their influence, it is not possible to separate their effects in atmospheric data.) They may be called collectively atmospheric harmonics of class A (A for atmospheric).

But in addition to these atmospheric harmonics having the same time arguments as those in the tidal potentials, there are further atmospheric harmonics that arise because the atmsophere undergoes seasonal changes. If a potential harmonic has a time argument T, its action on the seasonally varying atmosphere results in additional atmospheric harmonics with the time arguments $(T \pm nh)$, where n is an integer.

We propose that these be called *seasonal* lunar, solar or sidereal-time tidal atmospheric harmonics, and, collectively, harmonics of class A^S (s for season).

Besides the sun's gravitational attraction, there are other causes, most notably the sun's heating action, that produce atmospheric variations whose arguments are t, 2t (the same as that of the solar tidal atmospheric harmonic), 3t, 4t, ...

We propose that these be called solar *thermal* tidal atmospheric harmonics, and that the totality of these variations, caused tidally and (mainly) thermally by the sun, be called simply *solar daily atmospheric harmonics.*

All these harmonics have unique frequencies, each with its own definite origin.

Tidal Geomagnetic Variations.

Geomagnetic variations result from electrical currents produced by the interaction of (a) the movements of the atmosphere with (b) the main geomagnetic field and (c) the conductivity of the ionosphere. The main geomagnetic field changes are very slow, and the associated changes in the tidal geomagnetic variations are likewise very slow, significant, at most, from decade to decade. The conductivity κ varies regularly with solar time, t, and season, h, and also irregularly because of changes in the solar wind. The regular variations arise from the solar zenith angle dependence of ionisation by the sun's short-wave radiation; this zenith angle varies throughout the day and year. Thus the regular variations of κ may be represented by a series of harmonics having time arguments of the form (mt ± nh), where m and n are positive integers.

The irregular changes in κ, produced by solar wind variations, also influence the geomagnetic tidal harmonics in ways that may be investigated observationally by dividing the data according to the magnetic activity, and sunspot number. Because of the irregular variation of the solar wind, these geomagnetic changes cannot be represented by pure harmonics.

The Mean Conductivity.

The constant term (m = n = 0) in the harmonic development of κ represents the mean conductivity, and, in conjunction with (a) and (b), produces tidal geomagnetic variations having the same periods as those in (a). *We propose* that these be called respectively *lunar, solar or sidereal-time tidal geomagnetic harmonics* (from the class A atmospheric harmonics), or *seasonal* lunar, solar, or sidereal-time tidal geomagnetic harmonics (from the class A^S atmospheric harmonics). (The occurrence of seasonal lunar tidal geomagnetic harmonics was implied by Schneider, 1963.) Each of these harmonics has a frequency unequal to that of any other of the set, as in the case of the A, A^S harmonics. But when we take into account the *variations* of the conductivity, new harmonics and frequencies arise, some of which have the same periods as those so far mentioned, and there are different terms of this new set that have the same frequency as each other.

The Variable Part of the Conductivity.

The harmonics of κ for which m and n are not both zero, in conjunction with (b) and the atmospheric harmonics (a), give rise to geomagnetic variations whose time arguments differ from those of the lunar and solar atmospheric harmonics (A and A^S) by ± (mt + nh). *We propose* that the geomagnetic harmonics thus produced from the *lunar* tidal atmospheric harmonics be called *lunisolar** variations.

For every seasonal lunar tidal geomagnetic harmonic there will be at least one lunisolar geomagnetic harmonic with the same frequency. Hitherto such harmonics have not been distinguished from those above defined and denoted. *We propose* that this usage be continued.

Summary.

The following nomenclature is therefore suggested: *Lunisolar

By analogy, one might refer to soli-solar and sidereal-time-solar variations, but these terms are not recommended, partly because of their clumsiness, and partly because there will, in general, be solar harmonics with the same time argument.

(i) The significant tidal potential terms:

lunar tidal potential harmonics (M_2, O_1, N_2), the solar tidal potential harmonic (S_2), the sidereal-time tidal potential harmonics (K_1, K_2).

(ii) Atmospheric variations:

lunar tidal atmospheric harmonic, solar tidal atmospheric harmonic, solar thermal atmospheric harmonic, solar daily atmospheric harmonic, sidereal-time tidal atmospheric harmonic (class A).

Any of these expressions may be further qualified by adding 'seasonal' for the terms of class A^S.

(iii) Geomagnetic variations:

lunar tidal geomagnetic harmonic, (seasonal) solar (tidal) geomagnetic harmonic, (seasonal) sidereal-time (tidal) geomagnetic harmonic, luni-solar geomagnetic hármonic (seasonal lunar tidal geomagnetic harmonic is not recommended, being included in the title lunisolar).

(iv) Any of the above may be called a partial tide. (This expression was originally used by Dr. Schneider with a more limited meaning). Alternatively, *tidal harmonic* may be used. The totality of the lunar-produced harmonics may be called the lunar daily variation.

It is proposed to publish separate notes explaining in detail how the lunar tidal potential harmonics generate a multiplicity of atmospheric and geomagnetic harmonics, many frequencies having several different causes.

References:

Doodson, A. T., *Proc.Roy.Soc., A;* 100, 305 (1922).

Schneider, O., *Nature,* Lond., **199**, 548 (1963).

SCIENTIFIC COMMUNICATIONS

A scientific session was held on Monday, September 8 at 16:00. In addition to the papers announced in the Program and Abstracts (IAGA Bulletin No. 26, p. 49), five late papers were presented as follows:

XI – 7 S. Chapman and P. C. Vendall, Theoretical Effects of the Sea and Ocean Tides on the Geomagnetic L_2 Variations.

XI – 8 C. A. Esponda, Calculation of Solar and Lunisolar Harmonic Cofficients of the Earth – Currents Daily Variations in 'San Miguel' – Argentina, 1950–1958.

XI – 9 R. G. Rastogi and N. B. Trivedi, Lunar Tides in H at Stations within the Equatorial Electrojet Belt.

XI – 10 R. G. Rastogi and R. P. Sharma, Lunar Tides in Electron Density at Different Heights of the Ionosphere

XI – 11 I. V. Maksimov, V. N. Vorobyov and B. N. Gindysh, On the Quasi-Periodic Character of the Long-Period Variations of the Solar and Lunar Tide-Generating Force.

In addition to the papers presented at the scientific session of the Lunar Committee, the chairman drew attention to the following papers on associated topics, to be presented at other IAGA sessions:

IV – 41 J. L. Redding (IAGA Bulletin 26, p. 50)

IV – 42 D. G. Rivers (IAGA Bulletin 26, p. 50)

III – 103 J. C. Larsen (IAGA Bulletin 26, p. 64)

SYMPOSIUM ON GEOPHYSICAL STUDIES ON THE EVOLUTION OF THE EARTH'S DEEP INTERIOR

(Convened by E. A. Lubimova)

Several general symposia were scheduled by IAGA and IASPEI jointly for the second week of the assembly. These programs are listed under A in IAGA Bulletin No. 26. Only one detailed highlight report was received covering a part of one of these symmposia. This was submitted by J. A. Jacobs and is given below.

Following a brief introduction by V. A. Magnitsky, K. E. Bullen gave a review of the principal mechanical properties of the Earth's interior. He pointed out that recent data had rendered his Earth Models A and B obsolete. The new data come from a variety of sources including better seismic observations, shock wave experiments, and the free oscillations of the Earth. He also stressed the scientific method behind his approach to these problems. He was followed by R. A. W. Haddon who gave a brief account of the details of the most recent Earth Models (HB1 and HB2) which he had constructed in collaboration with K. E. Bullen.

The next speaker, J. Oliver, adopted a very different approach, taking into account lateral inhomogeneities in the Earth. He considered the role of Global tectonics and believes that geology will play an increasingly important role in our understanding of the evolution of at least the outer regions of the Earth.

V. A. Magnitsky described the different methods which have been used to estimate the thermal gradient at various depths within the Earth. Using values of the thermal conductivity, it is then possible to estimate the heat flux at various depths. These heat flux values appear to be remarkably high.

H. K. Lee discussed the global variation of terrestrial heat flow for which there are now about 4,000 measurements. He pointed out that the variation has high correlation with major geological features and that the distribution of heat flow was consistent with the hypothesis of sea-floor spreading and the new global tectonics.

The session was concluded by M. G. Rochester who gave an excellent review of core-mantle interactions in the Earth's rotation (both wobble and rate of spin) and then considered the different mechanisms of core-mantle coupling that might account for these variations.

E. A. Lubimova discussed the evolution of melting zones in the Earth's mantle with particular regard to it's possible connection with geologic cycles – there were most probably 13 thermal cycles in the upper mantle.

S. K. Runcorn then discussed possible modes of convection in the Earth's mantle. He gave a number of order of magnitude calculations and showed that in the mantle, the viscous term is dominant in the Navier-Stokes equation and is approximately balanced by the buoyancy term. He finally pointed out that the most reliable source of information concerning convection in the mantle comes from our increased knowledge of the shape of the geoid.

D. C. Tozer discussed in detail those factors which determine the temperature distribution in a planet – his approach was to look at the stability of possible temperature profiles in a convecting Earth, the initial thermal conditions are not so important.

L. Knopoff described in detail a number of laboratory experiments which he is carrying out in order to investigate the mechanism of continental drift, and the session closed with a paper by H. Takeuchi in which he showed the results of his calculations on convection in a mantle with variable viscosity. He found a variable velocity distribution in the mantle with a "jet stream" type of flow in a narrow upper layer.

There was considerable discussion after the papers which were well attended and much appreciated.

The papers were given as described in IAGA Bulletin No. 26 except papers A–27 by N. I. Khitarov, A–30 by M. F. Machado, A–39 by M. N. Berdichcoski et al., and A–40 by G. N. Petrova were cancelled. An unscheduled paper by M. G. Rochester on Core-Mantle Coupling: Geophysical and Astronomical Consequences was given.

RESOLUTIONS

RESOLUTIONS OF THANKS

1. L'Association Internationale de Séismologie et de Physique de l'Intérieur de la Terre et l'Association Internationale de Géomagnétisme et d'Aéronomie prient

Monsieur le Vice-Président du Gouvernement
Monsieur le Ministre de l'Education et de la Science
Monsieur le Ministre de l'Information et du Tourisme

d'accepter l'expression de tous leurs remerciements pour l'intérêt personnel qu'ils ont porté aux problèmes de l'organisation des deux assemblées scientifiques générales et pour les moyens qu'ils ont fournis à l'organisation des deux Congrès à Madrid du premier au douze septembre 1969.

1. The International Association of Seismology and Physics of the Earth's Interior and the International Association of Geomagnetism and Aeronomy express their warmest thanks to

The Vice President of the Spanish Government
The Minister of Education and Science
The Minister of Information and Tourism

for the personal interest which they have taken in the organizational problems of the two General Scientific Assemblies, and for the support which they have given to these assemblies in Madrid from the lst to the l2th September 1969.

* * * * * * *

2. L'Association Internationale de Séismologie et de Physique de l'Intérieur de la Terre et l'Association Internationale de Géomagnétisme et d'Aéronomie adressent leurs plus vifs remerciements au Conseil Supérieur des Recherches Scientifiques et à son Président le Professeur M. Lora-Tamayo pour le soutien direct apporté à l'organisation des deux Congrès par un secrétariat très effectif dés l'origine et pour le travail constant qui a conduit au développement harmonieux des deux assemblées scientifiques générales à Madrid du premier au douze septembre 1969.

2. The International Association of Seismology and Physics of the Earth's Interior and the International Association of Geomagnetism and Aeronomy warmly thank the Superior Council for Scientific Research and its President, Professor Lora-Tamayo for the direct support given to the organization of the two general scientific assemblies by means of a secretariat which was highly effective from the start, as well as for their constant work which led to the harmonious development of these assemblies in Madrid from the 1st to the 12th September 1969.

* * * * * * *

3. L'Association Internationale de Séismologie et the Physique de l'Intérieur de la Terre et l'Association Internationale de Géomagnétisme et d'Aéronomie adressent leurs sincères remerciements à l'Amiral J. Garcia-Frias Directeur de l'Institut Géographique et aux membres de son Institut non seulment pour leur préparation adéquate des deux assemblées scientifiques générales à Madrid du premier au douze septembre 1969, mais également pour leur participation active à l'organisation quotidienne des séances scientifiques.

3. The International Association of Seismology and Physics of the Earth's Interior and the International Association of Geomagnetism and Aeronomy sincerely thank Admiral J. García-Frías, Director of the Geographic Institute, and the other members of this Institute both for the excellent preparation of the two general scientific assemblies in Madrid from September 1 to 12, 1969, and for their active participation to the daily organization of the scientific meetings.

* * * * * * *

4. L'Association Internationale de Géomagnétisme et d'Aeronomie et l'Association Internationale de Séismologie et de Physique de l'Intérieur de la Terre prient M. le Recteur de l'Université de Madrid et M. le Directeur de l'Ecole Supérieure des Ingénieurs des Ponts et Chaussées de croire à leur gratitude pour les locaux universitaires mis à leur disposition et en particulier pour les nombreuses facilités de la Escuela Tecnica Superior de Ingenieros de Caminos Canales y Puertos.

4. The International Association of Seismology and Physics of the Earth's Interior and the International Association of Geomagnetism and Aeronomy sincerely express their gratitude to the Rector of the University of Madrid and the Director of the Advanced Technical School for Highway Engineering for the use of the University buildings and in particular for the use of the numerous facilities of the above mentioned school.

* * * * * * *

5. Les participants aux assemblées scientifiques générales de l'Association Internationale de Géomagnétisme et d'Aéronomie et de l'Association Internationale de Séismologie et de Physique de l'Intérieur de la Terre sont heureux de pouvoir exprimer au Réverend Père Romaña, S.J., Président et à tous les membres du Comité d'Organisation des Assemblées Générales Scientifiques IASPEI/IAGA 1969 de Madrid, leurs sentiments de gratitude pour l'accueil exceptionnel qui leur a été accordé, en les priant de croire qu'ils en conserveront le meilleur souvenir.

5. The scientists participating in the General Scientific Assemblies of the International Association of Seismology and Physics of the Earth's Interior and the International Association of Geomagnetism and Aeronomy are happy to express to the Reverend Father Romaña, S.J., President of the Organizing Committee and to all the members of his Committee, their gratitude for the exceptionally fine reception which they have received. They will keep a warm remembrance of it.

* * * * * * *

6. L'Association Internationale de Géomagnétisme et d'Aeronomie et l'Association Internationale de Séismologie et du Physique de l'Intérieur de la Terre désirent exprimer à Monsieur le Maire de Madrid leurs chaleureux remerciements pour la réception qu'il a offerte dan les Jardins de Cecilio Rodriguez aux délégués des deux Associations et à leurs familles à l'occasion des deux assemblées scientifiques IAGA/ IASPEI à Madrid du premier au douze septembre.

6. The International Association of Seismology and Physics of the Earth's Interior and the International Association of Geomagnetism and Aeronomy express their warm thanks to the Mayor of Madrid for the reception which he gave for the participants to the Assemblies and their families in the Cecilio Rodríguez Gardens during these Assemblies in Madrid, from September 1 to 12, 1969.

* * * * * * *

7. Les épouses des participants aux assemblées scientifiques génerales de l'Association Internationale de Géomagnétisme et d'Aéronomie et de l'Association Internationale de Séismologie et de Physique de l'Intérieur de la Terre sont heureuses de pouvoir exprimer leurs sentiments de reconnaissance aux Dames du Comité E
Congrès de Madrid.

Elles demandent également d'associer leurs époux et les membres de leur famille aux remerciements qu'elles adressent et pour l'excursion à Tolède et pour les diverses réceptions au cours de la période du premier au douze septembre 1969.

7. The wives of the participants in the General Scientific Assemblies of the International Association of Seismology and Physics of the Earth's Interior and the International Association of Geomagnetism and Aeronomy are happy to express their gratitude to the ladies of the Spanish Committee for their daily attention and assistance, during the Madrid Congress.

They join with their husbands and families in giving thanks, and also express gratitude for the excursion to Toledo and for the various receptions during the Assemblies.

SCIENTIFIC RESOLUTIONS

1. The IAGA, recognizing the availability of many observatory results on microfilm, through the World Data Centers, nevertheless *recommends* the continued publication of magnetic observatory yearbooks containing hourly values and important related data, as described in a recommendation of the Rome IATME 1954 Meeting (IATME Bulletin No. 15, p.392).

1. L'AIGA, tout en reconnaissant qu'un, grand nombre de donnés d'observatoires sont tenues à disposition sur microfilms, par les Cenlies Mondiaux de Données, *recommande* ne'anmoins la continuation de la publication dans les Annales des Observatoires des valeurs horaires et des données importantes qui s'y rattachent ainsi qu'il a été précisé dans une recommendation du Congrés de Rome de l'AITME, en 1954. (Bulletin AITME No. 15, p.392).

* * * * * * *

2. The IAGA, *considering* that the indices $D_s^e t$ (equatorial ring current), AE (auroral electrojet) and K_n, K_s, K_m, (semiplanetary indices for N- and S- hemispheres and their mean value) have been determined for recent years and *recognizing* that they provide new condensed information on the state of disturbances of the geomagnetic field *recommends* the continued determination of these indices and *urgently requests* those observatories which are selected for this purpose to send their data promptly in order to make possible regular and early monthly publications.

2. L'AIGA *considerant* que les indices $D_s^e t$ (anneau equatorial), AE (èlectrojet auroral) et K_n, K_s, K_m, (indices semiplanétaires relatifs aux hémispheres Nord et Sud et leurs valeurs moyennes) ont été calculés pour ces dernières années et *reconnaissant* que ces indices constituent une source d'information synthétique nouvelle sur l'état de perturbation du champ géomagnétique *recommande* que l'on continue à déterminer ces indices et *demande instamment* aux observatoires qui ont été choisis à cette fin d'envoyer leurs données sans retard de façon a en permettre la publication mensuelle régulière la plus rapide.

* * * * * * *

3. The IAGA *considering* the planetary and other derived magnetic indices from individual stations, and that more and more such indices are now available compiled from the data of individual stations, *recommends:*

(i) The discontinuation of the publication of C-indices for individual stations in the Bulletin,

(ii) The investigation of the possibility that K-indices be put in machine-readable form and stored at a center with facilities for the mechanical reproduction upon request,

(iii) If (ii) is implemented, then it is recommended that the centralized publication of K-indices of individual stations be discontinued but that their K-indices be published in their own yearbooks and bulletins.

3. L'AIGA, *considerant* que les indices magnétiques planétaires, ainsi que les autres indices magnétiques qui en dérivent, sont en général d'une importance plus grande, en ce qui concerne les études scientifiques, que les indices relatifs aux stations individuelles, et qu'un nombre croissant de ces indices ont été détermines à l'heure actuelle à partir des données des stations individuelles, *recommande*:

(i) d'arrêter la publication dans le Bulletin des indices C relatifs aux stations individuelles,

(ii) d'étudier la possibilité d'une mise en forme des indices K se prêtant au calcul automatique, ces indices etant ainsi rassemblés en un centre convenable doté de moyens permettant leur duplication sur demande,

(iii) si (ii) est mise en practique, alors on recommande d'arrêter toute publication centralisée des indices K concernant les stations individuelles, tout en priant les observatoires de publier leurs propres indices dans leurs Annales et Bulletins.

* * * * * * *

4. The IAGA, *noting* recommendation No. 8 made by the South American Meeting on Geomagnetism in Rio de Janeiro in January 1969, concerning desirable development of the network of magnetic observatories in South America, *gives its full support* to the recommendation that magnetic observatories be established or completed in the Republics of Chile and Bolivia. This resolution also reinforces Resolution

No. 12 of the International Union of Geodesy and Geophysics made at the 1967 General Assembly concerning the establishment of a permanent magnetic observatory on the mainland of Chile.

4. L'AIGA *prenant en consideration* la recommendation No. 8 faite par le Congrés Sud-Américain de Géomagnétisme tenu à Río de Janeiro en Janvier 1969, au sujet du développement désirable du réseau d'observatoires magnétiques d'Amérique du Sud, *donne son appui total* à la recommendation que des observatoires magnétiques soient établis ou renforcés dans leurs possibilités au Chili et en Bolivie. Cette résolution vient également à l'appui de la résolution No. 12 de l'UGGI adoptée lors de son Assemblée Générale de 1967, concernant l'éstablissement d'un observatoire magnétique permanent en territoire Chilien.

* * * * * * *

5. The IAGA, *recognizing* the scientific importance of the Moca Observatory located near the geomagnetic equator, *requests* the authorities responsible for the station to take appropriate measures to insure uninterrupted operation of the station at the present scientific level.

5. L'AIGA *reconnaissant* le rôle scientifique important assuré par l'observatoire de Moca situé au voisinage de l'équateur géomagnétique, *demande* aux autorités compétentes de bien vouloir prendre les mesures appropriées destinées à assurer la continuation de cette station ainsi que le maintien du niveau scientifique actuel.

* * * * * * *

6. The IAGA *recognizing* the interest in completing the network of Southern observatories used for the determination of the K_S indices (see Resolution 2) *recommends* that a permanent magnetic observatory be established on Crozet Island by the responsible organization.

6. L'AIGA *reconnaissant* l'intérêt de compléter le réseau d'observatoires de l'hémisphere Sud servant a la détermination des indices K_S (cf. résolution 2) *recommande* qu'un observatoire magnétique permanent soit installé aux îles Crozet par l'organisation responsable.

* * * * * * *

7. The IAGA *considering* the scientific value of the experiments conducted at the conjugate stations of Kerguelen and Sogra for the study of dynamics and the structure of the magnetosphere and the need to reach a more precise definition of the conjugacy, *recommends* that two additional pairs of conjugate station be put in operation at the following locations: Crozet and Pskov, Heard and Dologoschelie.

7. L'AIGA *considerant* l'intérèt scientifique des experiences entre les stations conjugées de Kerguelen et de Sogra pour l'étude de la dynamique et de la structure de la magnétosphère, et la nécessité d'arriver à une définition plus précise de cette conjugaison, *recommende* que deux couples supplémentaires de stations conjugées soient établies entre les points suivants: Crozet et Pskov d'une part, Heart et Dologoschelle d'autre part.

* * * * * * *

8. The IAGA, *considering* the interest which represents the organization of multidisciplinary geophysical observations in conjugate points located in Australia and USSR, *requests* the appropriate Institution in these countries to take every possible measure to ensure this cooperation.

8. L'AIGA *considerant* l'intérêt attaché à l'organisation d'observations multidisciplinaires entre des points conjugues d'Australie est de l'URSS, *demande* aux Institution compétentes de ces pays de prendre toute mesure possible de façon à assurer une telle coopération.

* * * * * * *

9. The IAGA *endorses* the continuing conjugate point program concerning geomagnetic field phenomena at Great Whale River, and Byrd Station, and *encourages* the efforts to locate a geostationary satellite with a sensitive magnetometer near the field line connecting these stations.

9. L'AIGA *donne son accord* au programme continue en action entre les points conjugués de Great Whale River et Byrd Station concernant les phénomènes liés au champ géomagnétique et *encourage* les efforts destinés à placer un satellite géostationnaire, equipé d'un magnétomètre sensible, prés des lignes de force reliant ces deux stations.

* * * * * * *

10. The IAGA, *reemphasizes the importance of electromagnetic induction studies in the accessible East African Rift System and encourages* organizations with the capability to undertake this work to do so in cooperation with interested African institutions. Both in this respect and for other reasons the continuation of the magnetic observations at Nairobi Observatory is highly desirable.

10. L'AIGA *reaffirme* l'importance de l'étude des phénomènes d'induction èlectromagnétique dans la partie accesible de la dorsale Est-Africaine et *encourage* les organismes ayant les moyens de s'attaquer à ce problème de le faire effectivement en coopération avec les Institutions Africaines intéressées. En fonction de ce qui précéde, et également pour d'autres raisons la poursuite des observations magnétiques à l'observatoire de Nairobi est jugée très désirable.

* * * * * * *

11. The IAGA, *emphasizes* its scientific interest in magnetotelluric and geomagnetic depth sounding studies in West Africa and *encourages* such work in the sedimentary basin of Senegal.

11. L'AIGA *tient a affirmer* son intérêt scientifique pour les ètudes par sondages profonds magnétotelluriques et géomagnétiques en Afrique Occidentale et *encourage* particuliérement ces ètudes dans le bassin sédimentaire du Sénégal.

* * * * * * *

12. The IAGA *recognizing* the interest in magnetic profiles across the equatorial electrojet presently in progress or planned for the near future, *recommends* that, during the next solar minimum, those institutions interested in this work coordinate their efforts to make simultaneous profiles at various suitable longitudes.

12. L'AIGA, *reconnaissant* l'intérêt des profils magnétiques de part et d'autre de l'électrojet equatorial qui font l'objet d'operations en cours ou sont prévues dans un proche avenir, *recommande* que, durant le prochain minimum d'activité solaire les organismes participants à ces opérations coordonnent leurs efforts en vue de réaliser des profils simultanés pour diverses longitudes bien choisies.

* * * * * * *

13. The IAGA *considering* the importance of obtaining a self consistent picture of distributions and variations of composition, density, temperature and winds in the upper atmosphere, and noting the recommendations of the 9th and 11th Working Groups of the IUCSTP concerning the study of the structure of the upper atmosphere, (Arising from the conference on cooperative solar terrestrial physics for the International Years of the Active Sun, London, January 1969), *recommends*:

a) That in combination or as an alternative to drag measurements, accelerometer and density gage measurements be made on satellites with high eccentricity, to obtain density measurements with a single satellite over a large range of altitudes.

b) That special efforts be made to obtain data for comparison of satellite measurements of diurnal density variation of ion temperature.

c) Simultaneous measurements be made of composition by means of both mass spectrometers and monochrometers.

d) (i) Measurements be made of composition, temperature and winds from 100 to 200 km in the winter polar region, where the sunlight has been cut off.

(ii) Wind profiles be measured above 200 km to establish global circulation patterns and to test the concept of excess rotation of the upper atmosphere.

e) That more coordinated ground based measurements of optical emissions from hydrogen and helium be made, and that high resolution studies of 0I6300 Å for temperature and wind measurements be extended.

f) Development of experiments for measurements of the eddy diffusion coefficient, especially in the height range 80 – 120 km.

g) Extension of theoretical studies for construction of representative models describing composition, dynamics, the thermal regime and their interconnection.

h) Extension of laboratory experiments for measuring rates of aeronomical reaction, including those determined by the minor components, and including those relevant to meteor processes, particularly atomic collision phenomena in the energy range 100 – 1000 eV

i) (i) That although there has recently been an increase in the network of meteor stations, there should be an extension of the network in high latitudes.

(ii) That when possible the meteor-wind stations be associated with existing rocket launching sites.

j) That since there exist uncertainties in the interpretation of ionospheric drift measurements, and a means of calibration would in many cases enable these observations to become a useful source of wind information, radio meteor winds should be used to provide a comparison for this purpose, particularly with ionospheric-drift techniques that extend to lower heights and overlap the meteor region.

13. L'AIGA *considerant* l'importance qu'il y a d'arriver à une représentation d'ensemble cohérente de la répartition et des variations de la composition de la densité, de la température et des vents dans la haute atmosphère et *prenant note* des recommendations des groupes du travail 9 et 11 de l'IUCSTP relatifs à l'ètude de la structure de la haute atmosphère, (Issues de la Conférence sur la coopèration du physique des relations Soleil-Terre pour les Années Internationales du Soleil Actif-Londres, Janvier 1969), *recommande*:

a) que, simultanement ou en remplacement des mesures d'amortissement, des mesures d'acceleration et de densités par prélévement soient faites par les satellites ayant des orbites très excentriques et ceci dans une large marge d'altitudes.

b) que des efforts particuliers soient faits pour l'obtention de données permettant la comparaison des mesures faites en satellite relatives à la variation diurne de la densité, avec les mesures de diffusion Thompson, de la variation diurne de la température ionique,

c) que des mesures simultanées de composition soient faites qu moyen de spectromètres et de monochromètres.

d) (i) que des mesures soient faites de la composition, de la température et des vents entre 100 et 200 km. d'altitude, en saison hivernale des régions polaires oú la luminère solaire a disparu,

(ii) que des mesures de répartition des vents soient faites suivant des profils d'altitudes supérieures à 200 km. afin d'établir les schémas de circulation générale et de vérifier la validité de l'idée d'un excés de rotation de la haute atmosphère.

e) que des mesures au sol mieux coordonnées soient faites sur les emissions lumineuses de l'hydrogène et de l'hélium et que des études d'un grand pouvoir de résolution de OI6300 Å relatives aux mesures de température et de vents soient généralisées,

f) que l'on développe les expériences axées sur la mesure des coefficients de diffusion incohérente, tout spécialement dans la zone 80 à 120 km. d'altitude.

g) que l'on développe les études théoriques en vue de la réalisation de modéles représentant la composition, la dynamique des régimes thérmique et leur interconnexion.

h) que l'on développe les expériences de laboratoire pour la mesure des vitesses de réaction aeronomiques, y compris celles dépendant de composants mineurs et celles dépendant des trainées de météorites, et tout particulierement les expériences relatives aux chocs entre atomes dans la gamme d'énergie 100 – 1000 eV.

i) (i) que, bien qu'il y ait eu récémment une extension des réseaux de stations d'observation des météores, cette extension devrait etre poursuivue pour les réseaux des hautes latitudes.

(ii) que, chaque fois que cela est possible, des stations d'observation de vents de météores, soient associés aux sites existants de lancement de fusées.

j) que, étant donné les incertitudes qui se manifestent dans l'interprétation des mesures sur les derives ionosphériques et remarquant que des étalonages convenables permettraient dans beaucoup de cas de valoriser ces mesures pour la connaisance des vents, on devrait utiliser les vents de radio-méteores en tant que moyens de comparaison permettant ces étalonages particulièrement en utilisant les techniques de dérive ionosphérique qui s'etendent aux basses altitudes et recouvrent la région des météores.

* * * * * * *

14. The IAGA *considering* the importance for space studies to have systematized information on micropulsations occurring on a worldwide scale, *urges* the national

research groups working on micropulsations to work out planetary indices based on the different existing types of micropulsations.

14. L'AIGA *considerant* l'importance pour les études spatiales de disposer d'informations systématiques sur les micropulsations se produisant à une échelle mondiale *demande instamment* aux groupes de recherche des divers pays travaillant sur les micropulsations, d'èlaborer des indices planétaires à partir des différents types connus de micropulsations.

* * * * * * *

15. The IAGA, *considering* that the World Data Centers for Geomagnetism have the necessary magnetic observatory data in their archives, and *considering* the scientific need for the magnetic activity indices AE and Dst, *urges* the World Data Centers for Geomagnetism to undertake the computation of these indices.

15. L'AIGA *considerant* que les Centres Mondiaux de Données pour le géomagnétisme disposent dans leurs Archives, des données requises d'observatoires et *considerant* la nécessiteé scientifque d'une connaisance des indices d'activité magnétique AE et Dst, *demande instamment* aux Centres Mondiaux de Données pour le Géomagnétisme d'entreprendre la détermination de ces indices.

* * * * * * *

16. The IAGA, *noting* the importance of mapping the plasmapause on a continuous worldwide basis, and noting that achievement of such mapping will require basic research, technical development, and a high level of international cooperation, *encourages* its member countries to support cooperative studies of the problem of worldwide plasmapause monitoring.

16. L'AIGA *relevant* l'importance d'une cartographie de la plasmapause à assurer d'une façon continue à l'echelle mondiale, et *remarquant* que la réalisation d'une telle cartographie necessitera certaines recherches fondamentales, des progrés techniques, et un degré élevé de coopération internationale, *encourage* ses états membres à donner leur appui à des ètudes coopèratives du problème de l'exploration de la plasmapause à l'echelle mondiale.

* * * * * * *

17. The IAGA, *considering* the value of satellite data that are of a routine monitoring nature, such as measurements of solar wind parameters, magnetospheric boundary crossings, local time variations of the magnetic field at the synchronous orbit, etc., for a synoptic patrol of the magnetosphere and the establishment of new indices, *recommends* that countries, institutions and scientists operating such satellites, in conjunction with the World Data Centers, establish a mechanism for the quick release of these routine data and their distribution in convenient format to the scientific community.

17. L'AIGA *considerant* la valeur des données fournies par les satellites suivant une base réguliere telles que les mesures concernant les paramètres caractéristiques du vent solaire, les traversées des frontières magnétosphériques, les variations en fonction du temps local, du champ magnétique sur les orbites synchrones, etc, ceci dans le but

d'une surveillance synoptique de la magnetosphére et l'établissement de nouveaux indices, *recommande*, que les états, institutions et personnalités scientifiques, responsables de l'emploi de ces moyens, mettent en oeuvre, en accord avec les Centres Mondiaux de Données, une logistique assurant une mise à la disposition rapide de ces données régulières et leur distribution sous une forme convenable à la communauté scientifique.

* * * * * * *

PARTICIPANTS .

A list of IAGA participants by countries as supplied by the local organizing committee is given below:

ALGERIA

Aubert, M.
Institut de Météorologie et Physique du Globe
Bl. 1137
Alger

Kacimi, M.
Institut d'Etudes Nucléaire Alger – DEN BP 1147
Alger R.P.

ARGENTINE

Cazeneuve, H.
Instituto Antártico Argentino – Cerrito 1248
Buenos Aires

Ghielmetti, H.S.
Centro Nacional de Radiación Cósmica – Peru 272
Buenos Aires

Schneider, O.
Instituto Antártico Argentino – Cerrito 1248
Buenos Aires

Vila, F.
Servicio de Hidrografía Naval – Montes de Oca 2124
Buenos Aires

AUSTRALIA

Barret, K. E.
Dept. of Mathematics, University of Melbourne
Melbourne, Victoria

Cole, K. D.
La Trobe University
Bundoora, Victoria, 3083

Mainstone, J. S.
University of Queensland, Physics Dept.
St. Lucia, Queensland Q4067

Slaucitajs, Leónidas
Dept. Applied Mathematics, The University of Sydney
Sydney, NSW.

BELGIUM

Ackerman, M. E. H.
Institut d'Aeronomie Spatiale dė Belgique
3 Avenue. Circulair
Uccle-Bruxelles 18

Gerard, J. C.
Université de Liége
Institut d'Astrophysique
Cointe-Sclessin

Hus, Josef
Centre de Physique du Globe de IRM
Dourbes (Nismes-Prov. Namur)

Kockarts, Gaston
Institut d'Aeronomie Spatiale de Belgique
3 Avenue Circulaire
Uccle-Bruxelles 18

Koenigsfeld, J. L.
Rue Etat Tiers 17
Lieja

Lemaire, Joseph
Institut d'Aeronomie Spatiale de Belgique
3 Avenue Circulaire
Uccle-Bruxelles 18

Louwet, G. W. J.
Bira-Ias
3 Avenue Circulaire
Uccle-Bruxelles 18

Monfils, André
Institut d'Astrophysique
Cointe-Sclessin

Nicolet, M.
Institut d'Aeronomie Spatiale de Belgique
3 Avenue Circulaire
Uccle-Bruxelles 18

Pastiels, Roger
Institut d'Aeronomie Spatiale de Belgique
3 Avenue Circulaire
Uccle-Bruxelles 18

Scherer, Marc
Institut d'Aeronomie Spatiale de Belgique
3 Avenue Circulaire
Uccle-Bruxelles 18

Vuyst, A. de
Centre de Physique du Globe de l'I.R.M.
Dourbes(Nismes-Prov. Namur)

BULGARIA

Sachanski, S.
Bulgarian Academy of Sciences, National Committee
on Earthquake Engineering "7 Noemvri" 1
Sofia

CANADA

Bhartendu,
Meteorological Service of Canada, 315 Bloor St W.
Toronto 181, Ontario

Brisbin, W. C.
University of Manitoba
Winnipeg, Manitoba

Caner, B.
Officer-in-charge, Victoria Magnetic Observatory R.R. 7
Victoria B.C.

Carmichael, C. M.
University of Western Ontario
London, Ontario

Chimonas, G.
Dept. Physics, University of Toronto
Toronto 181, Ontario

Davies, F.
Defence Research Board, Canada
Ottawa, Ontario

Deutsch, E. R.
Physics Dept., Memorial University of Newfoundland
St. Johns, Newfoundland

Doggo, H. W.
Dept. of Physics, University of Victoria, Box 1700
Victoria, B.C.

Duffus, J. H.
Royal Roads Military College
Victoria, B.C.

Ellis, R. M.
University of British Columbia
Vancouver, B.C.

Evans, W. J.
Institute for Space and Atmospheric Studies
University of Saskatschewan
Saskatoon

Forsyth, P. A.
8 Linksgate Road
London, Ontario

Fowler, N. R.
Royal Roads Military College
Victoria, British Columbia

Garland, G. D.
Geophysics Laboratory, University of Toronto
Toronto, Ontario

Gattinger, R.
National Research Council, Reed, M50, Room 266
Montreal Road
Ottawa 7, Ontario

Gherzi, Rev. Pére E.
Observatoire de Geophysique, College J. de Brebeuf
3200 Chemin St. Catherine
Montreal 26, Quebec

Gough, D. I.
University of Alberta, Dept. of Physics
Edmonton, Alberta

Jacobs, J. A.
Killam Memorial Professor of Science
University of Alberta
Edmonton, Alberta

Larochelle, A.
Geological Survey of Canada, 601 Booth St.
Ottawa, Ontario

Lyon, G. F.
Dept. of Physics, University of Western Ontario
London, Ontario

Moorcroft, D. R.
Physics Dept., The University of Western Ontario
College of Science
London, Ontario

Niblett, E. R.
Division of Geomagnetism, Dominion Observatory
Ottawa 3, Ontario

Rankin, D.
University of Alberta, Dept. of Physics
Edmonton, Alberta

Rochester, M. G.
Dept. of Physics, Memorial University of Newfoundland
St. John's, Newfoundland

Rostoker, G.
University of Alberta, Dept. of Physics
Edmonton, Alberta

Schiff, H. I.
York University
Toronto, Ontario

Schwarz, E. J.
601 Booth Street
Ottawa, Ontario

Schwarz, E. T.
Geological Survey of Canada, 601 Booth Street
Ottawa, Ontario

Screenivasan, S. R.
University of Calgary, Physics Dept.
Calgary 44, Alberta

Serson, P. H.
Division of Geomagnetism, Dominion Observatory
Ottawa, Ontario

Shand, J. A.
Defence Research Establishment Pacific, F.M.O.
Victoria, B.C.

Shepherd, G. C.
York University
Toronto, Ontario

Strangway, D. W.
Dept. of Physics, University of Toronto
Toronto 181, Ontario

Sullivan, Harry
Dept. of Physics, University of Victoria,
P.O. Box 1700
Victoria, B.C.

Weaver, J. T.
University of Victoria, Box 1700
Victoria, B.C.

Young, R. A.
Physics Dept., York University
Toronto, Ontario

CZECHOSLOVAKIA

Bucha, V.
Geophysical Institute of Czechoslovak Academy of Sciences
Bocní II, 1401 Sporilov
Praha 4, Sporilov

Halenka, Jaroslav
Geophysical Institute of Czechoslovak Academy of Sciences
Bocní II 1401, Sporilov
Praha 4

Hanus, Václav
Geological Institute of Czechoslovak Academy of Sciences
Praha 6, Suchdol 2

Jiricek, Frantisek
Geophysical Institute of Czechoslovak Academy of Sciences
Bocní II
Praha 4, Sporilov

Ochabova, Petronela
Geophysical Institute of the Slovac Academy of Sciences
Kijevská II
Bratislava

Petr, Vaclav
Geophysical Institute of Czechoslovak Academy of Sciences
Bocní II 1401
Praha 4, Sporilov

Praus, Oldrich
Geophysical Institute of Czechoslovak Academy of Sciences
Bocní II 1401
Praha 4, Sporilov

Rajchl, J.
Astronomicky Ustav
Observator Ondrejov
Ondrejov

Triskova, Ludmila
Geophysical Institute Czechoslovak Academy of Sciences
Bocní II 1401
Praha 4, Sporilov

CHINA

Huang, Chung-Ming
Dept. of Electrical Engineering
National Taiwan University
Taipei, Taiwan

Rivers, D. G.
Physics Department
University of Hong Kong
Hong Kong

DENMARK

Abrahamsen, Niels
Laboratory of Applied Geophysics
University of Aarhus
Carl Blochsgade 28
8000 Aarhus C

Andersen, Einar
Treasurer of the IUGG
Geodetic Institute of Copenhague
Copenhague

Kring Lauridsen, Emil
Danish Meteorological Institute
Magnetical Observatory
Rude Skov
Birkeroed

Laursen, V.
Meteorological Institute
2920 Charlottenlund

Lundbak, Asger
Geophysics Department
Esplanaden 15
DK 1263 Copenhague K

Ungstrup, E.
Danish Space Research Institute
2800 Lyngby

ETHIOPIA

Gouin, Pierre
Director of Geophysical Observatory
Haile Selassie I University
Bon, 1176
Addis Ababa

FINLAND

Kataja, Eero
Geophysical Observatory of the Finnish Academy of Science and Letters
Sodankyla

Kivinen, Matti
Finnish Meteorological Institute
Box 10503
Helsinki 10

Koivumma, Seppo
Geophysical Observatory
Sodankyla

Sucksdorff, C. G.
Finnish Meteorological Office
Rucholahdenkatu 8
Box 10503
Helsinki, 10

FRANCE

Barsczus, H. G.
Bureau Géophysique, Orstrom 24 Rue Bayard
Paris

Biquand, D.
Lab. of Geomagnetism, 4 Av. Neptune, 94 St.
Maur-des-Fosses

Bitterly, Jacques
Inst. Physique du Globe, 4 Av. Neptune, 94 St.
Maur-des-Fosses

Blamont, J.
BP 3 CNRS,
Verrieres 91

Bollo, Robert
Bureau de Recherches Geologiques et Minières
74, rue de la Federation
Paris 15

Bosaned, J. M.
C.E.S.R., B.P. 4057, 31
Toulouse

Boutonnet, Alain
C.E.S.R., BP 4057, 31
Toulouse

Bruston, P.
Laboratoire de Physique Stelaire
4 Av. de Neptune 94
St. Maur-des-Fosses

Bureau, J. L.
Geophysique Appliquèe,
9 Quai St. Bernard
Paris 5

Cambou, F.
C.E.S.R., BP 4057
Toulouse 31

Coulomb, J.
Physicien du Globe, Faculté des Sciences
9 Quai St. Bernard
Paris 5

Chanin, M. L.
CNRS, Service d'Aeronomie
Verrieres le Buisson 91

Christophe, J. Dr.
Institud D'Astrophysique, 98 bis Bd. Arage
Paris 14

Daly, Lucien
Laboratoire de Géomagnetisme, 4 av. Neptuen
St. Maur 94

Dunlop, D. J.
Lab de Géomagnetisme du Parc St. Maur
4, Av. de Neptune, 94
St. Maur-des-Fosses

Etcheto, J.
Groupe de Recherches Ionospériques
4 Av. Neptune 94
St. Maur-des-Fosses

Fambitakoye, D.
ORSTROM, 24 rue Bayard
Paris 8

Fournier, H. G.
Inst. de Physique du Globe, Université de Paris
9 quai St. Bernard
Paris 5

Glangeaud, F.
Inst. de Physique du Globe, 9 quai St. Bernard
Paris 5

Godivier, K.
Directeur de Recherches a Orstrom, 24 rue Bayard
Paris 8e

Grandclement, C. C. F.
100, route de Paris,
Massy 91

Grenet, Prof.
Faculté des Sciences, 9 quai St. Bernard
Paris 5

Lacourly, Sylvaine
3 Av. de la Republique, Group de Recherches Ionosphériques
Issy Les Moulineaux 92

Laval, G.
ONERA CERT DERTS, 51 rue Caraman
Toulouse 31

Legrand, S. P.
8. rue des Vertugadim
Meudon

Le Mouel, J.
Inst. de Physique du Globe, Tour 14, 9 quai St. Bernard
Paris 5

Leorat, J.
Inst. d'Astrophysique, 98 bis Bd. Arage
Paris 14

Link, F.
Inst. d'Astrophysique, 98 bis Bd. Arage
Paris 14

Mauaud, P. N.
Inst. de Physique du Globe, 9 quai St. Bernard
Paris 5

Niel, M.
C.E.S.R. BP 4057,
Toulouse 31

Ortner, J.
Assistant Director for Space Missions, European Space Research Organization, 114 Av de Neuilly
NEUILLY 92

Petitdidider, Monique
Service d'Aéronie, CNRS
Paris

Philippon, J. P.
Onera CERT DERTS, 51 rue Caraman
Toulouse 31

Pozzi, J. P.
Lab. de Geomagnetisme, 4 Av. de Neptune, 94
St. Maur-des-Fosses

Prevot, M.
Lab. de Geomagnetisme, 4 Av. de Neptune, 94
St. Maur-des-Fosses

Rechenmann, J.
Géophysicien a ORSTROM, 24 rue de Bayard
Paris 8

Reme, Henri
CESR, B.P. 4057,
Toulouse 31

Remiot, R.
Directeur de Recherches a ORSTROM, 24 rue Bayard
Paris 8

Rigaud, Pierre
Station Scientifique du Val Joyeux
Ville Preux 78

Rimbert, Francine
Cie. Francaise des Pétroles, 5 rue Michel Ange
Paris

Robley, R.
Observatoire de Pic du Midi
Bagneres de Bigorre 65

Roche, A.
Institut de Physique du Globe, 5 rue Descartes,
Strasbourg 67

Roquet, J.
Institut de Physique du Globe,
9 Quai St. Bernard,
Paris 5

Royer, Gilbert
Compagnie Générale de Géophysique, 6 rue Galvani
Massy 91

Schlich, R.
Institut de Physique du Globe, 4 Av. de Neptune, 94
St. Maur-des-Fosses

Selzer, E.
Institut de Physique du Globe, 9 Quai St. Bernard
Paris 5

Storey, Dr.
Groupe de Recherches Ionosphériques du CNRS
4 Av. de Neptune 94
St. Maur-des-Fosses

Tanguy, J. C.
Lab. de Géomagnetisme, 4 Av. de Neptune 94
St. Maur-des-Fosses

Vigneron, J.
Lab. de Géomagnetisme, 4 Av. de Neptune 94
St. Maur-des-Fosses

Weill, G. M.
CNRS Institut d'astrophysique, 98 bis Bd. Arage
Paris 14

GERMAN DEMOCRATIC REPUBLIC

Kautzleben, H.
Geodätisches Institut, Telegrafenberg A 17,
15 Potsdam

Taubenheim, Jens
Deutsche Akademie der Wissenschaften zu Berlin
Zentralinstitut für Solar-Terrestrische Physik
Rudower Chaussee 5,
1199 Berlin Adlershof

Wagner, C. U.
Geomagnetisches Institut,
Deutsche Akademie der Wissenschaften
15 Potsdam

GERMAN FEDERAL REPUBLIC

Allkofer, O. C.
Institut für Kernphysik, Universität Kiel
Kiel 23 Olhausenstrasse 40/60

Berckhemer, Hans
Universitätsinstitut für Meteorologie und Geophysik
6000 Frankfurt a Main
Feldbergstr. 47

Brommundt, Günther
Physikalisches Institut der Universität
Heidelberg Philisophenweg 12

Engelhardt, Wolf von
Universität Tübingen
Tubingen Wilhelmstr. 56

Fischer, Fritz
Arbeitgruppe für Physikalishe Weltraumforschung
78 Freiburg i. Br. Kronenstr. 13

Haak, Volker
Institut für angew. Geophysik Universität München
8 Munchen Richard Wagner Str. 10/0

Haerendel, Gerhard
Max-Planck Institut für Physik und Astrophysik
8046 Garching bei München

Hahn, A. G.
Niedersächsisches Landesamt für Bodenforschg.
Postfach, 54
Hannover-Buchholz

Heinrich, H.
Institut für Geophysik
Braunchsweig Mendelssohnstr. 1A

Hollweg, Joseph V.
Max-Planck Institut für Extraterrestrische Physik
8046 Garching bei München

Knott, Karl
Zweites Physikalisches Institut der Universität Heidelberg
Heidelberg Philosophenweg 12

Kremser, G.
Institut für Stratosphärenphysick am Max Planck
Institut für Aeronomie
3411 Lindau uber Northeim/Hann

Lange-Hesse, Dr. Günter
Max Planck Inst. für Aeronomie
3411 Lindau über Northeim/Hann Postfach 20

Lauche, Hans
Institut für Ionosphärenphysik
Max Planck Institut für Aeronomie
3411 Lindau/Harz

Lortz, D.
Institut für Plasmaphysik
8046 Garching bei München

Meyer, Dr. Bernhard
Max Planck Inst. für Extraterr. Physik
8046 Garching bei München

Meyer, Prof. Dr. Otto
Dtsch. Hydrographisches Institut
Bernhard Nocht Str. 78
2000 Hamburg 4

Muhleisen, Prof. Dr. Richard P.
Astronomisches Institut der
Universität Tübingen
Aussenstelle Weissenau
7981 Weissenau

Petersen, Nicolai
Institut für Angewandte Geophysik
München

Pfotzer, Prof. Dr. G.
Max Planck Institut für Aeronomie
Institut für Stratosphären-Physik
3411 Lindau/Harz
Postfach

Preuschen, Erika
Max Planck Institut für Aeronomie
Abt. Weltraumphysik
3411 Lindau/Harz

Rieger, Dr. Erich
Max Planck Institut für Extraterr. Physik
8046 Garching bei München

Ruster, Dr. Rüdiger
Max Planck Institut für Aeronomie
3411 Lindau/Harz

Schubert, Prof. Gerald
Max Planck Institut für Physik
8 München 23 Foehringer Ring 6

Schumann, Dr. Gerhard
Zweites Physikalisches Institut
der Universität
Heidelberg Philosophenweg 12

Seidl, D.
Geophysikalisches Institut
Universität Karlsruhe
Hertzstr. 16
75 Karlsruhe

Simon, Manfred
Institut für Kernphysik
Universität
23 Kiel Ohlshausenstr. 40–60

Soffel, Dr. Heinrich
Institut für Angewandte Geophysik
der Universität München
8 München 2
Richard Wagnerstrasse 10

Stubbe, Dr. Peter
Max Planck Institut für Aeronomie
3411 Lindau/Harz

Unger, Lothar
Arbeitsgruppe für Physikalische Weltraum-forsehung
78 Freiburg Kronenstr. 13

Untiedt, Prof. J.
Institüt füer Geophysik
34 Goettingen Herberger Landstr. 180

Völk, Dr. H. J.
Max Planck Institut für Extraterrestrische Physik
8046 Garching bei München

Voppel, D.
Wingst Observatory
German Hydrographic Institute
2171 Hoeftgrube

HUNGARY

Aczel, E.
Geofizikai Intezet
Budapest

Adam, Antal
Geophysical Research Laboratory of the Hungarian
Academy of Sciences, P. O. Box 9
Sopron

INDIA

Rastogi, Prof. R. G.
Physical Research, Laboratory, Navrangpura
Ahmedabad 9

Sarabhai, V. A.
Physical Research Laboratory
Ahmedabad,

Vohra, K. G.
Bhabha Atomic Research Center
Bombay 85

IRELAND

Riddihough, R. P.
Dublin Institute for Advanced Studies
School of Cosmic Physics – 5 Merrion Square
Dublin 2

ISRAEL

Eviatar, Aharon
Department of Environmental Sciences
Tel–Aviv University – Ramat Aviv
Tel–Aviv

ITALY

Alpers, W.
Esrin – Casella Postale 64
Frascati 00044 (Rome)

Bertotti, Bruno
Esrin of ESRO – C.P. 64
Frascati 00044 (Rome)

Castagnoli, Gulini
University of Turin – Instituto di Fisica
Generale – Via Giuria 1, 10125
Turin

Fiorgi, Maurizio
Director del Instituto de Fïsica de la Atmósfera
Piazzale Luigi Sturzo 31
Rome 00144

Gregori, Giovanni P.
I.F.A. Consiglio Nazionale delle Ricerche
Piazzale L. Sturzo 31
Rome 00144

Mariani, Franco
Instituto di Fisica Universita
Piazzale delle Scienze, 5
Rome

McKenzie, James F.
ESRIN – C.P. 64
Frascati 00044 (Rome)

Schindler, Karl
ESRIN – C.P. 64
Frascati 00044 (Rome)

Verniani, Franco
Instituto de Fisica de la Atmosfera
Via Zamboni 36
Bolonia

Vuyst, Dr. A. P. de
Institut Royal de Belgique
Université Libre de Bruxelles
Centre de Géophysique
Dourbes (Prov. de Namur)

JAPAN

Kato, Y. K.
Laboratory for Space Science
Faculty of Engineering – Tokai University
Tomigaya Shibuyaku
Tokyo

Nagata, T.
Geophysical Institute – University of Tokyo
Bunkyo-ku
Tokyo

Nishida, A.
Institute of Space and Aeronautical Science
University of Tokyo – Komaba, Meguru-ku
Tokyo

Ogawa, T.
Ionosphere Research Laboratory
Kyoto University
Kyoto

Ota, M.
WDG C2 for Geomagnetism
University Library – Kyoto University
Kyoto

Rikitake, T.
Earthquake Research Institute – University of Tokyo
Tokyo

Tazima, M.
Chief of Crustal Movement Research Office
Geographical Survey Institute, Higashiyama 3
Meguro-ku
Tokyo

Yonezawa, T.
Radio Research Laboratories, Kokubunji,
Joganei-shi
Tokyo

KENYA

Brock, A.
University College, P. O. Box 30197
Nairobi

Goecil, P.
University College, Box 30197
Nairobi

LEBANON

Plassard, J.
Directeur de l'Observatoire de Ksara
Par Zahle

MEXICO

Chargoy, A.
Instituto de Geofisica de Mexico, Ciudad Universitaria
Mexico 20 D.F.

MOROCCO

Demnati, A.
28, rue de Moulouya
Rabat–Agdal

NETHERLANDS

AS, J. A.
Royal Netherlands Meteorological Institute
De Bilt

Oster, A. L.
ESRO
Noordwijk

Tunaley, J.
European Space Research Organization, ESTEC
Domeinweg
Noordwijk

van Sabben, D.
Royal Netherlands Meteorological Institute
De Bilt

Veldkamp, J.
Koninklijk Nederlands Meteorologisch Institute
De Bilt

Zijderveld, J. D. A.
Paleomagnetic Laboratory, Forth Hoofddijk
Budapestlaan
Utrecht

NEW ZEALAND

Dowden, R. L.
University of Otago
Dunedin

Evison, F.
Victoria University of Wellington, P. O. Box 196
Wellington

NIGERIA

Dawson, J.
Ahmadu Bello University, Department of Physics
Zaria

Ette, A. I. I.
Department of Physics, University of Ibadan
Ibadan

Oni, C. E. F.
Department of Physics, University of Ibadan
Ibadan

Hutton, V. R. S.
Department of Physics, University of Ibadan
Ibadan

NORWAY

Gjellestad, G.
Geofysik Institutt, Avd. C.
Bergen 5000

Omholt, A.
University of Oslo, Box 1038, Blindern
Oslo 3

Orsini, N. A.
Tuengen Alle 25
Oslo 3

Sörnes, A.
Seismological Observatory, Villavei 9
Bergen 5000

Trefall, H.
Department of Physics, University of Bergen
Bergen

POLAND

Jankowski, J.A.
Polaska Akademia Naur, Z ahzad Geofizyki
Ul. Pasteura 3
Warszawa 22

PORTUGAL

Figueira, M. F.
Servicio Meteorologico Nacional
Lisbon

Mata, L.
Servicio Meteorologico Nacional, Rua Saravia do
Carvalho 2
Lisbon

RUMANIA

Demetrescu, C.
Geophysical Research Center
Bd. Ana Ipatescu 21, Sector 1
Bucharest

Moldovanu, A.
Centre de Recherches Physiques de l'Academie
Aleea Gr. Ghica–Voda no 41 A
Iassy

SENEGAL

Metzger, J.
Centre ORSTROM de Geophysique, B.P. 50
M'Bour

SOUTH AFRICA (Republic of)

Clarence, N. D.
Department of Physics, University of Natal
King George V Avenue
Durban, Natal

Gledhill, J. A.
Department of Physics, Rhodes University
Grahamstown

Scheepers, G. L. M.
Hermanus Observatory, P. O. Box 32
Hermanus

Stoker, P. H.
Department of Physics, Postchefstroom University
Postchefstroom

Torr, M.
National Institute for Telecommunication Research
P. O. Box 3718
Johannesburg

Torr, D. G.
National Institute for Telecommunication Research
of S.A.C.S.I.R., P. O. Box 3718
Johannesburg

SPAIN

Alfonso–Faus, D. A.
INTA, Equipo y Armamento,
Torrejon de Ardoz (Madrid)

Azcarraga Arana, A.
Instituto Nacional de Técnica Aeroespacial
Serrano, 43
Madrid

Cardus, J. O.
Observatorio del Ebro
Roquetas (Tarragona)

Gamboa, J. M.
Vicesecretario Asuntos Científicos del Consejo
Superior de Investigaciones Científicas, Serrano 117
Madrid

Martin-Albo, J. C.
Instituto Geográfico y Catastral
General Ibañez de Ibero, 3
Madrid

Miguel Gonzalez Mirana, L. de
Instituto Geográfico y Catastral, Servicio Geomagnetismo
y Aeronomía, Apartado 3007
Madrid

Miguel Lafuente, T.
Instituto Geográfico y Catastral, Observatorio
Geofísico de logroño, Apartado 191
Logroo

Moran Samaniego, F.
Instituto Nacional de Meteorologia, Serrano 43
Madrid

Peña, V.
Instituto Geográfico, General Ibañez de Ibero 3
Madrid

Perez Alonso, S.
Instituto Nacional de Técnica Aeroespacial
Serrano 43
Madrid

Perez Marin, A.
Instituto Nacional de Técnica Aeroespacial
Serrano, 43
Madrid

Ramos, A.
Instituto Geográfico y Catastral
General Ibañez de Ibero 3
Madrid

Romaña, A.
Observatorio del Ebro
Roquetas (Tarragona)

Sanchez Martinez, F.
Observatorio del Teide, Universidad de la Laguna
Tenerife Canarias

Sanchez Muniosguren, L.
Instituto Nacional de Técnica Aeroespacial
Serrano, 43
Madrid

Torroja, J. M.
Decano de la Facultad de Ciencias de la Universidad
Madrid

SWEDEN

Block, Dr. Lars P.
Royal Institute of Technology
10044 Stockholm

Bostrom, Rolf
Department of Plasma Physics
Royal Institute of Technology
Stockholm 70

Eleman, Dr. Volke
Geological Survey of Sweden
Stockholm 27

Fahleson, Dr. Ulf V.
Dept. of Plasma Physics
Royal Inst. of Technology
10044 Stockholm

Fälthammar, Dr. Carl–Gunne
Royal Institute of Technology
Division of Plasma Physics
S 10040 Stockholm 70

Gustafsson, G.
The Royal Swedish Academy of Sciences
Kiruna Geophysical Observatory
Kiruna C

Joseph, Dr. J. H.
c/o Dr. Georg Witt
Institute of Meteorology, University of Stockholm
Tulegatan 41, P. O. B. 19111
Stockholm

Vogel, Prof. Andreas
Solid Earth Physics Institute
University of Uppsala
Villa Viola, Box 556
75122 Uppsala

SWITZERLAND

Miyamura, Prof. S.
c/o Délégation de Japon
10, Av. de Budé
Geneve

TURKEY

Ispir, Yilmeiz
Istanbul Universitesi
Fen Faküìtese
Jeofizik Kürsüsü
Istanbul
(Corresp.:
School of Physics
The University
Newcastle upon Tyne NE1 7RU
ENGLAND)

Ozdogan, Prof. Dr. I.
Jeofizik Kürsüsü
Fen Fakultesi
Istanbul

Sipahioglu, N.O.N.
Vaniköy Nr. 40/1
Cengelköy – *Istanbul*

UNITED ARAB REPUBLIC

Ashour, A
Faculty of Science – Cairo University
Cairo

UNITED KINGDOM

Aitken, M. J.
Archaeological Laboratory
Oxford University
Oxford

Ambraseys, N. N.
Department of Civil Engineering
Imperial College of Science and Technology
London, S.W.7

Argent, C. R.
The Royal Society
6 Carlton House Terrace
London S.W.1

Briden, J. C.
University of Leeds – Department of Earth
Sciences – Division of Geophysics
Leeds, LS2 9JT

Bullard, Sir Edward
Cambridge University
Department of Geodesy and Geophysics
Madingley Rise – Madingley Road
Cambridge

Bullerwell, W.
Institute of Geological Sciences
5, Prince's Gate
London S.W.7

Burrows, D. K.
Radio and Space Research Station
Ditton Park – Slough
Bucks

Chapman, F. W.
Sixberries, Ashurst
Steyning, Susex

Childress, S.
c/o Atlantic Hotel
Newquai Cornwall

Creer, K. M.
University of Newcastle on Tyne
School of Physics
Newcastle on Tyne

Dungey, J. W.
Physics Department
Imperial College, Prince Consort Rd.
South Kensington
London, S.W.7

Edwards, R. N.
Dept. of Geodesy & Geophysics
Cambridge University – Madingley Rise –
Madingley Road
Cambridge

Girdler, R. W.
Department of Physics
University of Newcastle
Newcastle-upon-Tyne

Gretton, H. W.
Dept. Applied Mathematics
Sheffield University
Sheffield

Hide, R.
Meteorological Office 021
London Road
Bracknell, Berks

Hobbs, B. A.
13/15 High St. – Brompton
Gillingham, Kent

Jones, F. W.
Department of Mathematics
University of Exeter
Exeter, Devon

Kaiser, T. R.
Department of Physics
University of Sheffield – Hicks Building –
Hounsfield Road
Sheffield 2TN

Kendall, P. C.
Dept. of Applied Mathematics and
Computing Science – The University
Sheffield S10 2TN, Yorkshire

Leaton, B. R.
Royal Greenwich Observatory
Herstmonceau Castle
Hailsham, Sussex

Lomax, R.
Rosco Hall – Greenbank Lane
Liverpool 17

Lowes, F. J.
Physics Department
University Newcastle
Newcastle-upon-Tyne 1

Martelly
University of *Sussex*

Nichol, A. W.
Dept. of Physics
University of Exeter – The Queens Drive
Exeter

Orr, D.
Physics Department – University of York
Heslington, York

Price, A. T.
2 Earlsdon Way, Highcliffe
Christchurch
Hants – BH 23 2 AU

Roberts, G. O.
Department of Applied Mathematics
University of Newcastle upon Tyne
Newcastle

Rothwell, P.
Physics Dept. of
Southhampton

Runcorn, S. K.
School of Physics
University of Newcastle upon Tyne
Newcastle-upon-Tyne NE1 7RY

Russell, D. M.
Dept. Physics, University of Alberta
Edmonton, Canada

Smith, P. J.
Oliver Lodge Building
The University
Liverpool 3

Smith, R.
Queen University of Belfast
Dept. of Applied Mathematics
Belfast

Sonnett, C. P.
Dept. Of Physics – Imperial College
Prince Consort Rd.
London, S.W.7

Southwood, D. J.
Physics Department
Imperial College
London S.W.7

Srnka, L. J.
School of Physics
University of Newcastle
Newcastle-upon-Tyne

Stone, D. J.
Director of the Computer Unit
Dept. of Mathematics
The University
Exeter (Devon)

Stuart, W. F.
Institute of Geological Sciences
Edinburgh

Sutcliffe, R. C.
Dept. of Meteorology – University of Reading
White Knights Park
Reading, Berks

Thomas, L.
S.R.C. Radio and Space Research Station
Ditton, Slough, Bucks

Weaver, G. H.
Rugby College of Engineering Technology
"Bengtsfors". Dunton Road
Leire. Rugby

Wilkinson, I.
University of Newcastle
Dept. of Geophysics and Planetary Physics
Newcastle-upon-Tyne

Willis, D. M.
Radio and Space Research Station
Ditton Park
Slough, Bucks.

Wison, R. L.
Geophysics Department
Liverpool

Worthy, J. E. Rev.
Science Observatory Stonyhurst
College, Whalley, Via Blackburn
Lancaster

UNITED STATES OF AMERICA

Aikin, A. C.
Goddard Space Fight Center
Greenbelt Maryland 20771

Akasofu, S.
Geophysical Institute University of Alaska
College Alaska 99701

Alldredge, L.
ESSA Research Labs.
Boulder, Colorado 80302

Anderson, K. A.
University of California. Space Sciences Laboratory
Berkeley, California 94709

Antoine, J. W.
Dept. of Oceanography. Texas A & M University
College Station, Texas 77840

Backus, G. E.
P. O. Box 109
La Jolla, Calif. 92037

Barth, C. A.
Space Science Building. University of Colorado
Boulder, Colorado 80302

Behannon, K. W.
NASA Goddard Space Flight Center, Code 616
Greenbelt, Maryland 20771

Bellew, W.
Emmanuel College Marret RD.
Lexington Mass. 02173

Best, G. T.
L. G. Hanscom Field
Bedford, Mass. 01730

Bird, H. H.
15 Shawger RD
Denville, New Jersey 07834

Bird, J. M.
1400 Washington Ave.
Albany, New York 12203

Blank, J. L.
Bellcomm, Inc. 955 L'Enfant Plaza North, S. W.
Washington, D. C. 20024

Bostrom, C. O.
Applied Physics Laboratory. Johns Hopkins University
8621 Georgia Avenue
Silver Spring, Maryland 20910

Bowhill, S. A.
Department of Electrical Engineering
University of Illinois
Urbana, Illinois 61803

Brinkmann, R. T.
Jet Propulsion Laboratory
Pasadena, California 91109

Cain, J. C.
Goddard Space Flight Center, NASA/GSFC (612)
Greenbelt, Maryland 20771

Campbell, W. H.
ESSA Research Laboratories
Boulder, Colorado 80302

Carovillano, R. L.
Professor and Chairman Boston College.
Department of Physics
Chestnut Hill, Mass. 02167

Carpenter, D. L.
Radioscience Laboratory. Stanford University
Durand Building, Rm 319.
Palo Alto, California 94305

Clark, D. L.
University of Wisconsin, Science Hall
Madison, Wisconsin 53706

Cloutier, P. A.
Dept. of Space Science, Rice University
Houston, Texas 77001

Coleman, P. J.
Inst. Of Geophysics, University of California, at Los Angeles
Los Angeles, California 90024

Cook, R.
ESSA Geoacoustics Group, R 45x7.
Rockville, Maryland 20852

Cox, A.
Department of Geophysics, Stanford University
Palo Alto, California 94305

Chapman, S.
High Altitude Observatory
Boulder, Colorado 80302

Chernosky, E. J.
Sea Farm Research Foundation, 48 Berkeley Street
Waltham, Massachusetts 02154

Dalgarno, A.
Professor Harvard College Observatory
60 Garden Street
Cambridge, Massachusetts 02138

Davis, L.
Professor Caltech, 412 Downs
Pasadena, California 91109

Davis, L. R.
NASA/Goddard Space Flight Center (Code 6011)
Greenbelt, Maryland 20771

Dessler, A. J.
Space Science Dept. Rice University
Houston, Texas 77001

Dingle, A. N.
University of Michigan
4072 E. Eng. Bldg.
Ann Arbor, Mich. 48104

Doell, R. R.
Geophysical Survey, 345 Middlefield Road
Menlo Park, California 94025

Dolezaler, H.
1812 Drury Lane
Alexandria, Virginia 22307

Donahue, T. M.
University of Pittsburgh
Pittsburgh, Pennsylvania 15230

Dryer, Murray
ESSA, Space Disturbance Laboratory
Boulder, Colorado 80302

Dubois, R. L.
Earth Sciences Observatory, University of Oklahoma
830 South Oval, Rm. 107
Norman, Oklahoma 73069

Dunkelman, L.
Lab. for Space Sciences (613) NASA.
Goddard Space Flight Center
Greenbelt, Maryland 20771

Dziewonski, A.
Southwest Center for Advanced Studies
Division of Geosciences, P. O. Box 30365
Dallas, Texas 75230

Eather, R. H
Lockheed Palo Alto Laboratories
Dept. 52–10 Bldg. 202
3251 Hannover St.
Palo Alto, Calif. 94304

Edgar, N. T.
Scripps Institution of Oceanography, Box 109
La Jolla, California 92037

Fastie, W. G.
The John Hopkins University
Baltimore, Maryland 21218

Ferguson, E.
Aeronomy Laboratory, ESSA Research Laboratories
Boulder, Colorado 80302

Frank, L. A.
University of Iowa, Department of Physics
Iowa City, Iowa 52240

Fuller,
University of Pittsburgh
Pittsburgh, Pennsylvania 15230

Gadsden, M.
1031 Lincoln Place
Boulder, Colorado 80302

Gans, R. F.
California Inst. of Technology
Pasadena, California 91109

Gassmann G. J.
Upper Atmosphere Physics Laboratory
Headquarters AFCRL (CRPC) L G Hanscom Fld.
Bedford, Mass. 01730

Glass, N. W.
Los Alamos Scientific Laboratory
University of California
Los Alamos, New Mexico 87544

Green, A. W. J.
600 Kirby Lane
Richardson, Texas 75080

Greifinger, Carl
The Rand Corporation 1700 Main Street
Santa Monica, California 90401

Groves, G. V.
Air Force Cambridge Research Lab.
L. G. Hanscom Field
Bedford, Massachussetts 01730

Hale, L. C.
Pennsylvania State Univ. Ionosphere Research Lab.
University Park, Pennsylvania 16802

Harrison, C. G. A.
Institute of Marine and Atmospheric Sciences
University of Miami
Miami, Florida 33124

Hartle, R. E.
NASA–Goddard Space Flight Center
Greenbelt, Maryland 20771

Heckman, H. H.
Lawrence Radiation Laboratory
Berkeley, California 94720

Heikkila, W. J.
P. O. Box 30365
Dallas, Texas 75230

Heirtzler, J. R.
Woods Hole Oceanographic Institution
Woods Hole, Massachussetts 02543

Hemenway, Cartis
Dudley Observatory
Albany, New York 12205

Heppner, J. P.
NASA–Goddard Space Flight Center
Code 612
Greenbelt, Maryland 20771

Herton,
3213 Cherry Lane
Austin, Texas 78703

Hessler, V. P.
ESSA Research Laboratories, Earth Sciences Laboratory
Boulder, Colorado 80302

Hill, R. D.
General Research Corporation
P. O. Box 3587
Santa Barbara, California 93105

Hinteregger, H. E.
Air Force Cambridge Research Laboratories
CRAU
L. G. Hanscom Field
Bedford, Massachussetts 01730

Hinton, George F.
Code 7120
U. S. Naval Oceanographic Office
Washington, D. C. 20390

Hones, E. W.
Los Alamos Scientific Laboratory
Los Alamos, New Mexico 87544

Hoppel, W. A.
Naval Research Laboratory
Code 8325
Washington, D.C. 20390

Horton, Claude W.
Department of Physics, University of Texas
Austin, Texas 78703

Hundhausen, A. J.
University of California
Los Alamos Scientific Laboratory
P. O. Box 1663
Los Alamos, New Mexico 87544

Hunten, D.
Kitt Peak National Observatory
Box 4130
Tucson, Arizona 85717

Imhof, W. L.
Lockheed Palo Alto Research Laboratory
3251 Hanover Street
Palo Alto, California 94304

Inoue, Yuji
SRCC, University of Pittsburgh
Pittsburgh, Pennsylvania 15230

Karal, Frank
N. Y. University – Courrant Institute of Mathematics
251 Mercer St.
New York, New York 10012

Katz, Ludwig
Chief Cosmic Radiation Branch
Air Force Cambridge Research Labs
L. G. Hanscom Field
Bedford, Massachusetts 01730

Kasemir, H. W.
ESSA Research Laboratories, APCL., R31
Boulder, Colorado 80302

Kellogg, P. J.
School of Physics and Astronomy – University of Minnesota
Minneapolis, Minnesota 55455

Kendall, P. C.
High Altitude Observatory, Nat'l. Ctr. Atmospheric Research
Boulder, Colorado 80301

Kenney, J.
Boeing Scientific Research Labs. – P. O. Box 3981
Seattle, Washington 98 124

Kern, J. W.
University of Houston – Dept. of Physics
Houston, Texas 77004

Kim, J. S.
Professor Department Atmospheric Science.
University of New York
Albany, New York 12203

Knapp, D. G.
9520 Bruce Drive
Silver Spring, Maryland 20901

Kovach, R. L.
Department of Geophysics – Stanford University
Palo Alto, California 94305

Lang, R. H.
2206 Continental Life Bldg.
Fort Worth, Texas 76102

Lanzerotti, L. J.
Bell Telephone Laboratories
Murray Hill, N. J. 07974

Larsen, J. C.
ESSA Research Laboratory 2525 Correa Road
Honolulu, Hawaii 96822

Liemohn, Harold B.
Boeing Scientific Research Laboratories
Box 3981
Seattle, Washington 98124

Madden, T.
M. I. T.
Rm 54–GIA
Cambridge, Massachussetts 02139

Maeda, Kaichi
Goddard Space Flight Center
Code 641
Greenbelt, Maryland 20771

Maguire, John J.
Department of Physics
Boston College
Chestnut Hill, Massachusetts 02167

Malin, S. R. C.
High Altitude Observatory
University of Colorado
Boulder, Colorado 80302

Malone, T. F.
Senior Vice-President
One Tower Square
Hartford, Connecticut 06115

Markson, R. J.
New Mexico Institute of Mining and Technology
Socorro, New Mexico 87801

Masley, A. J.
3000 Ocean Park Boulevard
Santa Monica, California 90405

Matsushita, S.
High Altitude Observatory, NCAR
Boulder, Colorado 80302

McClay, J. F.
215 Summit Rd.
N. Abington, Massachusetts 02351

McElroy, Michael B.
Kitt Peak National Observatory, P. O. Box 4130
Tucson, Arizona 85717

Merril, R. T.
University of Washington, Dept. of Oceanography
Seattle, Wash. 98105

Meyers, Herbert
Environmental Science Services Administration
8060 13th Street
Silver Spring, Maryland 20910

Minear, J.
Research Triangle Inst.
Durham, North Carolina 27705

Mohnen, V. A.
Dept. of Atmospheric Science
State University of New York at Albany
1400 Washington Av.
Albany, New York 12203

Ness, Norman
National Aeronautics & Space Administration
Goddard Space Flight Center Code 616
Greenbelt, Md. 20771

Newman, M. M.
2218 Doswell Avenue
St. Paul, Minnesota 55108

Noxon, John F.
Harvard University, Pierce Hall
Cambridge, Massachusetts 02138

Olson, Donald E.
University of Minnesota, Duluth
Duluth, Minnesota 55812

Opdyke, Neil
Lamont-Doherty Geological Observatory, Columbia University
Palisades, New York 10964

Ostenso, Ned, A.
Office of Naval Research
Code 483
Washington, D. C. 20360

Parsignault, D.
11 Carleton St.
Cambridge, Massachussetts 02138

Patterson, T. N. L.
Atmospheric and Space Sciences
Southwest Center for Advanced Studies
Post Office Box 30365
Dallas, Texas 75230

Paulikas, G. A.
Aerospace Corp. P. O. Box 95085
Los Angeles, California 90045

Pearce, J. B.
Research Associate, University of Colorado
Boulder, Colorado 80302

Porath, Hartmut
Southwest Center for Advanced Studies
Post Office Box 30230
Dallas, Texas 75230

Pruett, R. G.
Aerospace Corporation 2350 E.
El Segundo, California 90245

Radoski, H. R.
358 Old Lancaster Road
Sudbury, Massachusetts 01776

Rees, M. H.
L.A.S.P. University of Colorado
Boulder, Colorado 80302

Reid, G. C.
Space Disturbances Lab
ESSA Research Labs
Boulder, Colorado 80302

Roederer, J. G.
Physics Department, University of Denver
P. O. Box 10127.
Denver, Colorado 80210

Rosen, A.
Director Space Sciences Laboratory TRW Systems Group
Bldg, R1, Room 1070. One Space Park
Redondo Beach, California 90278

Russell, C. T.
Institute of Geophysics, University of California
Los Angeles, California 90024

Ryan, W. B. F.
Lamont-Doherty Geological Observatory
Columbia University
Palisades, New York 10974

Sacks, I. S.
Department of Terrestrial Magnetism
Carnegie Institution of Washington
5241 Broad Branch Road, N. W.
Washington, D. C. 20015

Sandford, B. P.
AF Cambridge Research Labs. L. G. Hanscom Field
Bedford, Massachussetts 01730

Sartor, J. D.
National Center for Atmospheric Research, P. O. Box 1470
Boulder, Colorado 80302

Scarf, F. L.
Manager Space Physics Analysis Depart. TRW Systems
Group, Bldg R–1, Rm 1070, One Space Park
Redondo Beach, California 90278

Schield, M. P.
University of Iowa, Physics Research Center
Iowa City, Iowa 52240

Schuster, B. G.
National Center for Atmospheric Research
P. O. Box 1470
Boulder, Colorado 80302

Shimazaki, T.
2685 Table Mesa Ct.
Boulder, Colorado 80303

Sill, W. R.
955 l'Enfant Plaza S. W.
Washington, D. C. 20224

Smith, W. E.
Executive Director American Geophysical Union
2100 Pennsylvania Ave. N. W.
Washington, D. C. 20015

Spreiter, J. R.
Stanford University – Dept. of Applied Mathematics
Palo Alto, California 94305

Stampfar, D. F.
10 McFarland Drive
Rolla, Missouri 65401

Stockard, Henry P.
11111 Lochton Street
Upper Marlboro, Maryland 20870

Stolov, H. L.
2575 Palisade Avenue
Bronx, New York 10463

Sugiura
NASA, CSFC – Code 612
Greenbelt, Maryland 20771

Svendsen, K. L.
Geomagnetism Division – Coast & Geodetic Survey–ESSA
Rockville, Maryland 20852

Swider, W.
GRUB, AFCRL, L. G. Hanscom Fld.
Bedford, Massachussetts 01730

Tinsley, A. B.
Atmospheric and Space Sciences
Southwest Center for Advanced Studies –
Post Office Box 30365
Dallas, Texas 75230

Twitchell, P. F.
Office of Naval Research – 495 Summer Street
Boston, Massachusetts 02210

Vette, James
Director National Space Science Data Center
Goddard Space Flight Center, Code 601
Greenbelt, Maryland 20771

Vincenz, Prof. S. A.
Institute of Technology, Saint Louis University
P. O. Box 8020, College Station
Saint Louis, Missouri 63156

Vogt, P. R.
U. S. Naval Oceanographic Office, Code 038
Washington D. C. 20360

Walker, James C. G.
Department of Geology, Yale University
New Haven, Connecticutt 06520

Watanabe, Dr. Tomiya
1643–A, Walnut St.
Berkeley, California 94709

Watkins, Prof. N. D.
Florida State University
Department of Geology
Tallahassee, Florida 32306

Webb, Dr. V. H.
AFCRL (CRFC), L. G. Hanscom Field
Bedford, Massachusetts 01730

Whang, Dr. Y. C.
Catholic University, *Washington D. C. 20017*
Enviar correspondencia a:
13316 Tamworth Lane
Silver Spring, Maryland 20904

White, R. S.
University of California
Riverside, California 92502

Whitmarsh, C. M. Mrs.
Essa Research Laboratories, Earth Sciences Laboratory
Boulder, Colorado 80302

Wilson, Dr. Charles R.
Geophysical Institute of Alaska
College Alaska 99701

Young, G. A.
1301 Delaware Ave., S. W. Apt. N 204
Washington, D. C. 20024

Zmuda, A.
Applied Physics Laboratory
The John Hopkins University, 8631 Georgia Avenue,
Silver Spring, Maryland 20910

U. S. S. R.

Benkova, N. P.
Soviet Geophysical Committee, Molodezhnaya 3
Moscow B-296

Burlatskaya, S. P.
Academic of Science of USSR, Gurzinskaya 10,
Moscow B

Brunelli, B. A.
Polar Geophysical Institut Academy of Science
Apatiti Murmansk Region

Ivanov–Kholodny, G.
Inst. Applied Geophysics
Academy of Sciences of USSR
Moscow

Izakov, M. N.
Institute for Space Research,
Academy of Sciences of the USSR
88 Moscow

Kascheliev, B. L.
Kharkov Polytechnical Institute, Kharkov
RPI –2k Frunze
Kharcov

Khocholava, G. M.
Geophysical Institute
Toya Rukchadze Str. 1
Tbilisi

Kondorskaya, N. V.
Grusinskaya 10 Institute of Physics of the Earth
Molodezhnaya 3
Moscow D-242

Kosminskaya, I. P.
Sov. Geophysical Committee
Molodezhnaya 3
Moscow B-296

Marov, M. Ya.
Soviet Geophysical Committee
Molodezhnaya 3
Moscow B-296

Michnevitch, V. V.
Hydrometeorological Service Moscow,
Pavlik Morosov
Moscow

Mishin, V. M.
Sibizmir
Zenin Street, 5
Irkutsk

Ohl, A. I.
Arctic and Antarctic Research Inst.
Academy of Sciences,
Moscow.

Petrova, G. N.
Institute of Physics of the Earth USSR
Moscow Molodeynaje, 3
Moscow, B-296 Znaya

Rapoport, Z.
Scientific worker, Academy of Sciences
Izmiran

Raspopov, O.
University of Leningrad, Physic Fac.
Leningrad, B-164

Skuridin, G. A.
Soviet Geophysical Committee
Molodezhnaya 3
Moscow B-296

Troitskaya, V. A.
Soviet Geophysical Committee
Molodezhanaya 3
Moscow B-296

Valsberg, O. L.
Institute for Space Research, Propsoynznaya 88
Moscow V-485

Vershinin, E. F.
Radiophysic, Academy of Science of USSR
Institute of the Cosmophysics and Aeronomy
Yakutsk, Lenin 61

Vlasov, A.
Professor Geomagnetism, Academic of Science of the USSR, Krasnojarsk
Moscow

Yakimenko, V. L.
Moscow State University, Institute of Nuclear Physics
Moscow V-234

Yeveashin, L. S.
Murmansk Polar Geophys In. T., Murmansk 10, Vladimirskaj 17
Moscow

Zybin K. Y.
Inst. of Physics of Earth, Academy Sciences
Moscow

YUGOSLAVIA

Maric, M.
Institute of Geomagnetism
Grocka

Turajlic, R.
Institute of Geomagnetism
Grocka

No. 13	Transactions of the Oslo Meeting, 1948
No. 14	Transactions of the Brussels Meeting, 1951
No. 15	Transactions of the Rome Meeting, 1954
No. 15a	Le Noyau Terrestre, Rome 1954
No. 15b	Problèmes de la Physique de la haute atmosphère, 1954
No. 16	Transactions of the Toronto Meeting, 1957
No. 16a	Paléomagnétisme et Variation Séculaire, Toronto 1957
No. 16b	Aéronomie, Toronto 1957
No. 16c	Rapid Magnetic Variations, Utrecht 1959
No. 17	List of Resolutions
No. 18	Geomagnetic Planetary Indices Kp, Ap and Cp, 1932 to 1961
No. 19	Transactions of the Helsinki Meeting, 1960 and the Berkeley Meeting, 1963
No. 20	List of Geomagnetic Observatories
No. 21A-B	K Index Atlas
No. 22	Description of Instruments
No. 24	Program and Abstracts, St. Gall Meeting, 1967
No. 25	Transactions of the St. Gall Meeting, 1967
	Caractère Magnétique Numérique de Jours (from 1 January 1930 to 31 December 1939) and Caractère Mangétique Numerique des Jours pendant l'Année Polaire 1932-1933 (in complete sets only)
	International Auroral Atlas, published for the IUGG, to be obtained from University Press, Edinburgh, 1963
	IAGA Symposium No. 1, Copenhagen, 1960
	IAGA Symposium No. 2, Berkeley, 1963
	IAGA Symposium No. 3, Pittsburgh, 1964
	IAGA Symposium No. 4, Cambridge, Mass., 1965
	IAGA Symposium No. 5, San Paulo, Brazil
	IAGA Symposium No. 6, Birkeland, Aurora and Magnetic Storms, 1967
	IAGA Symposium No. 7, Upper Atmospheric Winds, Waves and Ionospheric Drifts, 1967
	IAGA Symposium No. 8, Laboratory Measurements of Aeronomic Interest
No. 26	Program and Abstracts, General Scientific Assembly – Madrid, 1969
No. 27	Transactions of Madrid Meeting 1969

PUBLICATIONS

by the

INTERNATIONAL ASSOCIATION OF GEOMAGNETISM AND AERONOMY

To be obtained from the IUGG Publication Office,
39 ter, rue Gay-Lussac, Paris (V)

No. 1	Organization, Minutes, and Proceedings of the Brussels Meeting, 1919 . . . .
No. 2	General Report of the Rome Meeting, 1922 . . . . . .
No. 3	Transactions of the Rome Meeting, 1922 . . . .
No. 4	General Report of the Madrid Meeting, 1924 . . . . .
No. 5	Transactions of the Madrid Meeting, 1924 . . . . . .
No. 6	Preliminary Reports on Subjects of Investigation, 1926 .
No. 7	Comptes Rendus de l'Assemblée de Prague, 1927 . . .
No. 8	Comptes Rendus de l'Assemblée de Stockholm, 1930 . .
No. 9	Comptes Rendus de l'Assemblée de Lisbonne, 1933 . . .
No. 10	Transactions of the Edinburgh Meeting, 1936 . . . . .
No. 11	Transactions of the Washington Meeting, 1939 . . . . .
No. 12	Geomagnetic Indices, C and K, 1940-1946 . . . . . .
No. 12a	Geomagnetic Indices, C and K, 1947 . . . .
No. 12b	Geomagnetic Indices, K and C, 1948 . . . .
No. 12c	Geomagnetic Indices, K and C, 1949 . . . .
No. 12d	Geomagnetic K-Indices, International Polar Year, August 1932 to 1933 . . . .
No. 12e	Geomagnetic Indices, K and C, 1950 . . . .
No. 12f	Geomagnetic Indices, K and C, 1951 . . . .
No. 12g	Geomagnetic Indices, K and C, 1952 . . . .
No. 12h	Geomagnetic Indices, K and C, 1953 . . . .
No. 12i	Geomagnetic Indices, K and C, 1954 . . . .
No. 12j	Geomagnetic Indices, K and C, 1955 . . . .
No. 12k	Geomagnetic Indices, K and C, 1956 . . . .
No. 12l	Geomagnetic Data, 1957, Indices K and C, Rapid Variations . . . .
No. 12m1	Geomagnetic Data, 1958, Indices K and C . . . . . .
No. 12m2	Geomagnetic Data, 1958, Rapid Variations . . . . . .
No. 12n1	Geomagnetic Data, 1959, Indices K and C . . . . . .
No. 12n2	Geomagnetic Data, 1959, Rapid Variations . . . . . .
No. 12o1	Geomagnetic Data, 1960, Indices K and C . . . . . .
No. 12o2	Geomagnetic Data, 1960, Rapid Variations . . . . . .
No. 12p1	Geomagnetic Data, 1961, Indices K and C . . . . . .
No. 12p2	Geomagnetic Data, 1961, Rapid Variations . . . . . .
No. 12q1	Geomagnetic Data, 1962, Indices K and C . . . . . .
No. 12q2	Geomagnetic Data, 1962, Rapid Variations . . . . . .
No. 12r1	Geomagnetic Data, 1963, Indices K and C . . . . . .
No. 12r2	Geomagnetic Data, 1963, Rapid Variations . . . . . .
No. 12s1	Geomagnetic Data, 1964, Indices K and C . . . . . .

(Continued inside back cover)