ON A REMARKABLE CUBE OF PYRITE, CARRYING CRYSTALLIZED GOLD AND GALENA OF UNUSUAL HABIT

By JOSEPH E. POGUE

Assistant Curator, Division of Mineralogy, U. S. National Museum

With One Plate

The intergrowth or interpenetration of two or more minerals, especially if these be well crystallized, often shows a certain mutual crystallographic control in the arrangement of the individuals, suggestive of interacting molecular forces. Occasionally a crystal upon nearly completing its growth exerts what may be termed "surface affinity," in that it seems to attract molecules of composition different from its own and causes these to crystallize in positions bearing definite crystallographic relations to the host crystal, as evidenced, for example, by the regular arrangement of marcasite on calcite, chalcopyrite on galena, quartz on fluorite, and so on. Of special interest, not only because exhibiting the features mentioned above, but also on account of the unusual development of the individuals and the great beauty of the specimen, is a large cube of pyrite, studded with crystals of native gold and partly covered by plates of galena, acquired some years ago by the U. S. National Museum.

This cube measures about 2 inches (51 mm.) along its edge, and is prominently striated, as is often the case with pyrite. It contains something more than 130 crystals of gold attached to its surface, has about one-fourth of its area covered with galena, and upon one face shows an imperfect crystal of chalcopyrite. The specimen came into the possession of the National Museum in 1906 and was obtained from the Snettisham District, near Juneau, Southeast Alaska. It is now on exhibition in the Mineral Department under number 86045. Three similar specimens were exhibited at the Seattle Exposition during 1909, one of which is stated by the owner, Mr. L. V. Winter, of Juneau, Alaska, to be 4 inches square and to show 170 crystals of gold upon its surface. So far as can be learned the four specimens are the sole representatives of a very unique association.

Crystallography of the pyrite.—The pyrite has four of its faces well developed; each of the two remaining ones is marred by an irregular pit, about one-half inch deep and the same in diameter, and the edge joining these two faces is imperfect. The crystal is striated parallel to the pyritohedron *e* (210), due to oscillatory combination of this form and the cube *a* (100), which gives rise to overlapping strips or laminæ parallel to (100) and bounded by (210), each lower strip being usually a bit broader than the one above. The ordinary arrangement across the laminations is: A smooth surface parallel to the cube face, 1 to 2 mm. in width; a series of steps down across alternations of cube and pyritohedron for about 1 mm.;

FIG. 81.—Pyrite cube with crystallized gold and galena. Natural size.

a flat-bottom valley 1 to 2 mm. wide; a course of steps up for 1 mm. to a second plane surface, and so on. Frequently a narrow strip extends only partly across the cube face when, cut off by two octahedral planes, it ends in a dull point, and the strip beneath continues until it perhaps is terminated by similar bounding planes. Scharff[1]

[1] Scharff, F. Ueber die Bau-weise der Würfel-förmigen Krystalle. Neues Jahr. f. Min., etc., 1860, pp. 385–425. See especially p. 412 and Figs. 41, 43, 47, Plate VI.

has figured and described natural etchings on pyrite from Traversella, Italy, which are somewhat similar to the ones here depicted. At times the gold crystals or small rounded knobs of galena are situated upon small six-sided pedestals composed of laminæ of pyrite bounded by two pyritohedron and four octahedral planes. The above features may be seen by referring to plate LIX, figure 1.

Crystallography of the gold.—The gold crystals are most abundant on the face shown in plate LIX, figure 1, though some are present on each of the other faces. They are usually from one-third to one-half buried in the pyrite, never more, and seem to have no definite orientation in regard to their host. Most of them show crystal outline and many are rather symmetrically developed; their average diameter is about 1 mm. The faces are slightly convex, without bright luster, and the edges are not sharp. No measurements were attempted on the goniometer, as the crystals were not fitted for giving reflection, nor, indeed, could they be easily plucked from their settings. The following forms, however, by aid of a hand lens, were

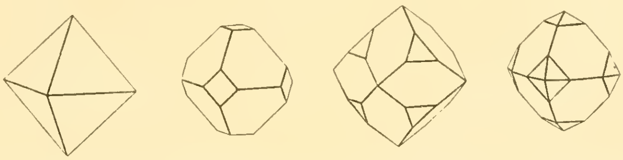

FIG. 82.—The most common shapes of the gold crystals. Enlarged octahedron; combination of cube and octahedron; combination of octahedron and dodecahedron; combination of octahedron and trapezohedron.

positively determined: cube, *a* (100); octahedron, *o* (111); dodecahedron, *d* (110), and trapezohedron, *n* (211) or *m* (311). To these should be added a hexoctahedron as probably present, this form possibly corresponding to *x* (18.10.1) described by Dana[2] on gold from California. The most common combinations, as shown in figure 82, are: Octahedron, cube and octahedron, dodecahedron and octahedron, and trapezohedron and octahedron.

Crystallography of the galena.—The galena possesses three distinct habits, two of which have two or more appearances, due to peculiarities of orientation:

(1) Normal galena. A very small part of the galena has the ordinary step-like appearance characteristic of this mineral and requires no special description. This phase is arranged with one cubic cleavage parallel to the cube faces of the pyrite, with the striations on the latter intersecting diagonally its other cleavages.

[2] Dana, E. S. On the crystallization of gold. Am. Jour. Sci., vol. 32, 1886, pp. 132–138.

(2) Galena laminated parallel to the octahedron (111). About one-fourth of the mineral is developed in this way and is arranged with its octahedral surface usually parallel, though at times slightly inclined, to the cube faces of the pyrite. Natural etching has given a triangular and hexagonal outline to the plates, as is shown in the lower right-hand corner of figure 2, plate LIX. This contour is explained by the fact that an octahedral plane alone is an equilateral triangle, and, when truncated by cube faces, forms a surface of six-sided outline. The strongly laminated nature of the galena may be due to polysynthetic twinning parallel to (111).

(3) Galena laminated parallel to the cube (100). This habit, which comprises about two-thirds of the galena, shows a varied orientation in respect to the pyrite. (*a*) The most common appearance is shown in the central portion of figure 2, plate LIX, where the laminæ are parallel to the surface of the pyrite. This is explained

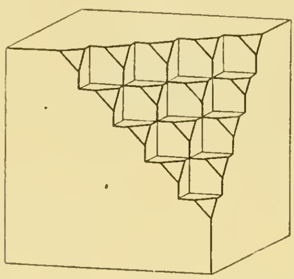

Fig. 83.—Greatly enlarged cleavage fragment of galena, showing eminent cubic cleavage modified by octahedral cleavage.

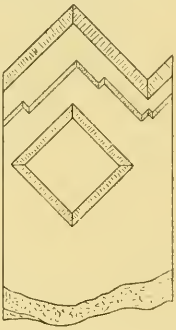

Fig. 84.—Fragment of galena, made up of laminæ, parallel to a cube face, bounded by octahedral slopes.

by the accompanying drawing (figure 84), which figures a fragment made up of plates parallel to the cube *a* (100), bounded by octahedral (111) slopes, this combination giving a square outline to the plates. (*b*) Occasionally there occur long, narrow strips, likewise made up of laminæ parallel to *a* (100) and bounded by elongated *o* (111) faces. These may have their *a* (100) faces parallel to *a* (100) of pyrite; or less often the long *o* (111) faces may have this relation. Crystals of like distortion, but without such platy structure or appearance, from Yellowstone, Wisconsin, have been described by Hobbs.[3] (*c*) Finally, the laminæ and the two cube

[3] Hobbs, W. H. Die krystallisirten Mineralien aus dem "Galena Limestone" des südlichen Wisconsin und des nördlichen Illinois. Zeitsch. für Kryst., vol. 25, 1895–'96, pp. 257–275. Especially plate 4, figure 10, and p. 263.

faces at right angles to these may all be equally inclined to the surface of the pyrite. The mineral with this arrangement has a rhombohedral appearance (imperfectly shown in the upper central portion of figure 2, plate LIX), but its true nature is revealed by exposing the cleavages, which are parallel to the external planes. At times, as is shown in plate LIX, figure 1, irregular branching forms, suggestive of fantastic figures, result from this orientation.

The preceding conclusions were arrived at by a study of dozens of cleavage fragments under the microscope and an examination with hand lens of the galena in place, the prominent cubic cleavage in all cases serving as a means of orientation. Measurements of the cleavage by the microscope gave 90½°, 89½°, 90°, 89°. Several fragments showed secondary octahedral cleavage, which is rare for galena. One example is pictured in figure 83, in which a corner of

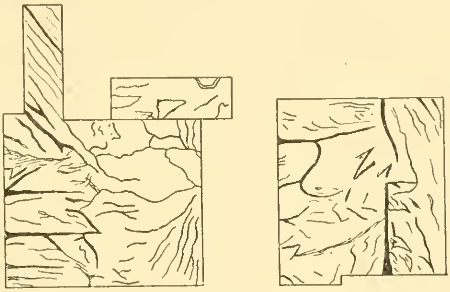

FIG. 85.—Greatly enlarged cleavage surfaces of galena, showing groovings visible by incident sunlight under the microscope.

a cleavage cube is broken across by a series of smaller cubes, with their corners, in turn, truncated by minute triangular octahedral faces.

An examination of cleavage surfaces under a high magnifying power, illuminated by incident sunlight, reveals a complicated series of striations and groovings. The striations are exceedingly minute, visible as fine hair-lines only under the most favorable conditions of reflection. There are two sets at right angles to each other and parallel to the edges of the square cleavage fragments, which may represent incipient cleavages; a third set, less distinct, is sometimes present, cutting the cubic cleavage and striations diagonally. The last holds positions identical with the trace of octahedral planes. More prominent than the striations, and much broader comparatively, are the members of a complicated series of sinuous grooves. Figure 85 is a free-hand sketch of the pattern made by these. It is seen that the groovings are predominantly parallel and diagonal to the cleavage, though many of the lines have apparently no definite orientation.

Qualitative chemical tests of the galena disclose, in addition to the lead and sulphur, the presence of silver and antimony. A careful examination for bismuth gave negative results. This becomes of interest in view of the fact that in much of the galena from other localities, known to possess octahedral cleavage, amounts of Bi_2S_3, ranging around 1 per cent, have been found, and it has been suggested that the peculiarity of cleavage might be due to the presence of this impurity.[4]

So far as the writer has been able to learn from a survey of the most important literature on the subject, the peculiar development of galena herein described has not been previously met with. Scharff,[5] Sadebeck,[6] vom Rath,[7] Hobbs,[8] Franke,[9] Miers,[10] Rogers,[11] Mügge,[12] Wada,[13] and others have described galena bearing some analogies to that here depicted, but in no case is the resemblance more than partial.

The chalcopyrite.—This mineral occurs in an irregular mass 7 mm. in diameter, shown in plate LIX, figure 1, and in two or three other smaller aggregates. It presents no peculiarities, either of crystal form or orientation.

Genesis.—The following features may have some bearing on the manner in which the specimen was formed: a few gold crystals are imbedded in the galena and one is partly enclosed by chalcopyrite; one small mass of the chalcopyrite is set in the galena; part of the

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[4] Dana's System of Mineralogy, 6th ed., p. 49.

[5] Previously cited.

[6] Sadebeck, A. Ueber die Krystallisation des Bleiglanzes. Zeitsch. für. Deutsch. geol. Gesel., vol. 26, 1874, pp. 617–670.

[7] vom Rath, A. Mineralogische Notizen. See Zeitsch. für. Kryst., vol. 4, 1880. p. 425.

[8] Previously cited.

[9] Franke, H. Galenite und Dolomite von Oradna in Siebenbürgen. Abhand. d. naturw. Ges. Isis., 1896, p. 25. Abstract: Zeitsch. für Kryst., vol. 30, 1898, p. 663.

[10] Miers, H. A. Mineralogische Notizen. Zeitsch. für Kryst., vol. 31, 1899, p. 584.

[11] Rogers, A. F. Minerals from the Joplin Zinc and Lead District. Kan. Univ. Quart., vol. 9, 1900, pp. 161–165.

[12] Mügge, O. Ueber regelmassige verwachsungen von Bleiglanz mit Eisenkies und Kupferkies mit Kobaltglanz. Tschermak's min. u. petrog. Mitth., vol. 20, 1901, pp. 349–354.

[13] Wada, T. Mineralien Japans, 1904. Abstract, Zeitsch. für. Kryst., vol. 43, 1907, p. 109.

gold and galena is surrounded by low ramparts of pyrite; the gold is never more than half buried; so far as the interior of the crystal can be examined by means of the two pits, none of the three associated minerals can be discovered within the pyrite. The most probable paragenesis is therefore regarded as this: The pyrite, when its present size was nearly attained, sustained a deposition of crystallized gold upon its surface followed by the precipitation of a small amount of chalcopyrite which, in turn, was succeeded by the formation of the galena. A further slight accretion of pyrite completed the development of the specimen.

EXPLANATION OF PLATE LIX

Fig. 1. Cube face of pyrite, showing crystals of gold, fantastic branching forms of galena, and aggregate of chalcopyrite. The striations on the pyrite, with their octahedral terminations, may also be seen. Magnified about one and one-half times.

Fig. 2. Cube face of pyrite, showing galena of various appearances. Magnified about one and one-half times.

1

2

CUBE FACE OF PYRITE

See explanation, page 484