

GEOLOGICAL RESEARCH IN THE CARIBBEAN

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THE island arc of the Greater and Lesser Antilles, and the Caribbean region generally, is an area which has long excited the interests of geologists.

Of recent years, chiefly since the end of World War II, there has been a marked increase in geological activity, due undoubtedly to the political changes that have been and are taking place and to the enhanced realization of the need for the full exploration and exploitation of economic resources.

In Puerto Rico, for example, which, apart from the rapid reconnaissance survey carried out by the New York Academy of Science expedition from 1914 onwards, had seen little or no geological work in progress, the establishment of the Economic Development Administration led to the formation of a section of Mineralogy and Geology in 1956 whose main task is the search for and the development of economic mineral deposits. The section now consists of three geologists. In addition, two cooperative projects are in progress with the U. S. Geological Survey, one for the systematic geological mapping of the island on which six geologists are currently engaged and the other for a long-term investigation of water resources, which occupies two geologists and an hydrologist. A further geologist has recently arrived to work on a watershed project of the Soil Conservation Service of the U. S. Department of Agriculture. Several geologists employed by commercial organizations are also actively engaged on mineral prospecting work.

In Jamaica, virtually no geological work had been done from the middle 1920's, until the end of the war saw the establishment of a Geological Survey in 1949, which now employs five geologists and is basically concerned with systematic geological mapping, as well as water supply problems, search for mineral resources and advice to appropriate government departments and the public in geological matters.

These are but two examples of the increase of interest in geological work in the Caribbean which has taken place during the last ten years or so. Of course, those islands which are fortunate in having abundance of oil—such as Trinidad and Barbados—have received continuous attention over the years.

There is no doubt that the basic driving force in this progress is the economic one, and there is equally no doubt that there is a great need for the education of the public in respect of the whole field of the earth sciences. The layman generally has little or no notion as to what problems are the essential concern of the geologist and has only the most nebulous idea as to what type of practical problem might advantageously be submitted to consideration by a geologist.

In many parts of the Caribbean, for instance, as indeed in other parts of the world, increasing population and changing economy—mostly in the direction of increasing industrialization—are emphasizing the need for adequate knowledge of water resources. The then Governor of the Leeward Islands, Sir Kenneth Blackmore, in his Opening Address at the First Caribbean Geological Conference in Antigua in 1955 paid a very marked and well-deserved tribute to the work of the government geologist in regard to his success in developing and improving the water resources of the Leeward and British Virgin Islands where water shortage was one of the basic problems. Incidentally, in passing he made reference to the commonly held opinion that the work of the geologist "has little to do with the man in the street".

Water shortage, however, is not the only problem, and particularly where industrial development and population shifts are in progress, the distribution and quality of available water is a question of primary importance in planning. This for example, has been recognized in Puerto Rico, where a detailed investigation of water resources is now in progress; but it is likely to be some years before the work is completed. The importance attached to water supply problems was also emphasized in several papers at the Antigua conference, dealing with Trinidad, British Guiana and Jamaica. In all cases the study and development of ground water resources assumes major importance, and this is essentially a geological problem. The work of the geologist engaged on groundwater investigations is greatly facilitated if adequate and reasonably detailed geological maps are available of the area under investigation. A fact that is rarely recognized by the layman and seldom by the government is that geological mapping at a scale to be of any real value takes considerable time and in fact is virtually never completed. The Geological Survey of Great Britain,

the earliest geological survey to be established, was formed in 1835 for the purpose of making a geological map of the British Isles and with the belief on the part of the government department concerned that when the maps were completed the Survey could be discontinued. The Survey is still flourishing, with a large staff, and is still engaged in mapping and revising earlier maps as well as in various other matters of geological importance. In the same way with water investigations, although a survey can be carried out within a prescribed time, the work is virtually never complete, and reappraisals, revisions and added details are always required.

Whilst water is clearly a fundamentally and universally important mineral resource, other types of mineral products must not be forgotten. It would seem that the natural resources of the land are the most important part of a country's economy, and the search for and development of new sources of material should be a primary concern. Nevertheless, it is surprising how slow most governments are to organize this on a systematic basis. Following the discovery of rich mineral deposits, public opinion and hence government opinion tends to become better oriented towards the organization of systematic search and development, and thus slowly the need for basic geological work is realized.

The discovery of the bauxite deposits in Jamaica, for example, was quickly followed by the formation of the Geological Survey Department; and whilst there may not have been any direct connection between the two events, there was probably a definite arousal of interest in the public mind in things geological and hence the creation of an atmosphere favorable towards the establishment of the Survey. It requires an unusual imagination on the part of a government official to appreciate the need for basic geological work in a country which has no obvious mineral resources of the kind that make news, and yet it is in areas such as these where perhaps intensive geological work is most required in order to take the most advantage of what is there. In the absence of mineral occurrences of the more romantic kind, such as gold, silver and now radioactive minerals, the public and frequently the government are slow to realize the importance of developing the more mundane products such as building stones, roadstone, concrete aggregates, limestone for cement, clays for ceramics and so on.

In addition to the search for, evaluation of and development of actual mineral products, the need for geological investigations in connection with engineering works is becoming more and more evident though still far from adequately realized. Whilst in any individual instance a geologist can hardly be expected to guarantee the non-

occurrence of landslides, dam failure, subsidence, beach erosion, excessive sedimentation of reservoirs and so forth, there is little doubt that preliminary geological enquiries undertaken from the very earliest planning stage of a major engineering work will tend to obviate such occurrences and on the whole will result in considerable economy. Such works as highway construction, reservoir and dam construction, and major building, amongst other things, should always be preceded by geological investigation along with the more specifically engineering studies, such as that of the mechanical properties of the soil.

All these fundamental aspects of the economic development of a country—water supply, mineral resources, constructional work, in addition to agricultural problems such as land use, soil erosion, excessive flooding and so on, are all areas in which geology makes a vital contribution. It is seldom even in the most advanced countries that the contribution of geology is exploited to the full.

It is ever a difficult question to draw a clear distinction between what are usually referred to as pure and applied science, but in many ways it is even more difficult than usual in the case of the science of geology. The reason probably lies in the nature of the subject. Geological work in all its varied aspects calls for a man with a well developed and controlled imagination. Without it, even the strictly economic geologist is unlikely to succeed. Basically geology is an historical science. The geologist when investigating any problem, whether it be the structure of a mineral, of a region or of a continent, is essentially trying to answer two questions: What events led to the result that is found today, and in what order did they occur? For example the essential problem in mapping work—and mapping is the fundamental process of geological work—is the elucidation of the chronological sequence of the rocks and of the various events which have affected them, such as folding, faulting, metamorphism, etc. Hence a geological history of the area being studied is gradually put together and fitted into the historical scheme established elsewhere.

The economic geologist, whose ultimate aim is the practical one, of assessing mineral reserves, considering suitability of construction sites and so forth, is still faced with the same problems as the man who is studying an area for purely scientific, academic interest. This relationship between the pure and applied science is well brought out in the works of Charles Berkey, who was largely responsible for the growth of engineering geology in the United States and who in his reports always tried to convey to the engineer the full historical implications of the interpretation of the rocks.

All this tends to stress the need for basic geological research. A geologist called into consultation with regard to any special problem, will not and should not be content until he can see the problem in its full geological context, and hence he will commonly find it necessary to extend his investigations far beyond the limits of the immediate locality involved. Most problems will involve geological mapping, and geological mapping is not a process that can be done hurriedly. A little consideration will show, therefore, the tremendous advantage that a geologist will have, in considering a local problem—say, for example, water supply in a given area or mineral prospecting—if good geological maps are already available. This has been demonstrated time and time again.

A state geological survey department, though the time and energy of its members are frequently diverted to local and special problems, is primarily concerned with the geological mapping of the country. As has already been remarked, this is a process which is virtually never finished. Furthermore, even the preliminary mapping takes time, depending upon local conditions such as the nature of the terrain, accessibility, complexity of the geology and climatic conditions. In Puerto Rico, for example, it is estimated that the mapping program will take approximately one year per man per 1:30000 quadrangle sheet and that with five or six geologists engaged in the survey it will take something on the order of twelve years to complete the first mapping, a circumstance that renders self-evident the need for imaginative forethought on the part of economic planners, a need which is frequently overlooked. If the decision to institute a geological survey is delayed until geological knowledge and advice is needed, then it is already too late, though the geologist will generally try to do his best with what he has.

It comes down therefore to a need for public education. In spite of the experience of other countries, there is still, in countries with recently developing economies, a failure to appreciate the value and indeed necessity for geological research. It is sometimes said that this is due in part to geologists themselves, who have, in general as a profession, been somewhat backward in terms of public relations. There may be some truth in this. A glance at the editorials in 'Geo-Times', the professional magazine published by the American Geological Institute, will distinctly indicate that geology, of all the major sciences, is the one which receives the least public and governmental attention.

This leads to the whole question of geological education. From the economic and practical point of view it is clearly desirable for a

country to develop its own nucleus of scientists. In a rapidly developing area, such as the Caribbean, it is usually necessary to rely on imported experts to deal with specific problems. But this is hardly an economical way in which to deal with long-term research problems such as most geological problems are. Only men who live in and with the problems will usually make a lasting contribution to their solution. A brief survey of the situation in the Caribbean will show that nearly all the geological work in progress is being carried out by visitors—their visits varying in length from a few weeks to several years. In Puerto Rico, of the seventeen geologists at present working on the island, only two are native Puerto Ricans, though it is true that one or two of the others are in the nature of permanent residents. In Cuba nearly all the work that has been done has been by foreign geologists, mainly working for foreign companies. In the British territories most of the work is done by English geologists engaged through the Directorate of Overseas Surveys or by British or American companies. So far, there has apparently been little effort towards the development of a nucleus of native born geologists. The establishment of a Jamaican Group of the Geologists Association of London a year or two ago and of a Geology Club in Puerto Rico are moves in the right direction, towards the encouragement of public interest in the subject. Indeed, geology is one science in which the amateur can make real and important contributions. In Jamaica a start has been made to introduce the teaching of geology in schools; none of the universities in the Caribbean has yet fully established departments in this important branch of science, though favorable developments are being made in the University of Puerto Rico and in the Cuban universities.

Ultimately, the strength of any culture depends upon the intellectual development of the people; therefore, although the interest in immediate economic and material improvement is of obvious importance, attention should be paid to the nurturing of a solid intellectual activity; much lip service is paid to the need for improved education in science, but as this is usually inspired by the pressing need for qualified technicians to man the more complicated gadgetry of modern life, the importance of encouraging the thoughtful and contemplative attitude in science is largely overlooked. Much lip service is also paid to the need for science and engineering students to receive a 'liberal' education—to be exposed to the humanities—but it is seldom realized that true science itself is an 'humanity'.

A true interest in his environment, both immediate and cosmic, is surely to be expected of an intelligent and cultured man. Geology is

a study which is vital to an understanding both of the immediate physical environment and of the wider environment of mankind in time and space.

The Caribbean region is one which is of tremendous interest at both levels. It is a region abounding with local geological problems in need of study, and furthermore it is a region knowledge of which is vital to an understanding of some of the fundamental questions in geology.

For all the evidence points to the fact that the Caribbean island arc is a belt which represents an early stage in the development of a folded mountain system; the rock types and structures are comparable to those that are found in the older mountain belts such as the Appalachians or the Alps. In addition, it is an active earthquake region, with active volcanoes, and associated with it is a belt of anomalies in the earth's gravity field, the latter being close to the Puerto Rican trench which curves around the north and northeastern part of the arc and contains some of the greatest depths in the Atlantic. All these phenomena indicate that something is in progress here, something that is an essential process in the development of the earth's crust.

One of the age-old problems of geology is that of the origin of the continents and ocean basins: Have they always been distributed as they are at present or have they shifted in time? Or have the continental areas been gradually increasing in time? More recent geophysical evidence indicates that there is a real difference between ocean basins and continents, and present day opinion tends towards the hypothesis that the continents have grown by the addition of continental material around their edges, material generated in an environment similar to that found today, and in the recent past, in the West Indian island arc.

Associated with this basic problem are many others, almost as fundamental, such as the nature of the mountain-building—or 'orogenic'—process, the origin of various types of rocks, such as granites and serpentines, the process by which the great variety of volcanic lavas are generated and so forth. It is certain that studies in the Caribbean should be able to contribute to the study of these problems.

Many geological problems too, are interwoven with biological ones. Considerable interest attaches to the study of tropical marine and terrestrial ecology, and in addition the study of the distribution of many forms both fossil and living in the Caribbean region is almost certain to contribute to knowledge of the processes involved in speciation and evolution. This is an area of study where both sciences are

interdependent, since knowledge of the recent movement of land areas and their possible interconnections in the past is of interest to geologists, and this presents a problem which should be tackled both from the geological and from the biological standpoint.

Interest in the Caribbean region in connection with problems of this type is of long standing. In recent years the Caribbean Research Program of the Department of Geology at Princeton University, the submarine geological and geophysical investigations in the Caribbean, chiefly by the Lamont Geological Observatory of Columbia University, and studies of West Indian fossil and living vertebrates by the Museum of Comparative Zoology of Harvard University are a few examples of regionally coordinated studies that exemplify the fundamental attraction of the region to the scientific mind. All these are studies in what might be termed the frontier areas of science.

In an article of this sort it is not possible and indeed not desirable to enter into the details of the problems involved, but at least enough has been said to indicate the importance of geological studies in the Caribbean, on the one hand from the practical and economic viewpoint and on the other from the purely scientific and intellectual.

Although there has been a sharp increase in geological activity in the last few years, there is a tremendous amount yet to be done. The Caribbean abounds in fascinating problems in all areas of the earth sciences and there is no basis for us to be complacent about the situation.