

poorer in Al_2O_3 and Fe_2O_3 . Afwillite, killalaite, and portlandite of the Zone 3 are hydrothermal products of a former gel of Zone 1 type, which formed in accordance with the probable reaction, $[\text{Ca}_2\text{SiO}_4]_4 + n\text{H}_2\text{O} = [\text{Ca}_3\text{Si}_2\text{O}_7 \cdot x\text{H}_2\text{O}]_2 + [\text{Ca}(\text{OH})_2]_2$, the empirical formula $\text{Ca}_3\text{Si}_2\text{O}_7 \cdot x\text{H}_2\text{O}$ being common to high-lime gel, afwillite, and killalaite.

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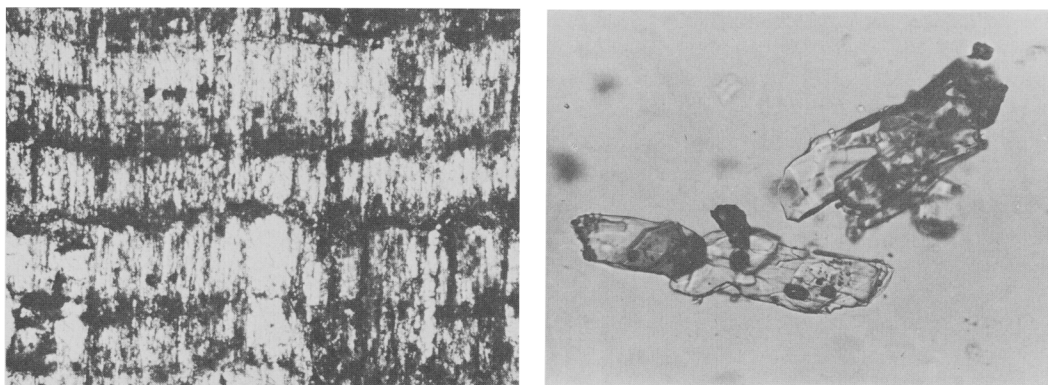
Darapskite, $\text{Na}_3(\text{NO}_3)(\text{SO}_4) \cdot \text{H}_2\text{O}$, a new occurrence, in Texas

DARAPSKITE, $\text{Na}_3(\text{NO}_3)(\text{SO}_4) \cdot \text{H}_2\text{O}$, first described by Dietze (1891), is a widespread mineral in the Chilean nitrate deposits where it occurs alone and with other saline minerals in veins, pods, cementing material, and cavities in the nitrate ore. Ericksen and Mrose (1970) very briefly mention its presence in saline materials from caves in the limestones of Funeral Mountains, Death Valley, California, but give no further details of that occurrence. This paper is the first detailed description of darapskite as a cave mineral.

Darapskite occurs intimately mixed with halite in Flower Cave, one of a group of caves located at the southern end of Big Bend National Park, Texas, U.S.A. For details on the specific location of the occurrence and collecting restrictions, contact Big Bend National Park, Texas 79834, U.S.A. The cave is developed in the Santa Elena limestone, which is a massive, thickly bedded, dense, cherty, grey, escarpment-forming limestone of Lower Cretaceous (Comanchean) age (Maxwell and Dietrich, 1965). The eastern exposure of Santa Elena limestone is 60-70 m thick and contains about a dozen caves besides Flower Cave.

The Flower Cave entrance is a broad, slightly ascending, crawlway about 15 m long which terminates in a chamber 2 m in height and 3 m in diameter. On the back wall of this room numerous cave flowers up to 8 cm in length protrude from the bedrock along a horizontal bedding plane. The flowers are white and opaque and consist of radiating 'petals', which curve away from the centre of the flower. These 'petals' consist of alternating growth layers of translucent darapskite and opaque halite, which are oriented parallel to one another, as well

as to the bedrock wall. The halite layers are 0.05–0.1 mm thick, and darapskite layers approximately 0.2 mm thick (fig. 1). The darapskite crystals within each darapskite layer are prismatic and elongated along the *c*-axis perpendicular to the layering sequence. Sometimes these prismatic crystals terminate at the adjacent halite layers; in other cases individual crystals extend across the halite layers. The darapskite crystals average 0.1 mm in length and reach a maximum size of 0.2 mm (fig. 2). Approximately one-third of the total flower mass is halite; the remainder, darapskite.



FIGS. 1 and 2: FIG. 1 (left). Alternating layers of light darapskite (0.2 mm) and opaque halite (0.05 mm) under crossed-nicols. Note that some of the larger darapskite crystals are continuous across the halite layers. FIG. 2 (right). Translucent, prismatic crystals of darapskite in plane polarized light. The small, dark inclusions are probably halite. The crystals are approximately 0.2 mm in length.

Darapskite is colourless, transparent, has a vitreous lustre and with the halite a bitter-salt taste. The prismatic crystals (*c*-axis) are biaxial (–) with $\alpha = 1.391(3) \parallel [010]$, $\beta = 1.480(3)$, $\gamma = 1.489(3)$, $\gamma: [001] 13(1)^\circ$, and $2V_{\text{calc}} = 33^\circ 35'$. In contrast to the descriptions of Erickson and Mrose (1970) and Larsen and Berman (1934), no dispersion was observed. Darapskite does not fluoresce under short- or long-wave ultraviolet light; but the flower (darapskite + halite) phosphoresces green for approximately 5 seconds after irradiation with short-wave ultraviolet light.

The $\{100\}$ cleavage is prominent but polysynthetic twinning parallel to $\{100\}$ is rare. Specific gravity measurements were not attempted because of the small size of the darapskite crystals and their intimate association with halite.

X-ray diffraction

The X-ray powder-diffraction data is in good agreement with that of Ericksen and Mrose (1970). Four of the additional lines may be attributed to halite, but two very weak lines (3.89 and 2.70) do not match those of darapskite or halite. The indexed diffraction pattern is compatible with the $P2_1/m$ space group determined by Sabelli (1967). Unit-cell parameters were refined after the method of Appleman *et al.* (1973): $a = 10.558(3)$, $b = 6.870(2)$, $c = 5.186(1)$, and $\beta = 101^\circ 46.1(5)'$. The calculated unit cell volume is 368.26 \AA^3 .

The cave flower consists essentially of a mixture of darapskite and halite. An analysis by J. N. Husler, Department of Geology, University of New Mexico, gave $\text{Na}^+ 32.85$, $\text{K}^+ 0.016$, $\text{Ca}^{2+} 0.93$, $\text{Fe}^{2+} 0.028$, $\text{Mg}^{2+} 0.054$, $\text{Sr}^{2+} 0.011$, $\text{Mn}^{2+} 0.005$, $\text{Ti}^{4+} < 0.120$, $\text{Al}^{3+} < 0.011$, $\text{NO}_3^- 12.80$, $\text{Cl}^- 28.00$, $\text{SO}_4^{2-} 21.53$, $\text{CO}_3^{2-} 0.90$, $\text{PO}_4^{3-} 0.01$, $\text{H}_2\text{O} 3.45$, total 100.72%. A normative mineralogical composition was calculated assuming that all of Cl^- was in halite; and

all of the NO_3^- , in darapskite. The residual components in weight percentages were SO_4 (1.71), Ca (0.93), CO_3 (0.90), and Na (0.456). Note that no X-ray diffraction lines could be matched with CaCO_3 , $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, CaSO_4 , or Na_2CO_3 . There is the slight possibility of the presence of $\alpha\text{-Na}_2\text{SO}_4$ [3.92 (100), 2.86 (90), 2.70 (90)].

Gypsum, epsomite, mirabilite, and halite have all been reported as cave flowers (Hill, 1976). The cave flowers form by precipitation of soluble salts when ground water moving along bedding planes reaches the cave surface. Each precipitated layer is subsequently forced outward parallel to the bedrock wall by the subsequent precipitating solutions. The flower-like morphology results when solutions are supplied to localized areas more rapidly than to other bedrock areas. The curvature of the flower 'petals' is always away from this area of precipitation, as the side nearest the centre grows faster than the side farthest from this centre.

The source of the halite and darapskite in the cave flower is unknown. There are no known evaporite deposits in the stratigraphic units above the Santa Elena Limestone. Bat guano was reportedly mined from another cave in the area and may be the source of the sulfate and nitrate. According to the calculated solubility products, the darapskite ($K_d = 1.606 \times 10^{-3}$) layers precipitate first and the halite ($K_h = 2.045 \times 10^{-1}$) precipitate last, coating the already formed darapskite crystals. For thin layers of halite, subsequent darapskite crystals may nucleate on previous darapskite crystals, thus forming an optically continuous crystal across the halite layer (see fig. 1). If the halite completely coats the darapskite, the succeeding layers crystallize in a different orientation. Each double layer (halite + darapskite) probably reflects a separate depositional cycle corresponding to seasonal or yearly variations in precipitation patterns.

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