

An unusual occurrence of bedded thenardite.

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A PECULIAR occurrence of anhydrous sodium sulphate, thenardite, has recently been discovered below the salt crystallizing pans at Didwana, Jodhpur State, India. Here salt (NaCl) is crystallized out by evaporation in open pans from brine obtained by sinking wells alongside the pans, to a depth of about 15–20 feet below the surface. The land surface consists of very fine sandy silt and the salt-pans are made by cutting shallow depressions about 120 feet long by 85 feet wide, a low ridge of silt about 2 feet high and 3 feet broad being left between them. The pans are cleaned out at the beginning of the salt season (February–March): the brine from the wells is run into them to a depth of 1 to 2 inches and the salt crystallizes out by evaporation. The crystallizing salt is occasionally rabled and ridged to break up the larger crystal accumulations, and is eventually scraped to one side as a ‘crop’. Brine is added regularly to keep up the brine depth. The process is continued until the monsoon (rains) interferes.

A peculiar feature of the process is that the well-brine fed to the pans contains a high proportion of sodium sulphate—much higher than in the salt (NaCl) produced by crystallization. This is illustrated by the two following average analyses.

Average analysis Well-brine.				Average analysis Salt crop.			
Sodium chloride	...	...	18.5%	Sodium chloride	...	...	87.2%
Sodium sulphate	...	...	6.6	Sodium sulphate	...	...	11.2
Sodium carbonate	...	...	0.4	Sodium carbonate	...	...	0.2
Sodium bicarbonate	...	...	0.4	Sodium bicarbonate	...	...	0.1
				Insoluble matter	...	...	0.64
Total	...	...	25.9	Moisture &c. (by difference)	...	...	0.66
				Total	...	...	100.00

The ratio of chloride to sulphate in the brine is 3 to 1 whilst in the salt it is 8 to 1. It is thus evident that sulphate of soda has disappeared from the above system in some manner. This disappearance is accounted for by the recent discovery of beds of thenardite immediately below the salt-pans and partly contaminated with silt.

The critical temperature for the formation of thenardite in pure solutions of the sulphate is 32.2° C. Above this temperature the anhydrous thenardite crystallizes, below it the decahydrate, Glauber’s salt, is produced. Sodium chloride depresses this critical temperature progressively until, in a solution saturated with the chloride, the critical temperature for thenardite is reduced to 18° C. At Didwana the pan-brine is practically always saturated in respect to the chloride, so that the critical temperature for the sulphate separation must lie in the lower region near 18° C.

It is only during the first few weeks of the salt crystallization season at Didwana that the night temperatures could possibly fall below 18° C. and only in this case could Glauber's salt crystallize out (to be ultimately converted to thenardite as the temperature rises). For the greater part of the crystallizing period thenardite alone would separate and this form of the sulphate must have crystallized simultaneously with the chloride during evaporation.

The separation, or partial separation, of this anhydrous sulphate from the chloride, and its recrystallization at the bottom of the salt-pans, appear to have proceeded as follows. The salt (NaCl) tends to crystallize as spongy 'boxes' which float on the surface until they become too heavy and sink. The thenardite, on the other hand, forms relatively dense and compact individual orthorhombic crystals of pyramidal habit (density 2.7, against a density of 2.2 for NaCl). These heavier and more compact crystals sink to the bottom and their separation from the lighter spongy salt crystals is assisted by the rabbling action of breaking and ridging the latter, on the lines of the 'jigging' action in ore dressing. This mechanical separation is assisted by the density of the brine (1.25) which accentuates the relative difference in density of the two compounds. The greater tendency of the sulphate to form supersaturated solutions may also have contributed to the separation and to the recrystallization of the sulphate beds in a much coarser form below the pans.

These beds of thenardite vary in thickness from one to three or four feet. The process appears to have been in operation for the past 150 years or more, and the total estimated accumulation over the whole of the salt-pan area is of the order of 250,000 tons. Supplies from this deposit have already replaced all the previously imported sulphate (salt-cake) and bid fair to continue to do so after the war.

In view of the fact that these thenardite beds have been formed in the presence of solutions saturated in respect to sodium chloride, their relative freedom from the latter is remarkable. This is shown by the following average analysis of some 300-400 tons of sulphate taken from these deposits.

Sodium sulphate, Na ₂ SO ₄	...	91.9%	Magnesium sulphate, MgSO ₄	...	0.30%
Sodium chloride, NaCl	...	0.80	Iron and aluminium (as sulphates)	...	0.56
Sodium carbonate, Na ₂ CO ₃	...	0.10	Insolubles...	...	5.7
Sodium bicarbonate, NaHCO ₃	...	0.40	Moisture	...	0.2
Calcium sulphate, CaSO ₄...	...	0.24			
			Total	...	100.20

As mined or quarried the thenardite is in the form of interlocking masses of crystals varying from $\frac{1}{4}$ inch up to an inch or more in size. Occasionally masses or slabs with pure water-clear crystals up to two or three inches in size can be separated. Several such specimens were selected for examination and for photographs (fig. 1). The crystals are orthorhombic and of the usual pyramidal habit, the face (111) being most prominently developed, with occasional prism faces (110) and less commonly the base (001). Twinning is common, the twin- and composition-plane being the front orthodome (101) giving rise to 'butterfly' twin forms. A distinct basal cleavage is observable. On heating to 197° C. the clear crystals suddenly become opaque and pearly; below this temperature there is little or no permanent change in the optic axial angle.

Optically the mineral is biaxial and positive with a measured optic axial angle of 83.1°. The axial plane is parallel to the base and the acute bisectrix (γ) is parallel

to the crystallographic axis b . The three refractive indices measured on an Abbe refractometer for sodium-light are α ($\parallel a$) 1.4667, β ($\parallel c$) 1.4729, γ ($\parallel b$) 1.4812.

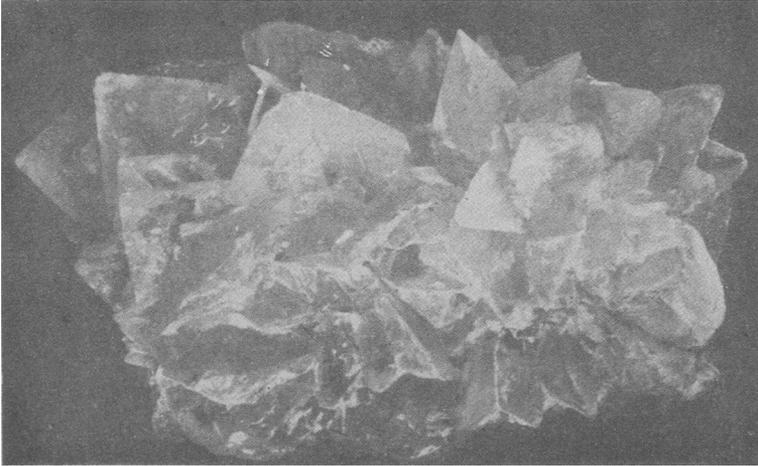


FIG. 1. Crystals of thenardite from Didwana, Jodhpur State, India. $\times \frac{1}{2}$.

This optical orientation differs from that given in the text-books, with the vibration-direction γ parallel to the crystallographic axis a , as quoted from C. Baerwald (*Zeits. Kryst. Min.*, 1881, vol. 6, p. 40).

My thanks are due to the Geological Survey of India for the photograph reproduced in fig. 1.
