FAYALITE AT ROCKPORT, MASSACHUSETTS*

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ABSTRACT

The facts are collected concerning the place and mode of occurrence of fayalite at four localities on Cape Ann, Massachusetts, with a description of one of them which yielded the largest and best-developed crystals. All of these occurrences are in pegmatite of a granitic nature but evidence is presented which seems to show that all are xenoliths, genetically related to a fayalite-bearing nordmarkite granite, older than and intruded by the dominant Rockport granite.

Fayalite is not a mineral of common occurrence. It is true that it has been found as a constituent of certain granites and is well known to be abundantly formed in the slags of iron smelters. But individual crystals of natural occurrence are very rare. Boulders of an iron silicate found on a beach on the island of Fayal in the Azores were supposed to have come from the local volcanic rocks and the name *fayalite* was based on their description. However, further study showed that in all probability the boulders were in reality lumps of slag, carried as ballast in some ship and left ashore there. Nevertheless the name has persisted. Minute crystals of great beauty have been found in the cavities of rhyolites and from them the crystal form has been well established.

These facts are stated in order to bring out the very unusual character of the four occurrences of fayalite known in the granite of Rockport on Cape Ann, Massachusetts, to the description of which the following pages are devoted.

The first to find fayalite at Rockport was Mr. J. H. Sears (1905), the Curator of the Peabody Museum at Salem. In 1890 he sent specimens to Professor Penfield at Yale University, reporting that they had been found in the granite of the large Rockport Granite Quarry at a depth of sixty feet. They were parts of a lenticular shell of varying thickness, from twelve to sixteen inches in diameter, filled on the inside with loose earthy material and enveloped by a layer of magnetite about one inch thick. This was in the granite but adjacent to a pegmatite boss or vein. There is a piece of this find in the Harvard Collection which shows a section of a large crystal like those to be described later. On fresh fracture the color is greenish black with resinous luster and two cleavages are shown. Penfield (1896) showed that these cleavages were very perfect parallel to the basal pinacoid; less perfect parallel to the branchypinacoid, thus correcting the previous description of this property. He made an analysis, finding it to be a very pure silicate of iron; and he determined for the first

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time its optical constants. Much later (Bowen and Schairer, 1932) it was found that the melting temperature of this fayalite was $1205° \pm 2°C$, exactly the same, within the limits of error, as that of pure synthetic ferrous silicate.

Fayalite was next reported from Rockport by Dr. Charles H. Warren, (1903) then of the Massachusetts Institute of Technology, who described a second discovery in the same quarry. This mass was found by two of his students and he did not see it in place. It was large, some 250 pounds having been obtained, and, as this was sold to dealers, the mineral was widely distributed in collections. The specimens were sections of large crystals, tapering from a thickness of ten inches down to a thin edge. There was a small amount of black lepidomelane mica on the surfaces of the crystals as well as minute zircon crystals. The main purpose of this paper was to describe a reaction zone developed where the fayalite was in contact with quartz; the zone consisted of a thin layer of a finely fibrous ferroan anthophyllite mixed with granular magnetite. It is now known (Bowen and Schairer, 1935) that this amphibole is gruenerite, it being monoclinic rather than orthorhombic as Warren thought.

We next hear of fayalite at Rockport in 1908 and, as the writer had a hand in obtaining these specimens which are undoubtedly the finest found anywhere of this mineral and have never been adequately described, the facts may well be recorded in detail.

In 1908 Dr. Dale of the United States Geological Survey wrote on the Commercial Granites of Massachusetts. In describing the Rockport granite he states that in the Babson Farm Quarry, which had been opened not long before on the extreme northeast point of Cape Ann, there had been found a "knot" or pegmatite of unusual character which contained, among other more usual minerals, "a mass six by two inches of yellowish brown color, determined by Mr. Johannsen as bronzite." As this mineral seemed wholly out of place in the paragenesis of granite pegmatite I at once suspected that another find of fayalite had come to light and took an early occasion to visit the quarry with a party of students.

We found the quarry itself well worth the journey. It had been opened by a contractor to supply rectangular granite blocks weighing thirty or forty tons each for the construction of a subsurface breakwater to protect the harbor of Rockport. The operation was on a gigantic scale, and the great blocks in process of being broken out of the quarry with wedges or hoisted out onto the surface for transfer by rail and scow were very impressive. The granite was coarse and wonderfully homogeneous with almost no sign of the dikes or pegmatite segregations so common in other Cape Ann quarries. By the side of the railway track stood the block which Dale had described, condemned because of its poor quality and

awaiting removal to the dump of waste rock. It measured about eight feet by four by two and a half, and was composed in large part of coarse pegmatite in sharp contact with the normal granite. The striking feature of this contact was its cross-cutting nature; the structure of the pegmatite bore no relation to it. The evidence was conclusive that the pegmatite was but a part of a larger mass which had been disrupted by the intrusion of the granite and that this angular block was one of the fragments, floated off as a xenolith in the granite. Search of the large waste dump and examination of the vast exposed faces of the quarry walls revealed no other like material. So this lone block, left by chance after being brought to the surface, to be seen by chance by a visiting geologist on a timely visit, was all there was found of this pegmatite.

The "bronzite," or rather fayalite as it proved to be, showed on two surfaces of the quarry block but getting it out looked like a hopeless task. However, two of the party, George M. Flint and A. C. Gosse, returned the next day armed with drills, hammers and plug-and-feather wedges. They obtained permission to break into the discarded stone, and ultimately brought back to Cambridge the larger part, perhaps a hundred pounds, of the pegmatite inclusion.

The chief constituent and latest mineral to form was quartz in large anhedra, glassy but of a peculiar hazy opalescent blue color; masses of several pounds weight were obtained. The feldspar was white microcline characterized by an unusual curvature both of platy masses and of individual crystals where it was embedded in quartz. In the feldspar were warped and cracked plates of ilmenite up to five inches in diameter but less than an eighth of an inch in thickness. There were also quite large prismatic crystals of a green pyroxene which proved to be hedenbergite. And lastly there was the fayalite, the large crystals of which were segregated in a single mass, lying against one another like sardines packed in a can. The principal specimen on exhibition in the Mineralogical Museum at Harvard University is estimated to weigh about sixty pounds of which perhaps twenty is due to fayalite. It is shown in the sketch, Fig. 1.

The most complete crystal broke away from the matrix but may be fitted back into its place and then appears to be about one-quarter of the whole individual. It measures five and one-half inches in the direction of the *b* axis, six inches parallel to *c* and one inch and a half parallel to the axis *a*. Its broken edges are cleavages; the faces are in part quite plane but the pinacoid curves into a vaguely developed prism form; the faces could be accurately measured with the contact goniometer yielding definitely the form shown in the drawing, Fig. 2. A second crystal, less complete, was thicker and probably larger in all its dimensinos. A fragment of a third crystal separates the two larger individuals. Embedded in the

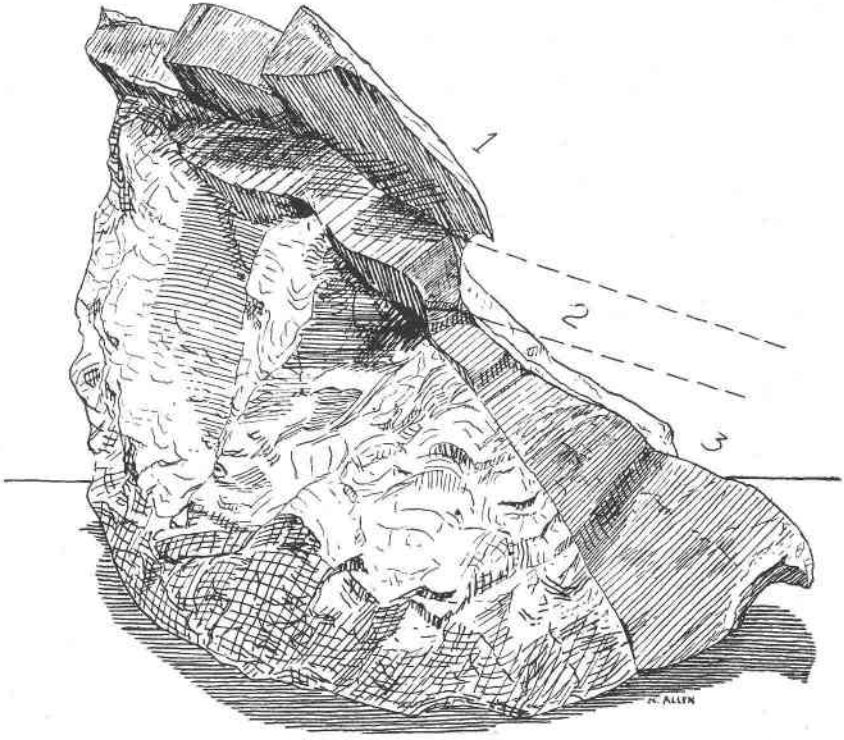

FIG. 1. Fayalite crystals in microcline. The three crystals are indicated. The termination of the uppermost complete crystal is not visible.

surface of the fayalite were a few much flattened grains of a black amphibole, not fibrous and of high index, probably hastingsite.

The latest description of fayalite in the Rockport area was by Warren and McKinstry (1924). They described the pegmatites and their minerals, and in several places refer to the last-described mass of pegmatite

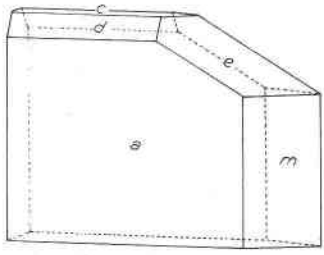

FIG. 2. Crystal of fayalite. $c\{001\}$, $a\{100\}$, $m\{110\}$, $d\{101\}$, $e\{111\}$. The prism is not plane on the crystal but curves into the pinacoid.

which was placed at their disposition. They were convinced, as I had been, that this mass was a xenolith in the Rockport granite. They also described a fourth occurrence of fayalite found in place by Dr. Warren on Brier Neck near Gloucester, on the opposite side of the Cape from the Babson Farm Quarry. This was in a dike-like mass of pegmatite which however is not well exposed and can not be proved to be an inclusion although they believe it to be one. This fayalite is in large part altered by a reaction with feldspathic material to a mixture of biotite, gruenerite and magnetite.

The fayalite from all four of these occurrences has the same optical and physical properties. Each was found in an isolated mass of considerable size and in the case of the Babson Farm Quarry the evidence for the xenolithic nature of the mass was clear. It is perhaps safe to conclude that all were of the same nature. If this be true then the formation of fayalite on Cape Ann belongs to a period of granitic intrusion and crystallization preceding that of the present dominant regional rock, the Rockport granite. Such a rock is described by Warren and McKinstry under the name of nordmarkitic granite. This granite, which is cut by the dominant granite, contains fayalite as one of its lesser constituents, which is in harmony with the preceding conclusion as to fayalite pegmatite. No fayalite has ever, so far as the record shows, been found in the very numerous pegmatites characteristic of the latest Cape Ann granite.

With the decay of the quarrying industry on the Cape, most of the quarries have been abandoned and it does not seem likely that any further finds of these scattered blocks containing fayalite will be discovered.

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