A butterfly-twin of Gypsum.[1]

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THE specimen[2] here described was acquired in 1913 for the mineral collection of the British Museum. It came from one of the numerous sulphur mines in the province of Girgenti, Sicily. Being of some size (15 cm. = 6 inches across) and with the two individuals well separated and symmetrically disposed, it affords a striking illustration of a twin growth. The crystal is colourless and perfectly transparent; it encloses one or two small patches of native sulphur and compact limestone. A portion, probably about one-third, of the original specimen has been broken away along the perfect cleavage of gypsum; and this fact, together with the small point of attachment, increases the resemblance of the twin to the butterfly form, which is here more striking than in the so-called butterfly-twins of calcite.

The habit of the individual crystals is tabular and lenticular, there being a large curved surface approximating in position to the plane *e* (10$\bar{3}$), which lies 11° 29′ behind the basal plane *c* (001) in gypsum. The faces *b* (010) and *m* (110) in the prism-zone are quite narrow, and these are the only surfaces on the crystal that are really plane. Between the rounded surface *e* and the faces *b*, *m*, and *m*′, and lying in these zones, there are other rounded surfaces with approximately the positions w_1 (1$\bar{2}$3), y_1 (123), and x_1 (2$\bar{1}$3). Rough measurements with the contact goniometer gave the angles: $ew_1 = 13$–$17°$, $ey_1 = 20$–$27°$, and $ex_1 = 12$–$15°$. Like the surface *e*, these are also prominently marked with rounded hillocks, ridges, and grooves of growth. A single, simple crystal developed on all sides would thus present the form of a six-sided lenticle, somewhat resembling the flat crystals of mimetite from Johanngeorgenstadt, Saxony.

[1] Communicated by permission of the Trustees of the British Museum.

[2] Regd. No. B. M. 1913, 339.

Fig. 1 reproduces a photograph, kindly taken by Mr. T. Crook, of the specimen, in which the butterfly form is well shown. Fig. 2 shows, more or less diagrammatically, the cleavage surface b (010), which is continuous through the two individuals. Here are indicated the fibrous cleavage (by double lines) parallel to n ($\bar{1}11$), the conchoidal cleavage

Fig. 1.—**Photographic reproduction of a twinned crystal of Gypsum from Girgenti, Sicily.**

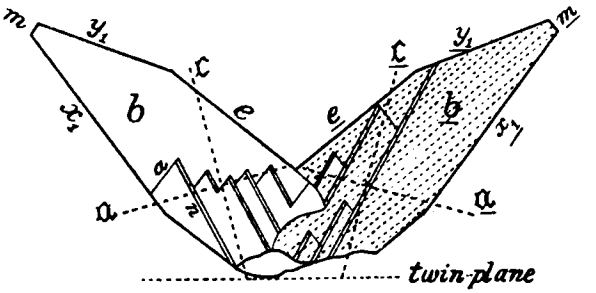

Fig. 2.—Diagrammatic sketch on the plane of symmetry of a crystal of Gypsum twinned on d (101).

parallel to a (100), and (by dotted lines) the directions of optical extinction. The re-entrant angle formed by the two e planes was measured from the tracing of the b cleavage (fig. 2) as 102°, the calculated[1] angle for twin-plane d ($\bar{1}01$) being $e\,\underline{e} = 100°\,28'$. The angle between the traces on b of the n cleavage in the two portions was found to be 57° (calculated $t\,\underline{t} = 57°\,9'$), and that formed by the a cleavages 74° (calculated $a\,\underline{a}\,74°\,9'$).

[1] Calculated from Des Cloizeaux's angles as quoted by Dana, 'System of Mineralogy,' 6th edition, 1892.

The minimum angle between the directions of optical extinction in the two portions was measured in a flake detached from the specimen as 30° (calculated $\varepsilon \underline{\varepsilon} = 30°$).

The law of twinning is therefore the common one in which d (101) is the twin-plane, but with this difference: whereas in the usual type of twin the two individuals are situated on opposite sides of the twin-plane, here they both lie on the same side of this plane. The former case gives the well-known 'swallow-tail' or Paris twin of gypsum; and another form of the same, but remarkable in showing no re-entrant angles, has recently been figured in this magazine.[1] The latter case does not appear to have been previously described for gypsum, except in the intercrossing twins (fig. 4) according to this law.

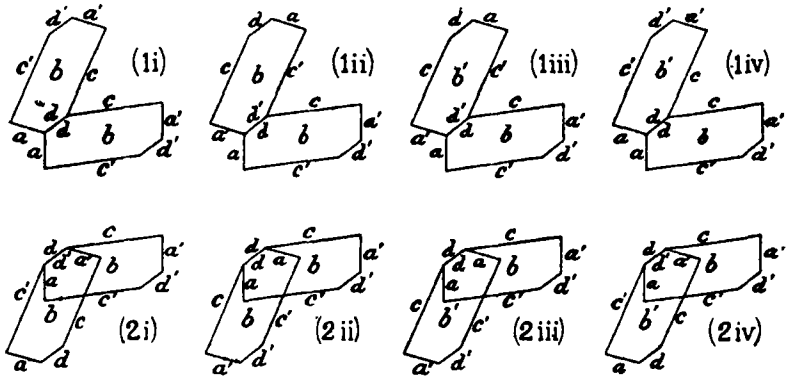

FIG. 3.—The several methods possible of twinning Gypsum on the plane d (101).

The diagrams in fig. 3 illustrate the several ways by which one portion of this twin may be brought into a position coincident with the other portion.

Type 1 (in which the two individuals are situated on opposite sides of the twin-plane):—

(1 i). By reflection (symmetrical repetition) across the twin-plane d (101).

(1 ii). By reflection across a plane perpendicular to d, and a parallel shift across the twin-plane (i.e. a parallel shift from the position given in (2 ii).

[1] M. Fletcher, 'Note on some artificially-produced crystals of Gypsum.' Mineralogical Magazine, 1911, vol. xvi, pp. 137-139.

(1 iii). By a rotation of 180° about an axis (twin-axis) normal to the twin-plane *d*, and a parallel shift across the twin-plane.

(1 iv). By a rotation of 180° about an axis parallel to the edge *db* (i.e. a zone-axis lying in the twin-plane and normal to the twin-axis).

Type 2 (in which the two individuals are situated on the same side of the twin-plane) :—

(2 i). By reflection across the twin-plane *d*, and a parallel shift across this plane.

(2 ii). By reflection across a plane perpendicular to *d*.

(2 iii). By a rotation of 180° about an axis normal to the plane *d*.

(2 iv). By a rotation of 180° about an axis parallel to the edge *db*, and a parallel shift across the twin-plane.

Each of the positions in either one of these types is obtained from the corresponding position of the other type by a parallel shift across the twin-plane; and the re-entrant angle in one type is the supplement of that in the other type. These operations are readily followed by using a piece of card lettered on the two sides.

In a holosymmetric monoclinic crystal like gypsum the four positions in each of the two types are of course identical, although they have been obtained by different operations. There would, however, be distinctions if the crystal belonged to the hemihedral or hemimorphic classes of this system.

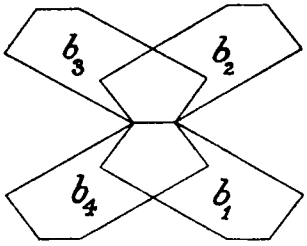

FIG. 4.—Intercrossing *d*-twin of Gypsum.

A combination of the two types gives the intercrossing *d*-twin of gypsum shown in fig. 4. Here the diagonally opposed portions are in parallel position, being related to one another by the parallel shift across

the twin-plane. Examples of this type have been described by F. Hessenberg[1] in 1872 and by A. Lacroix[2] in 1907.

Twins of the first type are usually described by stating that *d* (101) is the twin-plane and combination-plane; and those of the second type as having twin-plane *d* and combination-plane perpendicular to the twin-plane, i.e. parallel to the twin-axis. In the specimen here described the junction between the two individuals is clearly seen (fig. 2); it is not perpendicular to the twin-plane, but runs in an irregular direction. The difference between the two types would be better described by stating that the two individuals are situated on opposite sides of the twin-plane (as in type 1), or both on the same side of the twin-plane (as in type 2).

[1] F. Hessenberg, 'Mineralogische Notizen,' Abhandl. Senckenb. Naturf. Ges., 1872, vol. viii, p. 35, plate 2, figs. 22 and 25.

[2] A. Lacroix, 'Le Gypse de Paris . . .', Nouv. Arch. Muséum Hist. Nat. Paris, 1907, ser. 3, vol. ix, p. 214; 'Minéralogie de la France,' 1910, vol. iv, p. 182.