Development in International Geodesy*

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THE increase in the scope of geodetic work accomplished in recent years and planned for the early future is remarkable. The fundamental problem of geodesy is the precise determination of the shape and dimensions of the earth, or what may be described otherwise either as the figure of the earth or the form of the geoid. When this is fully solved, benefits will accrue to geophysics as well as to geodesy.

In the nineteenth century, Colonel Clarke derived values of the elements of the terrestrial spheroid, first in 1866 and later in 1880. In 1866 Clarke used several meridian arcs, namely, Anglo-Gallic 39° – 60° N., Russian 45° – 70° N., Cape 34° – 29° S., Peruvian 3° – 0° S.; and both of Clarke's determinations are utilized in one or other of the great geodetic surveys. They may be considered as the best of those made simply from arcs of triangulation; but all such deductions are vitiated, more or less, by deviations of the vertical. In 1909 Hayford derived a new set of values from the triangulation of the United States, introducing the hypothesis of isostasy so as to avoid the effects of anomalous deviation of the vertical; and his figures were adopted by the International Union of Geodesy and Geophysics in 1924 at Madrid as defining the international spheroid.

Now we are entering a new era. The figure of the earth can be determined either from triangulation arcs or areas, or from gravity surveys; or from a combination of both. The greater the extent of the work of either kind, the higher is the precision which may be looked for in the results, which also become more detailed. In the first method, the weakness of determination has derived from the relatively small scope of the data. Thus Clarke's determination of 1866 was based on a few arcs of meridian of total amplitude less than 60° ; while Hayford's determination rested on an area which is less than two per cent of the earth's surface. Later determinations from the gravity field have also suffered from incompleteness of data. It is in the direction of greater fullness of data that a remarkable change is taking place; and this change is rendered possible and being brought into being by the Union of Geodesy.

There are now triangulation projects of a very comprehensive nature. The first resolution adopted by the Union of Geodesy and Geophysics at Edinburgh contemplates the junction of European and American triangulation across Asia and the Bering Straits; for which collaboration of the U.S.S.R. in Asia, the U.S.A. in Alaska, and Canada is essential. This will lead to a longitudinal arc of no less than 316° , mostly about latitude 52° , from which it deviates for the Asia-America junction. Of this work, 188° have already been finished. There remains to be done 4,800 km. from Irkutsk to Bering, 1,400 km. thence to the Alaska-Canada border and 1,100 km. in Canada.

Work in the U.S.S.R. is proceeding apace, and a great grid of triangulation is rapidly spreading over all that territory. Not only will the work extend to Bering, but, within five years, I am informed, it

will also reach the region of Tashkent and make strong connexion through an existent link with the system of triangulation of British India. A report (of Commission 18) was presented to the Union at Lisbon on the present state and future possibilities of extension towards Australia. Already continuous triangulation exists between India and Siam and thence with French triangulation in Indo-China; and only small gaps exist between the triangulations of Siam and Malaya (four triangles) and that of the Dutch East Indies (250 km.) which extends to Sumbawa in longitude 117° E. There are possibilities of extension thence to Australia.

Again, in Europe there is already connexion between the Arctic Ocean and Crete, where there is a sea-gap of 300 km. to the North African coast. A project for spanning this is envisaged in Resolution XIV. In this or some other way, continuity will be obtained with the meridian arc, Cape to Cairo. Of this latter, of amplitude 65° , more than 60 per cent is accomplished, the main gap of 18° being in the Anglo-Egyptian Sudan. The combined system will lead to a meridian arc of 105° .

Resolution I refers also to the junction of the two Americas. At present the North American system is continuous through Canada, U.S.A. and Mexico down to latitude 17° N.

It will be seen that these schemes will lead to the ultimate connexion of all the main land areas; and it is probable that a decade will see the linking of all the main land areas of the northern hemisphere. It is much to be desired that the African arc should also be completed by that time.

Now consider the gravity surveys. Here activity has been great during the last thirty years, and there are some thousands of reliable gravity stations in various parts of the world. In 1849 Stokes showed how the detailed form of the geoid could be expressed in terms of gravity values; but we are still not in a position to obtain a full solution by this means. This is because the distribution of stations is not complete. It is essential that all portions of the globe should have a certain minimum density of stations. Lack of this cannot be made up by much greater density in special regions. Efforts accordingly need to be co-ordinated. This is well recognized by the Association of Geodesy, and a commission to consider the matter of geoidal determination was formed at Edinburgh. Most of the work required for this end is to be done at sea, though there are also land areas, some difficult of access, which remain to be dealt with. Here again we may confidently expect the situation to develop in the course of a decade, so that it will be possible to make good use of Stokes's method. The best means of combining results of this kind with those based on triangulation requires study.

The position of geodesy will be entirely changed when all geodetic surveys are linked and their results expressible in correct relative terms; and this we now expect to be realized in a reasonably short time, owing to the co-ordinating activities of the Union of Geodesy.

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