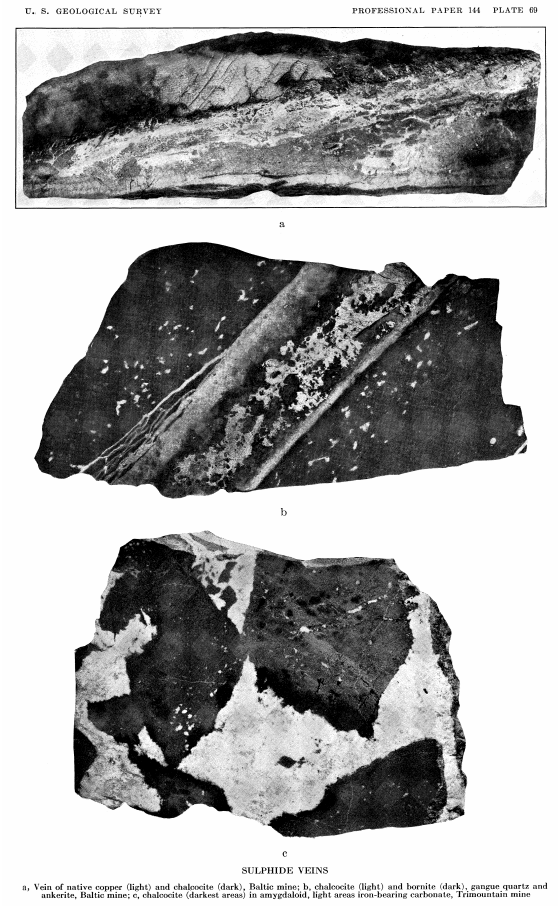
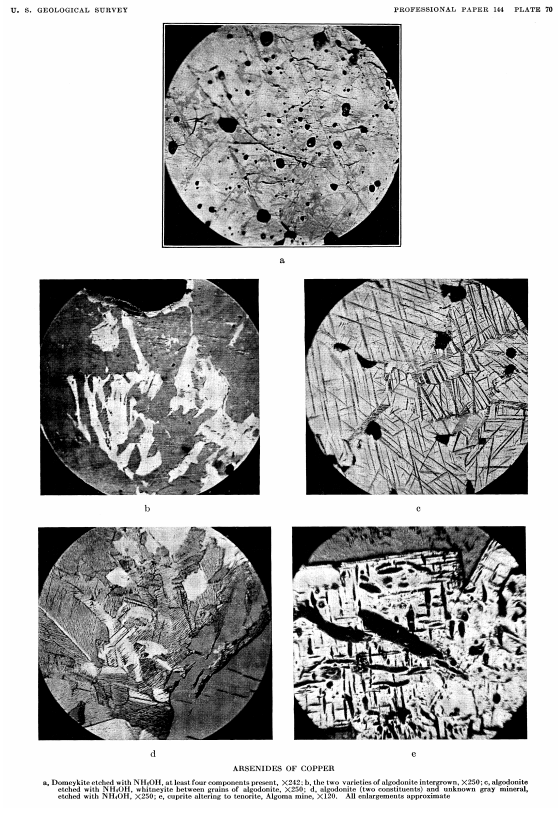
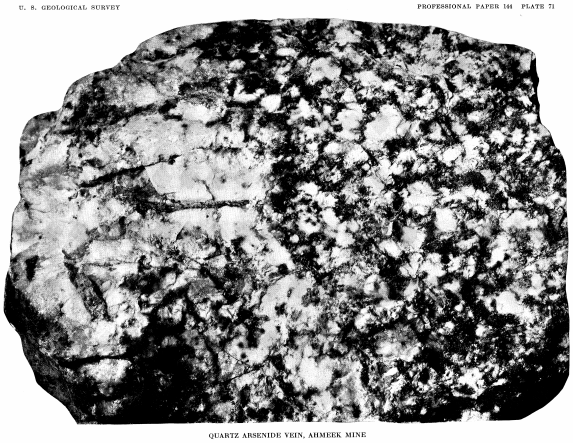


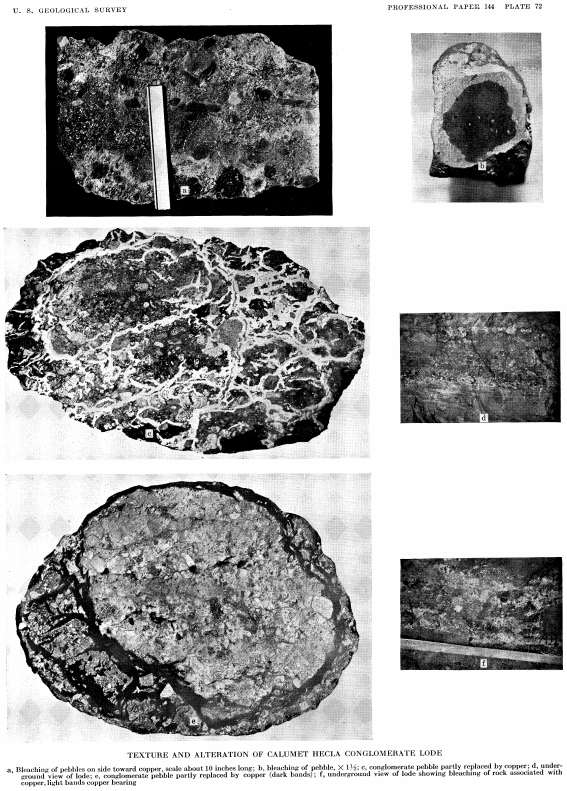
[PLATE 69. Sulphide veins.]



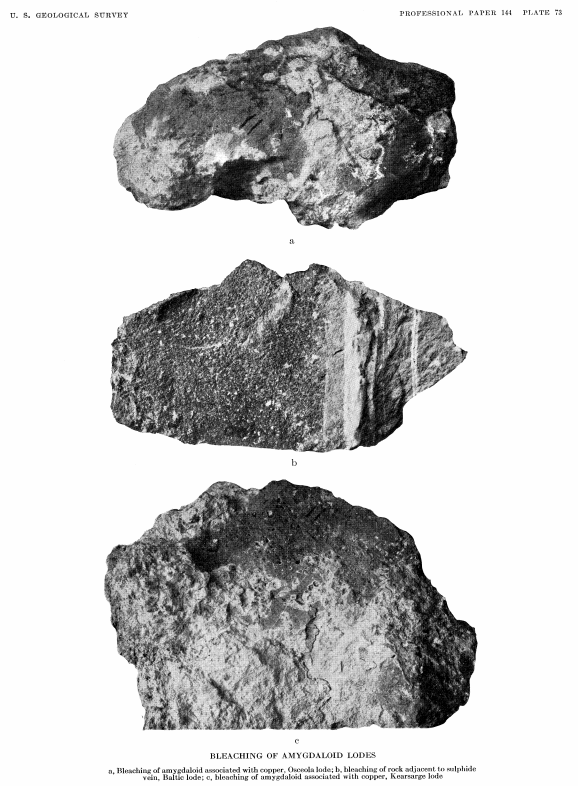
[PLATE 70. Arsenides of copper.]



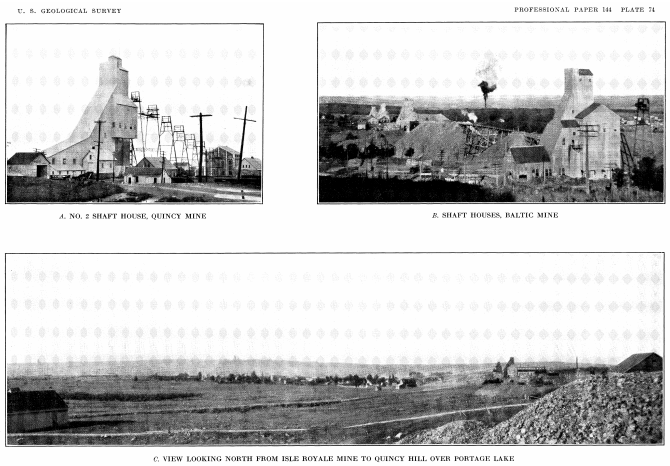
[PLATE 71. Quartz arsenide vein, Ahmeek mine.]



[PLATE 72. Texture and alteration of Calumet & Hecla conglomerate lode.]



[PLATE 73. Bleaching of amygdaloid lodes associated with copper and sulphide.]



[PLATE 74. *A*, No. 2 shaft house, Quincy mine; *B*, Shaft houses, Baltic mine; *C*, View looking north from Isle Royale mine to Quincy Hill over Portage Lake.]

The result might be that in lodes in which the solutions traveled long distances nearly all the sulphur and arsenic was oxidized, but where the distance was shorter some of the sulphur and arsenic would remain unoxidized. It might be expected that with increasing depth down a given lode—that is, toward the intersection with the Keweenaw fault—the proportion of arsenic and of sulphur would increase. There is a suggestion that this is true as related to arsenic, for it has long been believed that the arsenic content increases with depth; this relation, however, has not been proved. The Keweenaw fault is of course not proved to be the channelway for the ore solutions, but the relations outlined suggest that it was the channelway quite as much as they explain the distribution of sulphur and arsenic. They support the general hypothesis but without proving any part of it.

The copper contained in the pegmatitic streaks in trap occurs partly as sulphide; is this because the liquors that deposited it were never in contact with the oxidizing influence of red rock? Hematite is abundant in the pegmatite lenses, and it seems probable that as the rocks cooled these lenses went through much the same history as the copper deposits. At the proper temperature this hematite tended to oxidize the sulphur of the solutions but evidently was not sufficiently active to cause all of the copper to deposit as metal. Why the sulphur was not all oxidized is not clear. The copper occurring in fissures closely associated with intrusive masses, as at Mount Bohemia, and therefore deposited before having migrated far from its point of issue, is likewise chiefly or wholly in the form of sulphide, and the same lack of opportunity for oxidation may be the reason why it is not native.

Taken as a whole, the field evidence seems to indicate that metallic copper was deposited in abundance only in hematite-rich rocks or in close proximity to such rocks. Most of the sulphide and arsenide compounds of copper are confined to fractures that allowed the solutions to ascend either for long distances through trap or at any rate with less intimate contact with the hematite of the lodes. Further evidence of oxidation of the copper-bearing solutions is recorded in the following section.

DESTRUCTION OF OXIDIZING AGENT—BLEACHING

The amygdaloid and conglomerate layers have a red color because of their content of minute crystalline flakes of hematite that was formed before the deposition of copper. When copper was deposited the hematite was in part destroyed.

The following sets of analyses show the content of ferric and ferrous iron in the unaltered red rock and in the adjacent bleached equivalent close to metallic copper and the chemical change that has taken place in the rock during mineralization. This change is shown diagrammatically in Figures 17 and 18.

It is apparent from these chemical results, as well as from the microscopic study of the rocks, that the copper-depositing solutions first attacked the hematite and that the iron was largely removed or recombined before there was any conspicuous change in the other constituents. The copper replaced the rock substance as a whole, but in advance of this replacement the hematite was destroyed and the iron removed either entirely or in part, and whatever remained was combined into other minerals. (See pls. 72, 73.)