



Fig 6.—Comparatively fresh ore-rock, showing typical ophitic structure, with feldspar in excess, in a groundmass of diallage. Crossed nicols.—Magnified about 50 diameters.

quite large, with no approach to crystal form. Seen in ordinary light, the grains appear as one individual (See Figs. 2 and 4). But between crossed nicols, the mineral has a marked undulatory extinction, and the mass breaks up into a mosaic of small and irregularly oriented grains, showing the effect of severe crushing. The epidote is usually quite fresh, but where most crushed and granulated, it is intergrown with secondary hornblende and chlorite. (Fig. 3). The epidote stands in very close relation to the sulphides, and the origin of both is no doubt closely connected with the same metamorphic processes.

The chief pyroxene is diallage. It is usually in rather irregular plates, without crystal outline, and shows a more or less fibrous cleavage. A regular intergrowth with hornblende is common. (See Fig. 4). The diallage is in various stages of alteration, first changing to secondary hornblende, and then to the variety of chlorite, pennine. The alteration takes place along the cleavages, and from various centres. The brown color is bleached, the double refraction becomes weaker, and a fibrous aggregate of hornblende and chlorite results.

The next most important mineral is the brown hornblende. This is evidently primary, and shows the usual pleochroism and cleavage. In part it is quite fresh, but more often it is altered to secondary actinolitic and tremolitic hornblende, and finally to chlorite. (Hornblende, in various stages of alteration are seen in Figs. 1 and 2). The secondary green hornblende, which is very abundant, is derived from both the pyroxene and hornblende. It is partly in the form of irregular grains but more frequently in tufts, and fibrous masses, irregularly oriented. A further alteration ends in a confused mass of hornblende fibres and pennine, mixed with indefinite secondary products.

Calcite as a secondary product is often quite prominent, especially in connection with the ore and epidote. (Fig. 2). The usual accessory minerals of gabbro occur in small quantities, but are not important.

Relations of the Ore.

The relation of the sulphides to the rock minerals is very characteristic. In all the sections belonging to this type of rock described above, they are identical, and fully demonstrate the secondary nature of the ore.

That the rock has been subjected to the forces of dynamic metamorphism, is borne out by the microscopical examination. The constituent minerals are brecciated and deformed, and the rock is crossed by many small breaks and cracks, both of a megascopic and microscopic nature. Along these lines of weakness, the effects of pressure and strain are most apparent. The granulation and alteration of the minerals is here most pronounced, and ore is always present in the form of veinlets, following the direction of the fracture planes. Under these circumstances, calcite and epidote are usually abundant, and from this it may be inferred that the ore has been formed in part later, by means of circulating waters, as well as during the actual metamorphism. Such veinlets are shown in Figs. 2 and 3; very typically in the latter. It is not likely that actual open fissures resulted, or ever existed. The effect of the dynamic stresses was to prepare a line of least resistance, along which the ore-bearing solutions found their way, and left the minerals in such a condition that they could be easily replaced. Fig. 3 shows this distinctly. The ore has replaced the brecciated minerals along such a fracture plane, and left small residual grains unreplaced and surrounded by ore. The veinlets often cross the entire section, but are never uniform. They expand and contract, and send out ramifications among the surrounding minerals, in a very typical way, and replace them to a considerable extent.

In connection with the epidote also, the sulphides are prominent. They form an irregular network, between the grains, which make up the larger aggregates. They force their way between the grains, etching them, and finally isolating them from the main mass. They find their way along cleavage cracks, and planes of weakness, so that the grains finally appear in a matrix of sulphides, which holds them together. (See Figs. 2 and 4).

Replacement has gone on most actively in connection with the epidote, pyroxenes and hornblende, and their alteration products. But where the feldspar has been crushed and broken, it is also attacked and is very frequently seamed with sulphides, though to a smaller extent than the bisilicates.

The rock contains a considerable amount of magnetite, of a primary nature, but as before, it presents a strong contrast to the sulphides. It is in the form of rounded or elliptical grains, and never has the numerous vein-like ramifications, which characterize the latter.

(3). A third variety of ore-rock is found in the shaft. It belongs to the gabbro type, but is much lighter in color than the others, owing to the prominence of large individuals of a whitish feldspar. Taken as a whole, the rock is very similar to the last, but with a number of interesting variations. Alteration has reached an advanced stage: the feldspars are composed of turbid masses of secondary products, and both hornblende and pyroxene are almost completely changed to secondary hornblende and chlorite. The epidote which was so prominent in the other variety is here lacking, and diallage cannot be identified with certainty. It is evident that a great deal of the secondary hornblende was derived from original pyroxene, but this could not be directly proved.

The most interesting mineral is the feldspar. Along its cleavages, and bordering the altered mass, is a clear, fresh, glassy feldspar, which is much more acid in composition than the main mass. That it is not a simple zonal arrangement, appears from the fact, that the fresh feldspar is found along the breaks as well as around the edges. We must therefore be