ART. XLV.—*On the Corundum-bearing Rock from Yogo Gulch, Montana;* by L. V. PIRSSON.

THE corundums whose occurrence and character have been described in the foregoing paper, are found in a dike of igneous rock cutting the sedimentary beds near the entrance of Yogo Gulch. While the corundums, which are washed out as gems, occur in that portion of the dike which has been highly altered and decayed, comparatively little altered material is also obtainable, and the opportunity to study a specimen and some sections cut from it the writer owes to the kindness of Mr. W. H. Weed of the U. S. Geological Survey.

In the hand specimen the rock is of a dark gray, basic appearance and has an uneven fracture. It contains light green or white included fragments which form its most conspicuous feature, and these angular inclusions are probably pieces of limestone broken off and carried upward by the fluid rock in its ascent. They vary in size from those of microscopic dimensions to some that are a centimeter across. Many of them consist entirely of calcite, while others appear to be made up wholly of a pale green mineral which is probably a pyroxene. The largest inclusions show a reaction rim of the same green pyroxene, the rim being about one millimeter thick, while the entire center is of calcite with scattered prisms of the same green pyroxene. The rock itself shows only a few scattered tablets of mica two or three millimeters in diameter as phenocrysts, while the groundmass glitters with minute flecks of biotite, and considerable pyroxene is seen.

It is in this rock that the sapphire occurs imbedded in large, distinct, well-formed crystals as described in the previous paper. They show the corroded, etched surfaces characteristic of this occurrence and often have traces of a blackish crust upon them.

Microscopical. In thin section the rock at once shows its character as a dark, basic lamprophyre, consisting mainly of biotite and pyroxene. There is a little iron ore present, but its amount is small and much less than is usually seen in rocks of this class. The biotite is strongly pleochroic, varying between an almost colorless and a strong, clear, brown tint. It occurs in ragged masses, rarely showing crystal outline, and it contains a large amount of small apatite crystals. The pyroxene is of a pale green tint with the habit of diopside and is filled with many inclusions, now altered but probably originally of glass; in some crystals these inclusions are so abundant as to render the mineral quite spongy. The grains sometimes show crystal form but are mostly anhedral and vary in size, though the evidence is not sufficient to show two distinct generations.

These two minerals lie closely crowded together and no feldspars are seen in the rock. The interstices between them consist of a small amount of a clouded, brownish, kaolin-like aggregate, which appears to represent some former feldspathoid component, possibly leucite, perhaps analcite. The rock appears to have its closest affinities in the monchiquite group, of which it may be considered a basic, somewhat altered type. The abundance of biotite shows its relation to the minettes, but the rock is much richer in the ferro-magnesian components and lacks the feldspar of the minettes. It has evidently a close affinity with the minettes and shonkinite of the region whose occurrence has been already described,* and is clearly a more basic form of the same magma. It has the same richness in biotite and pyroxene as these, but differs in the feldspathic component. The Yogo Peak center is but a small number of miles distant from the locality.

Some calcite in agglomerated granules is also seen in the section and this, as is so often the case in lamprophyres, does not appear as if secondary in origin and is probably due to limestone fragments picked up as previously mentioned.

Origin of the sapphires. The occurrence of such well-crystallized corundum in a basic igneous rock is of great interest. It seems clear, from the many different ways in which this mineral occurs, that there must be several methods in nature for its formation. The association with metamorphic rocks such as gneisses, schists, etc., is well known and its occurrence with granites is also not uncommon. In all these cases, however, the association is with older, metamorphic or granular crystalline rocks, and we know of its occurrence in more recent, undoubted, basic, igneous rocks in but few cases. Lagorio,† in an article to be mentioned presently, gives a list of the known occurrences of corundum in igneous rocks, their tuffs, ejected fragments and contact zones. The number of occurrences where the mineral is found imbedded in igneous rocks is small, and to them the author can add Unkel on the Rhine and Steinheim near Frankfort on the Main, where, as he has observed, small blue sapphires enclosed in the fresh basalt have been found.

By a series of important and interesting experiments Morozewicz‡ showed that molten glass of a basic character dissolved alumina readily and in large quantity, and from this, on cooling, corundum and spinel crystals separated out. Lagorio,§ in commenting on these results and adding details of some experiments of his own, showed that the former idea which had been held concerning the origin of corundum in igneous rocks

* This Journal, vol. l, 1895, p. 467.
† Zeitschr. für Kryst., vol. xxiv, p. 285, 1895.
‡ Ibid., vol. xxiv, p. 281, 1895. § Op. cit., supra.

should now no longer be urged. This idea was that such corundums had been torn loose from some place below where they had previously existed, and being infusible had spread themselves through the magma. Others again recognized in these corundums infusible but recrystallized portions of rock fragments enclosed in the magma, other portions being converted into spinel, cordierite, etc. Lagorio points out, however, that this could not be the case, as corundum dissolves in molten glasses, and he calls attention to the confusion which has existed between *fusibility* of compounds in molten masses and their *solubility* in the same, the two being quite distinct. The characteristic form of corundum occurring with igneous rocks is the thin, flat, hexagonal table with low rhombohedron, described in the following paper.

This occurrence at Yogo Creek is an important addition to the list of pyrogenetic corundum. The clear-cut form of the crystals and their general distribution shows that they have crystallized out of the magma with as much certainty as the well formed phenocrysts of feldspar in a porphyry betray their origin.

The general character of the rock, however, and its close relationship to the minettes and shonkinite of the region shows that it could not originally have been sufficiently rich in alumina to have allowed a general separation out of corundum. The condition of it, as mentioned above, shows that the magma took up great quantities of inclusions from the sediments through which it passed. Among these sediments must have been a great, though unknown, thickness of the Belt formation, consisting of clay shales. This formation lies between the Archæan gneisses and the lowest beds of recognized Cambrian. The liability of the beds to be shattered by igneous rocks ascending through it and included as fragments, has already been shown elsewhere.*

Such included fragments of shale, if the magma maintained its heat sufficiently, as confined in dike form it naturally would do, would eventually be dissolved, as the experiments described show. There would thus be formed local areas in the magma very rich in alumina, which, on cooling, would allow crystals of corundum to separate out. This explanation seems to us most in accord both with the facts observed in the field and those obtained by experiment in the laboratory. The form of the crystals is also in accord with that of the pyrogenetic corundums.

This occurrence then agrees well with the experiments and views of Lagorio and is indeed an important confirmation of them.

Mineralogical Petrographical Laboratory, Sheffield Scientific School, Yale University, New Haven, June, 1897.

* Geology of Castle Mt., Bull. 139, U. S. Geol. Survey, p. 72.