ments do not warrant any immediate change in my theory of root-hair growth.

ROBERT G. H. CORMACK

Department of Botany
University of Alberta, Edmonton, Alberta, Canada

References

1. Ivar Ekdahl, *Symbolae Botan. Upsalienses* **11**, 5–83 (1953), p. 6.
2. R. G. H. Cormack, *New Phytologist* **34**, 30–54 (1935).
3. ———, *Botan. Rev.* **15**, 583–612 (1949).
4. Hugh M. Dale, *Science* **114**, 438–439 (1951).
5. Vera Facey, *New Phytologist* **49**, 103–116 (1950).
6. Marvin Weintraub, *New Phytologist* **50**, 357–382 (1952).
7. R. D. Northcraft, *Science* **115**, 296 (1952).
8. Norman G. Anderson, *Science* **117**, 627–628 (1953).
9. Hans Burström, *Physiol. Plantarum* **5**, 391–402 (1952).

Received February 25, 1954.

Geology of the Iron Deposits of the Congonhas District, Minas Gerais, Brazil

Large iron deposits in the state of Minas Gerais, Brazil, have been the subject of a continuing study by geologists of the U.S. Geological Survey and its Brazilian counterpart, the Departmento Nacional da Produção Mineral under the sponsorship of the Institute of Inter-American Affairs. These deposits are very large and will unquestionably have great future importance, although they have not yet been extensively developed because of their remoteness from the world centers of heavy industry. Reports and maps on the Congonhas district (600 km^2) and other parts of the ferriferous region, which has a total area of several thousand square kilometers, will be published as the work in each district is completed.

The deposits are of three general types: (i) laminated iron formation, or itabirite, consisting of varying proportions of specular hematite (Fe_2O_3) and magnetite (Fe_3O_4), quartz (SiO_2), and lime-magnesia carbonate; (ii) masses of nearly pure specular hematite enclosed in the iron formation; and (iii) surficial cappings of limonite ($Fe_2O_3 \cdot nH_2O$).

Itabirite is a metamorphosed sedimentary rock that occurs principally as the middle member of the pre-Cambrian Minas series. Within the Congonhas district, it ranges in thickness from about 100 to 600 m or more. The average iron content is estimated to be 40 percent. Quartzite and mica schist underlie the itabirite conformably; phyllite with lenticular quartzite, dolomite, minor amounts of itabirite, and some volcanic rocks overlie it. It is believed that the unusual ferruginous sediments were deposited as chemical precipitates of iron oxide, colloidal silica, and alkaline earth carbonates brought into a restricted marine environment by one or more large rivers. The landmass was low; hence, little or no clastic material was introduced. Somewhat acid conditions inhibited the precipitation of carbonates over most of the period of deposition. An offshore volcanic arc probably cut off circulation between the basin and the open ocean, and volcanic emanations may have aided in lowering the pH below the "limestone fence."

Regional metamorphism accompanying severe folding produced specularite and quartz from the siliceous precipitates and magnetite, dolomite, and quartz from the carbonate-bearing sediments. Platy specularite was partially oriented to form an incipient cleavage.

Faulting, in the course of superimposing several large thrust slices, brecciated the iron formation and opened channelways for hydrothermal solutions of unknown source. These solutions replaced the quartz and dolomite with new specularite, giving rise to the local development of high-grade ore deposits. Preexisting bedding, cleavage, and breccia structures were faithfully preserved by fine-grained (average 0.01 mm), unoriented, interlocking hematite that contrasts sharply with the unreplaced platy specularite. Magnetite octahedra, some a centimeter across, were partly or completely altered to hematite. Both proximity to faults and variations in the carbonate content of the original formation localized replacement; the largest known deposit of the district occurs where dolomitic itabirite was overridden by a thrust block.

Descending ground water has leached most of the carbonate and part of the quartz from the itabirite above the water table. Hydration and reprecipitation of iron as limonite over most of the outcrop areas have formed hard cappings, which protect the underlying softened material from rapid erosion. Remnants of old surfaces several hundred meters above present-day intermontane valleys indicate intermittent uplift in recent geologic times.

Surficial leaching has dissolved minor quantities of iron from some hematite ores, destroying the intergranular cohesion and producing friable or powdery material. Mosaic-textured ore with interlocking, sutured grain boundaries resists this leaching better than ore with tabular, oriented specularite grains; and weathering, therefore, exhumes original sedimentary structures that were preserved during metamorphism and replacement.

As the Congonhas deposits have many features in common with numerous iron formations and hematite ores on all continents, their genetic environment, although unusual, was presumably not unique.

PHILIP W. GUILD

U.S. Geological Survey, Washington 25, D.C.

Received March 29, 1954.

Special-Purpose Terrain Evaluations

The U.S. Geological Survey in collaboration with the Soil Survey of the U.S. Department of Agriculture has been engaged for more than 10 years in making special terrain evaluations for application to military planning and operations. This work has been supported mainly by the Corps of Engineers, U.S. Army.

The major military problems considered in the work deal with two main types of use of terrain. The first is construction on and below the ground surface of a wide variety of structures, some peculiar to military activity, but most having counterparts in civilian life. The basic terrain problems in construction have been formalized as a result of extensive and prolonged world-wide research in engineering geology and soil engineering for military and civilian purposes.

The second broad use of terrain is in rapid movement of men and equipment across the surface of the ground away from established roads. Unlike military construction, cross-country movement has few immediate counterparts in civilian life and, therefore, has been studied almost exclusively in terms of the military application. The special problem in cross-country movement for the earth scientist is the determination of the suitability of areas and types of ground for movement of men on foot or, more commonly, of vehicles equipped with wheels or treads. The basic scientific problem is the determination of significant interrelationships between the elements of terrain that influence movement. The evaluation of the influence is the link between the scientific and applied problems.

For successful attack on the problem of terrain evaluation for special purposes, such as those outlined, it has been necessary to reorient the thinking of geologists, soil scientists, botanists, and climatologists from preoccupation with isolated elements of terrain to a constant awareness of the terrain complex. This necessity is apparent in the purpose of the terrain evaluations, which calls for an exploitation of terrain areas, not terrain elements. At the same time, it becomes necessary to cultivate an understanding of the appropriate combination of elements that will define the essential qualities of a region for a specific use. In some cases, it is quite adequate to limit the consideration to two elements, such as rock and soil, soil and vegetation, soil and climate, or rock and terrain form; but commonly at least three or four elements must be appraised in combination. It has been found also that the significance of any one factor of terrain is commonly a variable. For instance, the significance of slope is not proportional to its steepness. In certain uses of terrain, such as off-road movement of tanks, there is a limit beyond which steepness becomes critical, regardless of other terrain characteristics, but below that limit its significance may be entirely dependent on one or more concomitant features. Thus, a steepness of 30 percent would be highly, or possibly completely, restrictive to movement of tanks, if the soils afford poor traction and large trees require sharp turning. On the other hand, an equivalent steepness would not be a serious obstacle where the soil traction is good and trees are lacking.

A second major problem in making special-purpose terrain evaluations is to find the most effective way to present the results. A familiar graphic approach consists in plotting areal data for each terrain element under consideration on separate transparent sheets. To obtain a composite picture, all the sheets can be superimposed and all boundaries that show through can be traced on a single sheet. By this means, it is hoped to delineate on one map all areas with unique combinations of the different terrain elements considered in the evaluation. The result tends to become complex in appearance and to obscure distinctions between boundaries of primary and subsidiary importance.

To overcome these shortcomings, many ingenious cartographic solutions have been attempted. The most sophisticated solutions are generally too difficult for the nonscientific user. Continual experimentation is going on, therefore, to establish simple formats that translate scientific concepts into terms that will permit the user to read directly qualities of terrain for a designated purpose. It is found, however, that greatest reliability is attributed by the nonscientific user to maps that show the scientific bases of interpretation, but in an unobtrusive manner, so that, if desired, an insight can be gained into the contributing factors. From a scientific viewpoint, this attitude is desirable. It gives the map increased flexibility of use and permits reinterpretation of basic data to accommodate certain changes in the conditions of terrain use without a return to original sources. The research is being conducted by trials with a map of a selected area using the same data in each trial and by applying the same principles to maps of different areas and scales.

FREDERICK BETZ, JR.
ARNOLD C. ORVEDAL

U.S. Geological Survey
Washington 25, D.C. and
Soil Survey, Soil Conservation Service
U.S. Department of Agriculture
Washington 25, D.C.

Received March 29, 1954.

Geological Survey Investigations of the Scurry Reef and "Horseshoe Atoll" in Western Texas

One of the most productive oil-bearing structures in North America is a horseshoe-shaped accumulation of limestone buried more than 6000 ft beneath the plains in western Texas. This structure, called the "Horseshoe atoll" because it resembles modern atolls in size, shape, and some lithologic characteristics, is 70 to 90 mi across and in some places more than 1000 ft thick. Its crest contains irregular mounds, basins, and channels; its flanks, which are indented by sinuous reentrants, slope from the crest at angles generally less than 6° and merge into a broad limestone platform on which the atoll is built.

The highest and most continuous part of the Horseshoe atoll is the southeastern part, which underlies Scurry County and is known as the Scurry reef. Oil was discovered in this reef in 1948. Intensive drilling showed that the Scurry reef is the largest oil-producing limestone reservoir in the Western Hemisphere; it is second only to the East Texas field in proved reserves. Prior to March 1954, 35 smaller fields had also been found in the limestone mounds along the crest of the Horseshoe atoll north and west of the Scurry reef.

The Geological Survey began an investigation of the Scurry reef in 1950 in cooperation with the Bureau of Economic Geology of the University of Texas in an effort to determine the age and lithology of the reef, its relationship to the shale that surrounds and overlies it, the genetic significance of the reef, and the probable origin and paths of migration of petroleum in the reef. The objective of this project was to obtain as much scientific information as possible about the nature and origin of this reeflike mass to