SOME PROBLEMS OF GONDWANALAND

SINCE the idea of Gondwanaland was first put forward seventy years ago, considerable work has been done in different areas on the stratigraphical, palæontological and tectonic aspects as a result of which we have some idea of the main events in the history of this ancient continent. But the picture of the geological history of Gondwanaland is still far from being complete. We find that new discoveries from time to time have often revealed new possibilities of interpretation, necessitating constant revision of our older ideas. From an overall review of the present position, it is clear that there are still quite a number of problems connected with Gondwanaland requiring proper elucidation. The object of the present paper is to draw attention briefly to some of these problems.

When and how exactly did the Gondwanaland come into existence? When and how exactly did it disappear? Although we commonly talk of the first appearance of Gondwanaland in the Upper Carboniferous period, and connect its birth in some way with the earth movements of that period (Hercynian), the main question is still there to consider, *viz.*, how was this continent actually built up? What exactly was the position regarding these land masses (comprised within the Gondwanaland) and their mutual relationships in the pre-Upper Carboniferous times? To tackle this point, it is necessary to make a detailed comparative study, age by age, of the terrestrial and fresh-water deposits of the earlier periods, with their faunas and floras, found in the present representatives of Gondwanaland, and determine their mutual relationships.

Regarding the disappearance of Gondwanaland, the current view is that this disruption took place in stages, at different times in different places, during the period ranging from Lower Cretaceous to the Lower Eocene. The exact chronological sequence of these stages, and their connection, if any, with the beginnings of the Himalayan upheaval on the one hand, and the Deccan Trap eruptions on the other, have yet to be worked out. There is also the more fundamental question of how this disruption took place,—submergence and/or drift? It may be pointed out that these studies regarding the appearance and disappearance of Gondwanaland have also an important bearing on the problem of fixing the lower and upper age limits of the Gondwana system in each of the present different parts of the old Gondwanaland.

There are also the questions regarding the land and sea connections during the Gondwanaland period. What exactly was the nature of the land connections, if any, between the southern Gondwanaland and the northern Laurasia? When and where did these connections exist? Were they continuously in existence in the same places, or were these connections of the 'make and break' (rhythmic) type shifting about in place and time? What exactly was the nature of the connections between the different parts of the Gondwanaland itself? Several views on these matters have no doubt been expressed from time to time, but there is still a lot of confusion and controversy. A proper solution of these palæogeographical problems must of course take into account the distribution and mutual interrelationships of contemporary faunas and floras. On the one hand, we have cases of admixture of the northern and southern land floras across the Tethys; and, on the other, there are the evidences of admixture of the Tethyan and Indo-Pacific marine faunas across Gondwanaland. All these have yet to be fully investigated and properly interpreted.

Then again, there are the problems connected with the glaciation in Gondwanaland. While the fact of glaciation has been established in several parts of Gondwanaland, the exact age and time-distribution of this glaciation in the different areas, the centres of dispersal of these ice sheets, the question whether there were local or uniformly spread glacial and inter-glacial periods, and, if so, their number and mutual correlation,—are still some of the points requiring full investigation. These studies will also have an important bearing on any theory accounting for this ice age.

In addition to the above, we have the whole field of 'Gondwana Floras' still requiring proper attention. The constituents of the Glossopteris flora in the different parts of Gondwanaland, and their relation to the other contemporary palæobotanical provinces have yet to be fully worked out. Our knowledge of the Upper Gondwana floras is also very limited. It may be said that the whole field of palæobotanical investigations of the flora of Gondwanaland still remains to be fully and systematically explored.

The above are some of the major problems (and at some stage, they all get interrelated)—connected with Gondwanaland, requiring further studies. While it is true that on many of these topics, ideas have been expressed and views put forward from time to time, on the basis of local researches, we have hardly dealt with these problems on a 'Gondwanaland basis', as we must do to evolve a consistent and comprehensive view of the geological history of this ancient continent, and fit it in properly within the wider picture of contemporary Earth History as a whole. These basic and fundamental problems cannot be solved by piecemeal and unco-ordinated research in scattered areas; what is really necessary now is to initiate and carry out intensive and co-ordinated team work according to a well considered 'master plan' to be drawn up by a competent and authoritative agency.

In this connection it is gratifying to note that an International Gondwana Commission has already been set up, and a memorandum incorporating the views of Indian geologists on the subject has been submitted by Dr. D. N. Wadia for discussion at the forthcoming session of the International Geological Congress at Mexico in September 1956.

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U.S. SATELLITE PROGRAM*

TWO additional areas of activity in relation to the worldwide programmes for the International Geophysical Year 1957-58 are of special interest: rocket studies of the upper atmosphere, and the recently announced satellite studies, which represent a logical extension, technically and conceptually, of the rocket programme.

Rockets permit us to make direct measurements of quantities that are either only indirectly observable or are not observable at all, from the ground. They also provide a technique for measuring the altitude dependence of various geophysical parameters. Unfortunately, rockets have two serious disadvantages: (*i*) their total flight is extremely short and the time spent in a particular altitude range is even shorter; and (*ii*) their flight paths are restricted in terms of geographic coverage.

Thus, in spite of the very great value of rocket data, much of which is attainable only by rocket methods, there exists a need for a device that can provide synoptic data over the earth at high altitudes, over appreciable periods of time. As examples, one can cite the following: fluctuations in such solar effects as ultraviolet radiations and X-rays, cosmic ray intensities, current rings encircling the earth, and particle streams impinging on the high atmosphere. These and other phenomena are among the most important problems connected with the physics of the upper atmosphere and with solar-terrestrial relationships.

Clearly an earth satellite would permit observations of the kind indicated above, and the following types of experiments would seem desirable: (*i*) determination of outer atmosphere densities by observation of the air-drag effect on the satellite's orbit; (*ii*) obtaining of more accurate measurements of the earth's equatorial radius and oblateness and of intercontinental distances and other geodetic data than are presently available; (*iii*) long-term observations of solar ultraviolet radiation; (*iv*) studies of intensities and fluctuations in intensity of the cosmic and other particle radiations impinging on the atmosphere; (*v*) determination of the density of hydrogen atoms and ions in interplanetary space; (*vi*) observations of the Stormer current ring; (*vii*) if possible, determination of the distribution of mass in the earth's crust along the orbital track.

How many and what experiments will be undertaken cannot be specified at this time. In part, these depend on the number, size, and pay-load capacity of the satellites. In part, they would depend on choices yet to be made by the United States National Executive Committee for the IGY, in collaboration with interested scientists, for in all probability, more experiments will be proposed than can be fitted into the IGY satellite program.

Work on technical details of the satellite is currently under way. Information now available indicate that the satellites will be small; they will contain scientific instruments; they will be trackable from ground by optical and radio techniques; they will probably be visible to the naked eye under optimum conditions at dawn and dusk, and certainly observable under good atmospheric conditions by means of binoculars and wide field optical equipment.

In size, the satellite may be described as about that of a basketball, although the shape

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* From an article by Joseph Kaplan and Hugh Odishaw in *Science*, 1955, **122**, 1003.