2. Chert and jasper have been formed in places by the replacement of limestone by the silica in these waters.

3. Jasper and ferruginous chert have been formed in many places by the replacement of the Hardyston quartzite by these waters.

4. The mapping of areas wherein jasper and ferruginous chert are found might be carried out on the basis of the following suggestions:
   a. In known limestone areas the presence of jasper and ferruginous chert may be considered as having been formed by replacement of the limestone.
   b. Where the areas of these materials are in structural continuity with the Hardyston, are found together with the Hardyston, or are on the higher slopes or tops of pre-Cambrian hills they should be considered as having been formed by replacement of the Hardyston.

**Shales.**—In scores of places limonite iron ore has been mined in the past from the Hardyston, as will be described in a later chapter. The ore was generally found in a matrix of yellow, red, white or black clay. An examination of numerous old mine dumps reveals many angular blocks of jasper, ferruginous chert and occasional sandstones. The occurrence leads to the conclusion that the ore bodies lie within this formation and it, therefore, is necessary to account for the origin of the clay. The siliceous types of rocks described above can not have been the source of the clay so it seems necessary to assume that the Hardyston contains much shale, especially in the upper portion, although the writers have never seen any development of shale in the formation in this region such as must have been present to explain the large deposits of clay. An exposure of calcareous shale near the top of the formation is reported in the bed of a brook near the old Thatcher Mine east of Stewartsville, N. J., only a few miles east of the Northampton County line. So far as known, no mine workings were ever deep enough to locate shale, although some were over 200 feet in depth. With the known facts, we reach the conclusion that shale masses occur within the Hardyston at different horizons from the base to the top, since ore in clay occurs at these different places, and that these shale bodies were lenticular, extending to variable distances along the strike, and absent in many places.

Since the overlying Tomstown contains numerous shale beds or lenses and its contact with the Hardyston is everywhere concealed where ores have been mined, it has appealed to some people to assign all the "mountain ore" limonite bodies to the Tomstown. The association with undoubted Hardyston and the characteristics of the ore do not seem to support this view, although it may well be that in some cases the mines shown on the map as included in the Hardyston may more properly be assigned to the Tomstown.

**Pinite.**—In several localities, many more in Lehigh than in Northampton County, a peculiar soft, dense, light-green rock is present