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Replaced fluorite crystals

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Some years ago lumbermen found crystals of a peculiar kind on Pumphrey Mt., one and a half miles south of the railroad station of Vader, Southern Washington. By courtesy of Mr. Edward Flickinger, Seattle, a well-preserved piece was given to me for examination. The crystals were so peculiar that, despite of lacking data about the exact location, a description seemed to be worth while.

The lumbermen could not again find the place from where the specimen was taken. Therefore, their description of the locality and the geologic map were the only sources of information about the geologic setup of the location. The lumbermen estimated the altitude of the place to be about 1100 feet. The outcrop had been formed by a derooted tree under which mainly clay with some gravel was observed. On the geologic map basaltic lavas, partly covered or interbedded with late Tertiary and Quaternary sediments are indicated.

Besides the specimen pictured in figure 1 the lumbermen also found waterclear crystals. These crystals, no piece of which was available any more, might possibly have been unreplaced fluorite.

1. Megascopic description (see figure). Two crystal forms are present: the cube a⟨100⟩ and the tetrahexahedron e⟨210⟩. Most crystals show a combination of both forms and only very few show only a cube. No other forms can be observed, but these characteristics render reasonably certain the identification of fluorite as the original material. About half of all crystals show a poorly or well-developed stair-like intergrowth of cubes. The reverse of the piece shows the conchoidal fracture of chalcedony or quartz. The color varies from a milky white to crème. The crystal surfaces are often enamel-like or even ivory-like. In one place on the reverse they loose the milky, pale color and appear slightly translucent, with vitreous to wax-like luster. The hardness is that of quartz (7) or chalcedony (6—7).

A very remarkable feature of the Pumphrey Mt. specimen are the well-developed and well-preserved structures on the crystal surfaces. Practically all cube faces show layers which have started from positions

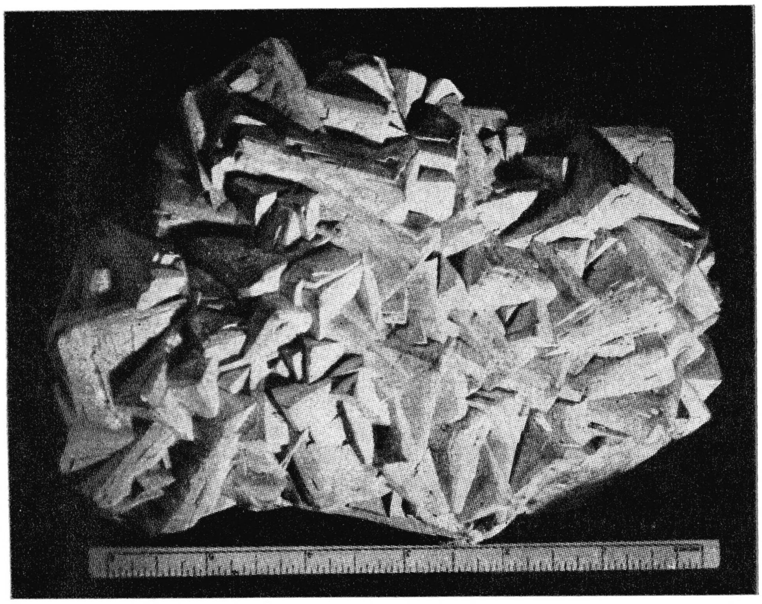

Fig. 1. Silica-fluorite pseudomorphs from Pumphrey Mt., Southern Washington.

inside the face boundaries. The tetrahexahedron faces, however, are, with a few exceptions, always smooth. Another interesting feature is the intergrowth of the different cubes. There are some regions on the specimen which suggest a certain regularity as to the angle between the neighboring cubes. In some places there are combinations of cubes which have the appearance of interpenetration twins.

2. Microscopic determination: Under the microscope the structure of the material appears to be directionless. The texture is mostly partially or completely spherulitic. A smaller part consists of normal quartz grains with simple or complex boundaries (Implikationsgefügen). The spherules are of a fibrous or "feathery" material which has exactly the same appearance as the fine fibrous silica pictured on figure 12 in Murdoch's paper (1936) on silica-fluorite pseudomorphs in California. The fibrous material shows aggregate polarisation. The grain size varies between 0.01 and 0.1 mm across. The indices of refraction of all grains so far determined are those of quartz. The mineral is mostly colorless. Only a few spots and thick portions are yellowish or even brownish. This color may originate from fine disperse limonitic material among the grains, the spherules or the fibres.

In between some of the grains or spheres a very narrow black seam can be observed with crossed Nicols. It is not possible to determine whether these seams are due to an optical effect on grain boundaries or perhaps to very minute traces of opal.

The megascopic and microscopic examinations lead to the assumption that the fluorite crystals have been replaced by silica, partly in the form of simple quartz grains and partly as chalcedony. It was not possible to derive from the grains examined under the microscope any conclusions on the age relationship between quartz and chalcedony or the mechanism of replacement. A thin section through a pseudomorphic crystal has not been available. It might be noted that practically all of MURDOCH's California specimens show a secondary replacement of the quartz by later chalcedony.

3. Spectrochemical examination: The specimen has been examined by Mr. SERAPHIM at the Cabot Spectrochemical Laboratory at the Massachusetts Institut of Technology. He has found no traces of CaF_2 at all. The detection limit of Ca is very low (about 0.00005%).

4. X-ray examination: The X-ray analysis made at the ETH in Zürich (figure 2) reveal clearly the quartz lines. Besides there are a few minor lines of some other material which might originate from impurities such as the limonitic material. It has not been possible so far to identify their origin.

MURDOCH (1936) (reporting about WHITE's and KERR's investigations) and MIDGLEY (1951) agree that the X-ray pattern is identical for quartz and any kind chalcedony. "Quartzine", "lutecite", and flint appear to be different kinds of chalcedony. They all produce the quartz pattern.

5. Genesis. Since no thin section could be made and no further specimens are available, it is impossible to derive safe conclusions on the mode of replacement and the exact origin of the solutions which carried Ca^{++}, F^{-}, and Si^{++++}ions.

The close association with basaltic lavas suggests, however, that the solutions are of hydrothermal origin; the same has been assumed by MURDOCH; his California specimens are also closely connected with basaltic lavas. According to his statement fluorite crystals are usually associated with acid magmas; the association with basic rocks is rather uncommon.

Silicous solutions are very common in volcanic areas of both acid and basic magmas. A good proof for this statement is e.g. the very widespread occurence of petrified wood in volcanic areas.

The silica originating from hydrothermal solutions is transported in colloidal state, deposited as a gel, and gradually dehydrated, and crystallized. The conversion of amorphous silica to quartz has been studied by BAILEY (1949) et al.

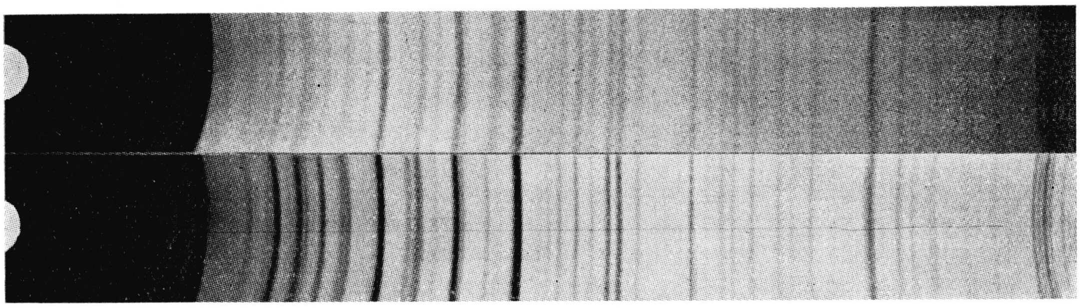

Fig. 2. X-ray powder photographs (Cu-radiation); bottom: standard quartz photograph, top: Pumphrey Mt. Specimen.

In his interesting paper MURDOCH (1936) gives a short theory on the mechanism of formation of pseudomorphs and discusses origin and form of the silica (p. 27—29).

6. Comparisons, Literature. The specimen has been compared with pseudomorphs of the same type at the Harvard University collections and the mineralogisch-petrographische Sammlung in Zürich. It has proven to be better preserved and larger than all the specimens of the two collections mentioned. Some specimens which reveal similar microstructures have been examined by MURDOCH (1936). He mentions some 17 localities of silica-fluorite pseudomorphs described in the literature. His paper is a short review of the literature on pseudomorphs. Some additional occurrences are described in HINTZE's Handbuch der Mineralogie (1904ff.).

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