

ART. XLVII.—*On Secondary enlargements of Feldspar fragments in certain Keweenawun sandstones*; by C. A. VANHISE.

RECENT observations by Sorby,\* Irving,† and others‡ have shown the occurrence in sands and sandstones, and even in the most indurated quartzites, of a secondary quartz, so placed upon each one of the original grains of quartz as to be crystallographically continuous with it. This occurrence and the explanation afforded by it of the change of a sandstone to a quartzite, naturally lead the lithologist to query whether similar enlargements may not occur in the cases of other minerals found as particles in rocks of fragmental origin, and thus still further light be thrown upon the origin of some of the crystalline schists. Bonney, for instance, in speaking of certain of the crystalline rocks of Cornwall, England, conjectures the possibility of such occurrences in the following words.§ “These larger feldspar grains, for instance, may have as their nuclei feldspar grains which were original constituents, and may have survived the dissolution of the finer sedimentary materials in which they were imbedded. Then in the process of re-constitution, feldspar (not perhaps always of the same species) may have been added to feldspar, quartz to quartz, mica to mica and hornblende to hornblende or altered augite.”

Of the minerals mentioned by Bonney, quartz and the feldspars, because of their abundance, are evidently by far the most important. For some time past, during my microscopic studies, I have been on the outlook for evidences of the existence of enlargements of feldspar fragments. In the slate conglomerates of the north shore of Lake Huron, I have found what seem to be enlarged feldspar grains, but the evidence that any of the material is of secondary origin is not sufficiently satisfactory, the lines of separation between the supposed new material and the nuclei being ill marked. However, I have found what seem certainly to be additions to grains of that mineral, in certain of the Keweenawan feldspathic sandstones. The specimens in which these supposed enlargements were first found are taken

\* Presidential Address before the Geological Society of London, Q. J. G. S., vol. xxxvi, 33.

† On the Nature of the Induration in the St. Peters and Potsdam Sandstones, and in certain Archæan Quartzites in Wisconsin, by R. D. Irving, this Journal, III, xxv, 401.

‡ Young, this Journal, III, xxiv, 47; Wadsworth, Bost. Soc. Nat Hist., Feb. 7, 1883; Philips and Bonney, Q. J. G. S., xxxix.

The same occurrence was noted in the quartzites of Eureka, Nevada, by Idings and Arnold Hague as long ago as the summer of 1881, although these observations are not yet published.

§ The Hornblendic and other Schists of the Lizard District with some additional notes on the Serpentine, by T. G. Bonney, Q. J. G. S., xxxix, 19.

from those portions of the sandstones almost in contact with overlying basic eruptives. This location is evidently a favorable one for the development of such enlargements, the heated alkaline waters which would naturally descend from the overlying lavas supplying appropriate conditions. Then too, quartz enlargements when most easily found, are shown by lines of ferrite about the nuclei, and are ordinarily best seen in the less indurated quartzites. The Keweenaw sandstones are highly ferruginous, and are of an open texture; hence, if among them feldspars have taken new growths, the conditions for their detection are favorable.

1.

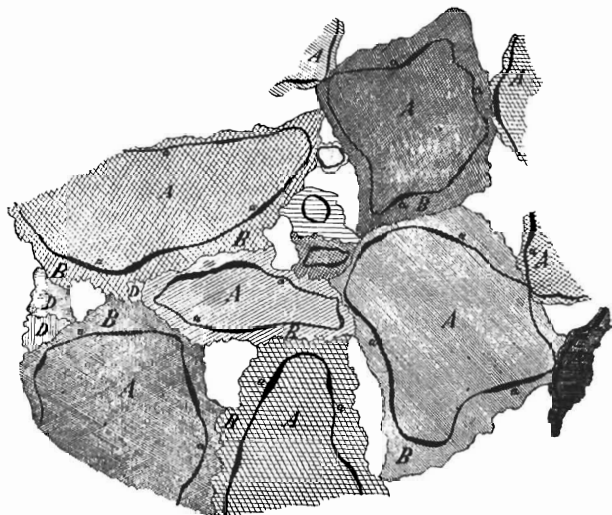


Fig. 1. Part of section of sandstone from Eagle Harbor, Mich.,  $\times 100$ ; in polarized light. AAA, fragments, each from a single feldspar individual; aaa, films of iron oxide on the borders of the original grains; BBB, secondary enlargement of the original grains; C, quartz grains; DD, unfilled spaces; EE, secondary feldspar grains polarizing independently of the original grains.

The feldspathic sandstone immediately underlying the diabase of Eagle Harbor, Michigan, is of a uniform medium grain, a magnifying glass showing but little quartz. The feldspar grains are stained red with iron oxide. Hydrochloric acid gives with the powder a slight effervescence. In thin section the sandstone is seen to be composed largely of grains of different feldspars, next to which in abundance are rounded complex fragments derived from a granitic porphyry,\* consisting of

\* The Copper Bearing Rocks of Lake Superior; by R. D. Irving. Third Annual Report United States Geological Survey, p. 114.

feldspars penetrated by a saturating quartz. Next in order of abundance are complex fragments of some altered basic rocks. Finally a few grains of quartz and a little secondary calcite are noted.

The feldspars are frequently somewhat kaolinized, but most of the grains are fresh enough to give quite uniform colors in polarized light, and, in the case of the plagioclases, well defined twinning bands. The grains are all rounded, their boundaries being marked by broad lines of ferrite. However some subsequent mineral has used these grains as nuclei, about which to deposit, and now each individual appears in the polarized light to extend beyond its original limits. These newly formed borders, as compared with the interiors, are different, in that they show no decomposition, and are freer from iron stains. When the borders from different feldspathic grains have extended so far as to come in contact, as they usually have done, they form sharply serrate, nicely fitting junctions, which are roughly comparable to the suture of a skull (fig. 1.)

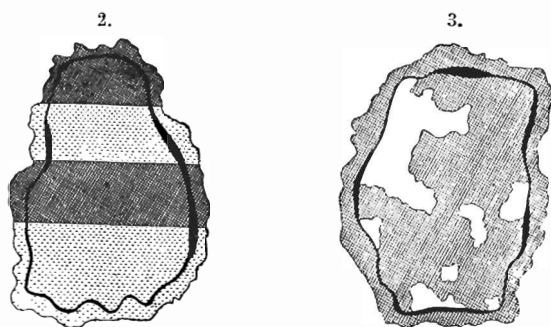


Fig. 2. In polarized light:  $\times 100$ . Plagioclase from Eagle Harbor sandstone, showing crystallographic continuity of original grain and secondary enlargement.

Fig. 3. In polarized light;  $\times 100$ . Fragment of a grain of a granitic porphyry from Eagle Harbor sandstone.

This newly added material appears to be feldspar which has coördinated crystallographically with the grains about which it has deposited. It possesses no optical properties which would exclude that mineral, but cleavage and decomposition being absent, no comparison with the feldspars can be made as to those characteristic features. The belief that the new material is feldspar is, however, supported by the following facts.

When the enlarged feldspar is orthoclase, the deposited substance polarizes uniformly with the nucleus about which it is

seen (fig. 1), exactly as quartz enlargements polarize with the grains on which they have grown. Further, when plagioclase is enlarged, as it frequently is, the new material has twinned uniformly with the old, the twinning bands in polarized light running continuously across cores and the added borders (fig. 2). This phenomenon was observed in many different grains and in different sections.

Again, the complex fragments above mentioned as derived from a granitic porphyry, and as containing quartz and feldspar, often have borders of new material and the added portions resemble, and usually polarize with, the feldspars instead of with the quartz, with which they would naturally coördinate, if with either, were they composed of silica. Frequently the exteriors of this class of grains are apparently all of feldspar, even when a third or more of the edges of the original fragments (and in some places for considerable spaces continuously) are of quartz (fig. 3). The grain figured consists of part of a single, orthoclase individual, including several areas of quartz. The secondary enlargement polarizes with the feldspar throughout its area.

4.

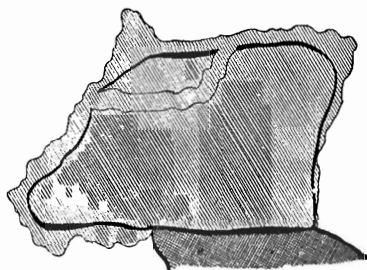


Fig. 4. In polarized light;  $\times 100$ . Part of section of Eagle Harbor sandstone, showing an orthoclase fragment broken and re-cemented by a secondary material crystallographically continuous with the original fragment and with the border of newly deposited material.

Finally, the complex basic fragments also have their borders of new material. These basic grains are often very feldspathic, the feldspar individuals being, however, small. Here an enlargement instead of being a unit, as it commonly is in the preceding cases, consists of several or many individuals. The feldspars at the edge of the nucleus have ordinarily controlled the new growth, so that the new material polarizes in parts with the old interior grains. These parts have, however, often extended upon each side beyond the adjacent feldspars, and thus at times overlapped other feldspars—whose conditions

were less favorable for renewed growth—or other minerals, if such chanced to be in contact with the division line between the clastic fragment and its border of new material.

The change which has taken place in one grain of orthoclase is of some interest. The grain has been broken into two parts, which have spread somewhat, and is now cemented with a new material which extinguishes with the original fragments, and also with the exterior second growth, with which it is continuous in one place (fig. 4).

In some cases the new material deposited on a grain, instead of continuing as a single individual until it meets a similar growth from another grain has crystallized independently in small interlocking grains (fig. 1). This independent feldspar (if we are correct in so considering it) is more plentiful about the basic fragments than about the feldspar grains or those of the granitic porphyry.

Uncovered thin sections were prepared and the supposed feldspar enlargements tested—so far as practicable—as to hardness with a needle and as to solubility in hydrochloric acid. With difficulty some of them were scratched, and they were not affected by the acid. The results of these tests accord well with the idea that the borders are feldspars, and show that they cannot be a carbonate.

Most of the sections of the Eagle Harbor sandstones also show quartz enlargements, but in one none were seen.

This same secondary material has been found in other sandstones in the Keweenaw series, and in two cases the sandstone directly underlies “greenstone.” Descriptions of these, however, will not be given, as they furnish no additional points of interest.