BOOK REVIEW

MICROSCOPICAL DETERMINATION OF THE OPAQUE MINERALS. JOSEPH MURDOCH, of Harvard University. 165 pp. Wiley and Sons, *New York, 1916*.

Metallography, the study of metals by polishing and etching their surfaces, and examining them under the microscope with vertical illumination, is widely practised, but *mineralography*, as the corresponding method of investigation applied to opaque minerals is termed in this volume, is but little known. Dr. Murdoch's pioneer work in this field is thus of great importance, and is presented in the book before us in a most useful form, comprising an elaborate account of the history of mineralographic work, a brief discussion of methods, and the presentation of the results of the examination of no less than 186 opaque minerals. The latter are arranged in a well worked out determinative table, based primarily on color, hardness, and behavior toward certain reagents.

One of the most interesting chapters is that entitled "Mineral composition and identity," in which the frequency of inclusions in opaque minerals is demonstrated, and the erroneous conclusions as to their composition usually drawn are pointed out. Many supposed mineral species are shown by mineralographic examination to be mixtures, and their withdrawal from mineralogic literature is recommended; some of the most important of these are as follows (listed by reviewer according to Dana's classification):

II. Sulfides, etc. A. Basic division: Algodonite, animikite, domeykite, keweenawite, mohawkite, and temiskamite;

C. Intermediate division: Barnhardtite, carrollite, and cubanite;

D. Disulfide division: Alloclasite;

III. Sulfo-salts. Brongniardite, klaprotholite, kobellite, plenargyrite, schapbachite, and tapalpaite.

On the other hand the existence of several new minerals is indicated by these studies, of which, as examples, may be mentioned: "orange bornite," orange yellow to yellow-brown inclusions often observed in ordinary bornite; "purple galena," a pale purplish gray mineral resembling galena in some respects, occurring associated with silver and niccolite; and "cream mohawkite," one of the constituents of the supposed species mohawkite and other similar materials. The compositions of these remain to be ascertained.

Dr. Murdoch's observations are most valuable, but it is to be regretted that he has not been able to "tie up" the compositions of the various minerals studied with their properties in more cases. Bornite it has been possible to analyze, and material determined by mineralographic examination to be free from inclusions has always proved to have the formula Cu_5FeS_4, a correction of the one given in most books; the crystals of smaltite and related minerals are shown in this way to be zoned, and "it is accordingly not surprising that analyses, even of crystals, have given variable results, and consequently some of the formulas assigned to these minerals are probably wrong." But in the vast majority of cases formulas are taken bodily from Dana and other sources without critical examination and without intimation that there is any doubt about them. In one case, chilenite, p. 125, the formula given (copied from Dana), is certainly wrong, as a moment's calculation from the analyses will show: it should be $Ag_{10}Bi$, rather than Ag_6Bi. In another, melonite, the latest work indicates $NiTe_2$ rather than Ni_2Te_3. In others formulas are used which have been calculated on the assumption that the analytical results are far more accurate than is usually the case, as for instance hauchecornite, which is given the ratio metal: acid$=7:8$, but for which $1:1$ seems more probable; polydymite, the isomorphism of which with linnaeite shows its ratios to be 3: 4 rather than 4: 5; and nagyagite, for which Hintze's ponderous formula, $Au_2Pb_{10}Sb_2Te_6S_{15}$ is retained.

Another possibility which is not considered is sub-microscopic intergrowth. As the reviewer has repeatedly pointed out, microscopic visibility ceases at about one-half the wave length of light, but mineral particles somewhat less than this size contain many thousands of molecules or atoms, and are therefore capable of individual existence, even tho invisible. The presence of such particles is the probable explanation of many of the apparent abnormalities in composition of certain minerals, so it is by no means safe to say that such minerals, of which steinmannite, antimoniferous galena, is a typical example, have the "extra" elements chemically combined, merely because the microscope shows no admixture.

These faults, however, do not detract essentially from the worth of Dr. Murdoch's contribution, which represents a most valuable addition to the literature of mineralogy. E. T. W.