

more different minerals present which might easily account for the foreign elements found by analysis. As has been seen in the case of cobaltite and smaltite, even the most perfect crystals may contain considerable amounts of foreign minerals either as inclusions or intergrowths. Such inclusions are very likely to be a mineral or minerals similar in crystal symmetry and analogous in chemical composition to the including mineral, e.g., the inclusions of niccolite in breithauptite (Fig. 8), or the smaltite-chloanthite intergrowth (Fig. 17). This is not always the case, however, examples of the latter type of intergrowth are furnished by inclusions of cobaltite (cubic) in niccolite (hexagonal), Fig. 13, and rammelsbergite (rhombic) in niccolite, Fig. 26. The former type of associations appears to be mixtures or intergrowths of more or less related, or isomorphous individual minerals, rather than homogeneous molecular mixtures.

Most of our knowledge of isomorphism rests on the data of chemical laboratory experiments. Nernst²¹ refers to isomorphous mixing as "the capacity of two crystallized substances for uniting to form a homogeneous mixed crystal." Retgers²² speaks of "the property of forming solid molecular mixtures." The chemist takes special precautions in order to obtain homogeneous mixed crystals. Retgers recommends in making mixed crystals, that "in order to obtain a product as homogeneous as possible, it is best to use a large quantity of solution and to study only the crystals which separate first."

In nature, however, these ideal conditions are probably seldom realized, and in the case of the arsenides and sulpharsenides of Cobalt, at least, the result is oftener a very intimate mixture or intergrowth of the two isomorphous substances than a true homogeneous molecular mixture, even when good crystals are formed. The etching methods described in the introduction enable us to distinguish very definitely the different components of such a mixture. The separation experiments performed on certain of these mixtures, e.g., niccolite-breithauptite, smaltite-chloanthite, seem to show that the individual components may be precipitated side by side as minute particles in extremely intimate microscopic mixtures or intergrowths and still retain their chemical identity and purity. There is this difficulty, however, with such etching separations, that only the residue may be expected to be pure and homogeneous, and if such a pure residue is obtained, it does not prove that some of the material which dissolved was not a homogeneous molecular mixture. It seems certain, however, that in most of the mixtures examined by the author, the amount of material which may represent true isomorphous molecular mixtures must be small compared to the amount which exists as pure chemical individuals.

Whether special conditions of precipitation were responsible for this character of the Cobalt minerals or whether it is a general characteristic of the arsenide and sulpharsenide groups of minerals, is a problem for the future. Baumhauer²³ and Vollhard²⁴ were the first to show that crystals of smaltite or chloanthite (from European localities) were really intergrowths, the different parts of which varied in composition. The writer suspects that such intergrowths are general among the minerals of these groups and that true molecular isomorphous replacements or mixed crystals are correspondingly rare.

²¹ W. Nernst—Theoretical Chemistry.

²² Idem, page 109.

²³ Loc. Cit.