Thénardite Na_2SO_4

Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals dipyramidal {111}, or tabular {010} with large {101}, rarely prismatic along [100], to 20 cm; as pulverulent crusts and efflorescences. *Twinning:* On {110}, commonly forming cruciform groups; as crude butterflylike twins on {011}.

Physical Properties: *Cleavage:* On {010}, perfect; on {101}, fair; on {100}, interrupted. *Fracture:* Uneven to hackly. *Tenacity:* Somewhat brittle. Hardness = 2.5–3 D(meas.) = 2.664 D(calc.) = 2.66 Soluble in H_2O, taste slightly saline.

Optical Properties: Transparent to translucent. *Color:* Colorless; grayish white, pale yellow, yellow-brown, reddish due to inclusions; colorless in transmitted light. *Luster:* Vitreous to resinous.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, weak.
$\alpha = 1.464$–1.471 $\beta = 1.473$–1.477 $\gamma = 1.481$–1.485 2V(meas.) = 82°35′

Cell Data: *Space Group:* $Fddd$. $a = 9.829(1)$ $b = 12.302(2)$ $c = 5.868(1)$ Z = 8

X-ray Powder Pattern: Synthetic.
2.783 (100), 4.66 (73), 3.178 (51), 2.646 (48), 3.075 (47), 1.864 (31), 2.329 (21)

Chemistry:

	(1)	(2)
SO_3	54.34	56.37
CaO	2.66	
Na_2O	41.91	43.63
H_2O	0.93	
Total	99.84	100.00

(1) Aguas Blancas, Chile. (2) Na_2SO_4.

Occurrence: Typically in lacustrine (salt and soda lake) evaporite deposits in arid regions, also as crusts and efflorescences, which may be ephemeral, in a wide range of geologic environments; as precipitates around fumaroles.

Association: Mirabilite, blödite, glauberite, epsomite, gypsum, natron, halite.

Distribution: Numerous minor occurrences; rarely in thick beds or as large crystals. From the Espartinas salt lake, near Aranjuez, Madrid Province, Spain. On Vesuvius, Campania, and Etna, Sicily, Italy. From Natron Lakes, northwest of Cairo, Egypt. At Etosha Pan, Namibia. In Chile, from Salar de San Sebastian and as large crystals at Salar de Pintados, near La Guaica, Tarapacá; from Aguas Blancas, near Copiapó, Atacama. In the USA, in California, large crystals from Searles Lake, San Bernardino Co., at Soda Lake, Carrizo Plain, San Luis Obispo Co., and from Bertram Siding, near the Salton Sea, Imperial Co.; at a large deposit five km southwest of Camp Verde, Yavapai Co., Arizona; in Kilauea Crater, Mauna Loa volcano, Hawaii. From the "Q" Basin [Jianghan Plain] potash deposits, Hubei Province, China.

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Type Material: Natural History Museum, Paris, France, 26.252.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 404–407. (2) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 895–896. (3) Nord, A.G. (1973) Refinement of the crystal structure of thenardite, Na_2SO_4(V). Acta Chem. Scandia., 27, 814–822. (4) Hawthorne, F.C. and R.B. Ferguson (1975) Anhydrous sulfates. I: Refinement of the crystal structure of celestite with an appendix on the structure of thenardite. Can. Mineral., 13, 181–187. (5) NBS Circ. 539, 2, 59.