GEOLOGICAL MINERALOGY*

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One of my predecessors (Bayley) in his presidential address, referred to mineralogy as "mainly a laboratory science." That has been the traditional classification of mineralogy. The early mineralogist was also a chemist; he was a discoverer of elements, and inorganic chemistry can be considered to be a lusty offspring of mineralogy. Obviously, these pioneers in mineralogy were laboratory men. Both they and their successors have depended mainly upon collectors for specimens on which to work. For the record, the approximate locality where the collection was made has been ascertained. Further data concerning the occurrence have not been sought as a general rule.

During the past the mineralogist has been a bookkeeper, recording observations made with goniometer, balance, refractometer, and other measuring tools. Or he has been a chemist, analyzing and recording the composition of minerals. Or he has been a technologist, determining how minerals can be utilized in our so-called civilization. All of these are laboratory pursuits.

Where are we today? With the exception of mineral technology have not these laboratory phases of mineralogy reached and passed their zenith? Have not most of the angles, indices, and other properties of the known minerals been measured? Have not the minerals been analyzed? It is true that new instruments and methods have made possible more accurate results and so the older observations can be repeated. But is that all that mineralogy has to look forward to, rerunning older work so that results are accurate to the third instead of the second decimal place? I hope not.

Is it not time for mineralogy to venture forth from the laboratory and find out something of the origin of minerals through field studies? We have done a splendid job in assembling facts; let us now turn our thoughts toward interpretation. The natural history of mineral deposits is geological mineralogy, or paragenesis in the broadest sense of the word. The development of paragenesis as a field study was described by Palache in his address as retiring president of the Geological Society. Of all the branches of mineralogy it has been the most neglected.

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Let us consider what is involved in geological mineralogy:

1. Field work. The geological mineralogist must map in detail and in three dimensions the mineral deposit under investigation. His studies should extend beyond the deposit contacts into the country rock. I feel very strongly regarding this latter point. Some years ago Newhouse invited me to contribute an article on the "Structure of Pegmatites" to his symposium on the structure of ore deposits. I then learned that there was very little published on the structure of the country rocks surrounding pegmatite intrusions. Furthermore, I learned, to my chagrin, that I was perhaps the worst offender in ignoring this important aspect of mineral deposition.

Concurrently while these studies are being made, the mineralogist is making an extensive specimen collection. And for his purpose, the most significant specimens are those containing a variety of minerals. A crystal in the hand is worth little compared to one in the matrix.

2. Laboratory work. This involves first the identification of every mineral, using all of the techniques of the laboratory mineralogist, and second, a careful study of the mutual relationships of the minerals in hand specimen, thin section, and polished section.

3. Cerebration. During this period the field and laboratory observations are assembled and studied, and a theory developed for the natural history of the mineral deposit which will be in accord with (*a*) the observations made, (*b*) the laws of physical chemistry,and (*c*) experimental work. This last point was stressed by Bowen in his presidential address in 1937.

4. Publication. With publication of findings the geological mineralogist has another opportunity to contrast his work with that of the conventional laboratory mineralogist. The publications of the latter, being in most cases at least entirely factual, are not subject to dispute. The conclusions of the geological mineralogist invite attack. Someone may duplicate the study and produce an entirely different theory. This leads to stimulating controversy. The only mineral deposit I have studied for which I am reasonably certain that my views on paragenesis will not be challenged during my lifetime is Barringer Hill, Texas. A power company very obligingly went in there after my studies were made and erected a dam which has caused the Barringer Hill pegmatite to become inundated under many feet of water.

Perhaps this account of the procedure followed in geological mineralogy has had a familiar ring. It is, of course, the procedure which has been followed by economic geologists of the "hard rock" type for many years. These geologists are also geological mineralogists, and some of their reports are classics in geological mineralogy. However, ore deposits are but one type of mineral deposit, and the other types also merit study.

The principal reason why the non-commercial mineral deposits have not been studied to any great extent is obvious. Neither a private mining company nor public institution is interested in paying salaries and expenses for such projects. However, I have never been refused a request for expense money from research foundations for studies of this type.

There is another handicap to geological mineralogy. That is the professional mineral collector. He has all the coyness of the old time prospector in divulging the location of the source of his specimens. For example, a number of papers written over 50 years ago describe some interesting minerals supplied by collectors, which came from "near Pike's Peak." A lot of country lies near Pike's Peak, and, on three sides of the peak at least, this country is extremely rugged. Consequently, the search for the source of the "Pike's Peak" specimens was difficult. I had better success in finding the Colorado cryolite deposit. It was described as, "from St. Peter's Dome," which is a mountain to the south of Pike's Peak. It took only five days of mountainside traversing to rediscover this vein.

One can appreciate the reason for reticence regarding the source of mineral specimens upon the part of an individual who is attempting to earn a living collecting. But when after making his collection, he discourages competition and prevents future study on the part of the geological mineralogist by setting off a blast which destroys access to the deposit, he is going much too far. To my surprise and regret I have also found museum curators, who are supposed to be men of science, guilty of such practices. It would not be so serious if the museum mineralogist took the proper notes and so collected his specimens that he, or someone else, could prepare later a paper on the paragenesis of the deposit. But, on the contrary the procedure of the usual curator, upon returning to headquarters, is to "clean" his specimens with cobbing hammer and dental tools until each is composed of a single mineral which has the purity of, and to the geological mineralogist about as much interest as, a bar of a well known brand of soap.

However, in spite of these handicaps, the opportunities in geological mineralogy were never greater than they are today. There are many here better qualified than I to tell of the opportunities which the economic geologists have, and have had during the war years, of working on the geological mineralogy of ore deposits. But the type of mineral deposit that has had the greatest relative development during the war years has been the pegmatite. No figures are available, but it is my humble guess that nearly as many pegmatites were opened up for exploitation during the war years as were developed in all previous historic time. I hope that someone better informed than I will tell us about the part played by the pegmatite minerals in World War II. One would gather, from the large number of geologists and mineralogists employed on pegmatite surveys by our government alone, that this role was an important one. The six papers on pegmatites listed on tomorrow afternoon's program are a result of these investigations. It is to be hoped that all who were assigned to pegmatites will prepare papers on the paragenesis of the deposits studied. But even if this should be done there will still be enough of these mineral deposits left to satisfy geological mineralogists for years to come.

But one does not have to work solely in ore deposits or igneous rocks in order to enjoy the pleasures of geological mineralogy. The sediments of both the present and the past contain many challenging problems. Tracing river and beach sands and gravels to bed rock source is a mineralogic and petrologic problem that has interested a number of investigators. The opportunities for further studies in this field are practically unlimited. Only a beginning has been made in using the mineral composition of drift materials to determine directions of ice movement.

Paleogeology, that relatively new field of study that promises to be so important in discovering the oil fields of the future, needs mineralogists to trace the grains in the sandstones back to their source. We in this country have not progressed as far in mineralogic studies of this type as the British had 40 years ago.

Last, but not least, among the opportunities for mineralogic work in sedimentary geology, are those presented by the chemical sediments. Since Van Tuyl's monograph on theories of dolomitization many of the great dolomite formations of the United States have been penetrated at innumerable points by wells drilled for oil, giving us a three dimensional picture of dolomite distribution not available before. New studies should be made of dolomitization, based on this evidence.

Likewise we now have excellent records, including well cores and cuttings, of many of the evaporite deposits in the United States. The experimental work of Usiglio on deposition of oceanic salts, now nearly 100 years old, does not have the applicability here that it has had at Stassfurt. The evaporites in the sedimentary basins of the United States present a magnificent opportunity for research in geological mineralogy.

Conclusion. Let there be more geological mineralogists! The only requirements, outside of educational background, are a prodigious curiosity, a vivid imagination, and a thick skin.