Part I

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ABBREVIATIONS USED IN THE INTRODUCTION

AGU	American Geophysical Union
BIH	Bureau International de l'Heure
FAGS	Federation of Astronomical and Geophysical Services
IAG	International Association of Geodesy
IAU	International Astronomical Union
ICSU	International Council of Scientific Unions
ILS	International Latitude Service
IPMS	International Polar Motion Service
IUGG	International Union of Geodesy and Geophysics
PZT	Photographic Zenith Tube
UNESCO	United Nations Educational, Scientific and Cultural Organization

INTRODUCTION

The hypothesis of continental drift has become of increasing interest to geophysicists in recent years. The IUGG Upper Mantle Committee has stated that the hypothesis of continental drift envisages horizontal displacements of the continents over thousands of kilometers, and that it is a principal objective of the Upper Mantle Project to prove whether or not continental drift has occurred. The origin of the hypothesis may be traced to the close similarity in outlines of the coasts on the two sides of the Atlantic Ocean. The theory that the eastern and western hemispheres are drifting apart was expounded in particular by A. Wegener.

Modern geophysical theories seek to explain paleomagnetic observations by assuming that two things have occurred in the past: (a) large-scale polar wandering, and (b) continental drift. A direct confirmation of drift, if it exists, is greatly desired.

Attempts have been made to prove that continental drift has occurred from observed changes in latitude and longitude. It was thought by some, in fact, that such changes had been detected. It became apparent, however, that the observed changes could be due to errors of observation. It is now clear that the rate of continental drift is so small, if not zero, that systematic errors must be eliminated, in particular, those due to errors in proper motions of the observed stars. If two stations utilize different star programs then any relative error in the proper motions will give a fictitious relative drift between the stations. Furthermore, changes in latitude and longitude due to continental drift must be separated from changes due to the secular motion of the pole.

The Second Symposium on Recent Crustal Movements, sponsored by the IAG of the IUGG and held at Aulanko, Finland in August, 1965, included several astronomical papers concerned with continental drift. It became evident to Dr. B. Guinot and the writer that new astronomical programs were required to study continental drift effectively. These programs would utilize existing stations for the most part, organized into chains of two or more on nearly the same parallel of latitude, which would observe the same stars. This practice has been employed by the ILS chain on latitude $+39^\circ\ 8'$ since 1899. No attempt would be made to utilize heterogeneous observations from a large number of stations.

Since there is not sufficient time at the General Assemblies of the IAU and the IUGG to study the scientific problems and to arrange specific cooperative programs it was thought desirable to hold a symposium, to be sponsored jointly by the IAU and IUGG, about five or six months before the holding of the General Assemblies in 1967.

Brigadier Guy Bomford, President of the IAG, who was present at Aulanko, gave his support to this idea. A proposal was submitted to the Executive Committees of the IAU and the IUGG, which gave their warm approval and offers of support.

It was decided that the symposium would be small in character. Its most important function would be to operate as a Working Group, to arrange cooperative observing programs by those concerned. Scientific papers concerned with related astronomical problems, such as the secular motion of the pole and the rotation of the earth, would be included. In addition, some geophysical discussion was planned, in particular, estimates of the expected rate of continental drift. Finally, the symposium would include a discussion on the possible future use of satellite techniques. No attempt would be made to decide whether continental drift was occurring.

In October 1966 Brigadier Bomford suggested that the selection of the minor axis of the earth, which geodesists required, might be considered at the symposium. This, in effect, would be to adopt a fixed origin of reference for the instantaneous coordinates of the pole of rotation. Accordingly, the second major objective of the symposium was to adopt a recommendation on the selection of such an origin.

Opening Session

The Symposium was opened formally on 21 March 1967 by Prof. F. Zagar. The Mayor of Stresa, Dr. Ing. G. Cattaneo, welcomed the participants. Remarks were then made on behalf of the Italian Geodetic Commission by Prof. P. Dore, the President; the IAU by Mr. D.H. Sadler, the Past General Secretary; the IUGG by Dr. G.D. Garland, the General Secretary and the IAG by Prof. P. Tardi, the Past General Secretary. Dr. Wm. Markowitz concluded the opening session by outlining the objectives of the Symposium.

Working Group

This consisted of B. Guinot, Chairman; H.J. Abraham, L. Arbey, J. Bonanomi, H. Enslin, R.G. Hall, D. Monger, A. Orte, A.C. Scheepmaker, H.M. Smith, R.W. Tanner, M. Torao, and S. Yumi.

The Group noted that to obtain observations useful for the study of continental drift it was necessary to eliminate the effect of errors in star positions and proper motions. This can be done by having a common observing program at stations which form a chain. If two stations of a PZT chain are 15′ apart in latitude then about $\frac{1}{2}$ the stars can be observed in common, which suffices to link the stations. Astrolabes, however, can be several degrees apart in latitude. Also, the Danjon astrolabe being a portable instrument, it was noted that observations might be made in 10-year cycles, with each instrument of a chain remaining on the same latitude for two years. It was estimated that relative latitudes and longitudes can be determined to about 1 m with a pair of PZT's in one year, and about 2 m with a pair of astrolabes.

One PZT chain is in existence, Mizusawa–Washington, at latitude $+39°$. Calgary–Herstmonceux, at $+51°$, and LaPlata–Mount Stromlo, at $-35°$, are PZT chains scheduled to begin in 1968. These chains could be strengthened or new ones formed

by moving existing PZT's. It was noted that an Ottawa–Pulkova chain could be formed at $+45°$ and that the Hamburg and Potsdam PZT's could be moved to the Calgary–Herstmonceux latitude.

Astrolabe chains in operation are: Mizusawa–Algiers, to which Washington can be added, at $+36°$, and Cape–Santiago, at $-34°$. Astrolabes also in operation include those at Richmond, Quito, and Sao Paulo. Others to be placed in operation will be at Milan, San Fernando, San Juan (Argentina), and Tierra del Fuego. These can be used to form additional chains.

The Working Group noted that zenith telescopes should be on the same parallel of latitude and that the only such chain existing is that of the IPMS, which determines the fundamental reference system of the polar motion. Meridian-passage instruments are not suitable for the study of continental drift.

The importance of having a central agency to discuss the results obtained from the cooperative programs was stressed.

SELECTION OF ORIGIN OF POLE

The numerical values of the coordinates of the pole, x and y, which are obtained from a group of stations, depend upon the observed variations in latitude, which in turn depend upon the adopted initial latitudes of the stations. The successive Central Bureaus of the ILS have used different initial coordinates, in effect different origins – sometimes several, for different 6-year intervals. This introduced an element of confusion for geodesists, who wished to refer their observations to the same origin.

At the Dublin meeting of the IAU, in 1955, it was recommended that observations for time be corrected for the motion of the pole, in a uniform manner. A Rapid Latitude Service to be conducted by the BIH was established. The polar motion deduced rapidly by the RLS was to be corrected systematically so as to agree with that obtained by the ILS, that is, the same origin would be used. This practice was not strictly followed; data were not obtained rapidly enough in the early stages.

The origin used from 1949 to 1959 by G. Cecchini, the Director of the Central Bureau of the ILS, was called by him the "system of Wanach, 1900–05". In 1959 Cecchini adopted an origin called the "new system, 1900–05" and which is now designated the "mean pole of 1903·0". The fixed, initial latitudes which define this origin are given in Resolution No. 1 adopted at Stresa. This origin was retained when the Central Bureau of the ILS was moved to Mizusawa in January 1962 and the name was changed to Central Bureau of the IPMS.

Meanwhile, the origin used for the computation of $\Delta\lambda$ by the BIH was moved in the interval 1958·75 to 1958·95 to the so-called "mean pole of epoch", which approximates the moving center of the observed polar motion. Thus, different origins were used at different times, and not even the same one by the ILS/IPMS and the BIH. This situation caused difficulties in the reduction of astronomical, geodetic, and satellite

observations. Indeed, one could not be certain of the corrections to be used to refer observations to a single origin. Requests therefore arose for the adoption of a single, fixed origin to be used by both the BIH and IPMS.

The discussions at Stresa made clear the desire to adopt a fixed origin. One letter on this subject was received, from Mr. Bruce Lambert of the Division of National Mapping, Australia, who suggested adopting the pole of 1962·0. There were reasons, however, for adopting the pole of 1903·0. It is the one used by the IPMS; also, the Directing Board of the BIH, meeting in Paris on 18 March 1967, had adopted a recommendation that the BIH use the pole of 1903·0. The Stresa Symposium recommended adoption of this origin also.

Resolutions

The resolutions adopted at Stresa were forwarded to the General Secretaries of the IAU and IUGG for consideration at the General Assemblies to be held in the fall of 1967. A brief explanation of the relations between some of the organizations concerned may be helpful here.

The BIH and IPMS are sponsored by the IAU and IUGG and receive financial support from FAGS. FAGS is an agency of ICSU; both receive financial assistance from UNESCO. The IAG is one of the seven Associations which form the IUGG and is the one most closely concerned with the BIH and IPMS. The BIH and IPMS are advised by Scientific Councils whose members include representatives of the IAU and the IUGG. The Directing Board of the BIH is the BIH Scientific Council. The Scientific Councils are guided on general scientific matters by recommendations of the IAU and IUGG. Recommendations adopted by the Scientific Councils, as well as the Symposium at Stresa, will be reported to the IAU and IUGG for their consideration.

Scientific Sessions

There were seven scientific sessions. The subjects and the Chairmen were as follows:

1. Geophysical estimates of rate of drift (P. J. Melchior).
2. Secular motion of the pole and secular changes in latitude and longitude from astronomical observations (H. M. Smith).
3. Continuation of topics of session 2 (M. Torao).
4. Polar motion from observations for time; Rotation of the earth (R. W. Tanner).
5. Artificial satellite techniques (D. H. Sadler).
6. Theoretical papers; Resolutions (J. Bonanomi).
7. Informal reports; Report of Working Group (B. Guinot).

The scientific sessions were opened with an invited paper by G. D. Garland on estimates of continental drift to be expected. In the discussion which followed, Dr. Garland was asked to provide, also, arguments against the theory of continental drift, which he did. The general feeling which resulted from the paper and the dis-

cussion was that continental drift of a few centimeters per year might be occurring and that it was worthwhile to attempt to detect this by astronomical observation.

The second and third sessions concerned attempts to disentangle the secular motion of the pole from crustal displacements of observing stations. The discussions concerned chiefly whether past astronomical observations show that crustal displacements had occurred. The arguments for and against are given in the papers.

The fourth session included two papers on the determination of the polar motion from observations for time and two theoretical papers relating to the variable speed of rotation of the earth and the secular motion of the pole.

The possible use of three artificial-satellite techniques for studying continental drift was discussed in the fifth session. The accuracy of a position obtained from optical tracking is now about 30 m. J. A. Weightman thought, based on a study of the Western European Satellite Triangulation Program, that an accuracy of 3 m might be obtained at the end of a 3- to 5-year program. The radio-tracking method described by D. W. Trask and C. J. Vegos gave an accuracy of 10 m for the difference in longitude between two stations and an expected accuracy of 1 m for the future. Latitude differences are not determined by this method. The discussions indicated that the accuracies to be obtained from the optical and radio tracking would not be good enough to compete with the classical astronomical methods.

Interest was therefore centered on the proposal of C. O. Alley and P. L. Bender to place corner reflectors on the Moon and use lasers for ranging. This method would provide a direct distance measurement, instead of an angular separation, between stations. The estimated accuracy is 15 cm. It was agreed that if this method were successful it would provide the most rapid method of detecting continental drift, possibly within 10 years as against 30 to 50 years by the classical methods.

The sixth and seventh sessions included theoretical papers and a few informal reports. T. Nicolini gave the definitive ILS coordinates of the pole for 1941·0 to 1949·0 for the first time. These had been long awaited.

Scientific Papers

A total of 19 papers was given. In accordance with IAU instructions the papers printed here have been shortened where possible, in particular, if a similar, more extensive paper has been or will be published elsewhere. The papers were reviewed by the Editors at Stresa and returned to the authors for revision. In some cases the revised papers printed here take account of the discussions held at Stresa.

Organization of Symposium

The Organizing Committee consisted of Wm. Markowitz (President), E. P. Fedorov, B. Guinot, P. Melchior, M. Torao, and F. Zagar (Chairman, Local Committee).

The Symposium was held in Stresa, Italy, 21 to 25 March 1967, upon invitation of the Italian Geodetic Commission. The sessions were held at the Hotel La Palma, Stresa, which also lodged the participants. This saved time and eliminated a transportation problem.

The program was left uncrowded so as to leave ample time for discussion of the papers and resolutions and for the conferences of the Working Group. There were no formal evening sessions. The instructions contained in the *Astronomer's Handbook* (*Trans. IAU*, Vol. 12C, 1966) were followed in organizing the Symposium and in editing the *Proceedings*.

The IAU and the IUGG jointly sponsored the Symposium and provided the principal financial grants, used chiefly for support of travel of participants. The IAU also undertook the publication of the *Proceedings* of the Symposium. A grant from the American Geophysical Union was used for expenses of organization. The Italian Geodetic Commission contributed for expenses of the Local Committee.

A total of 49 participants from 14 countries attended. The participants expressed regret that their colleagues G. Cecchini, E.P. Fedorov and N. Sekiguchi, who had contributed much to the study of the polar motion, were unable to attend.

Acknowledgments

On behalf of the participants of the Stresa Symposium, I thank the Organizations and the individuals whose interest and support made the Symposium possible. Dr. J.-C. Pecker and Dr. G.D. Garland, the respective General Secretaries of the IAU and IUGG, actively supported the Symposium. Dr. Luboš Perek, the Assistant General Secretary of the IAU, provided guidance for the organization of the Symposium and the preparation of the *Proceedings*. Dr. Waldo Smith, the Executive Director of the AGU, aided in obtaining a grant. The support of Prof. P. Dore was greatly appreciated.

Excursions and reception were kindly provided by the Mayor of Stresa, by the Italian Geodetic Commission, by the Local Committee, and by the Rector of the University of Milan, Prof. G. Polvani.

Everything possible for the smooth running of the meeting and the comfort of the participants at Stresa was done by Prof. F. Zagar and Miss T. Zagar, with the help of the efficient staff from the Brera Observatory.

Dr. E.P. Clancy served as Reporter.

I add, finally, my thanks to the officials of Marquette University for their support in carrying out my own tasks.

Conclusion

The Stresa Symposium had two objectives, which were attained. It is hoped that its

work will prove to be in some measure as useful to astronomy and geodesy as was the conference held in 1883, also in Italy, which resulted later in the creation of the International Latitude Service.

WM. MARKOWITZ
President, Organizing Committee

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