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Addendum

Since this manuscript was submitted, an article describing and illustrating this effect has appeared, as follows:

Dietz, Ralph W. (1957), Television ulexite: Gems and Minerals, No. 232, 16-17.

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THE HYDRATION OF KERNITE ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$)¹

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New observations and other data from the literature have led us to conclude that kernite ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$) hydrates directly to borax ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$) without going through the tincalconite ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$) phase, and that the many specimens of kernite that seem to have altered directly to tincalconite all once contained borax, which itself has dehydrated to tincalconite. Our evidence for these conclusions is presented below.

In their study of the system $\text{Na}_2\text{B}_4\text{O}_7\text{—H}_2\text{O}$, Menzel, Schulz, and others (summarized by Menzel and Schulz (1940)), showed that kernite hydrates to borax without going through the tincalconite phase, which is metastable. Gale (1946), in his work in the Kramer district, where kernite occurs, noted that kernite "is . . . altered to a later regeneration of tincal [sic] in places, especially as seen in zonal envelopes surrounding and retaining the outer forms of individual kernite crystals." Gale's observation serves as a starting point for our work.

In the mines at Kramer, most of the kernite crystals have a crystalline shell (Gale's envelope) around them. In the older workings, these shells, as seen in cross section on mine walls, are nearly all tincalconite that is white and easily distinguished from the clear cores of kernite. In more recent workings and in fresh cuts made into older mine walls, however, the shells are clear borax. We dug into the walls where kernite was rimmed with tincalconite and found that these shells gradually passed into massive clear borax farther away from the mine walls. All this sug-

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gests that: (1) the tincalconite seen in the older workings dates from the opening of the mine; (2) the tincalconite is a dehydration product of the borax rather than a hydration product of the kernite; and (3) the kernite has altered directly to borax.

Several large kernite fragments having clear borax attached to them (parts of the shells) were collected by Muessig in early 1953. Within a month the borax was covered with a coating of tincalconite and by 1956 the borax had dehydrated completely to tincalconite; however, the kernite is still clear (Feb. 1957). Again, it is the borax, not the kernite, that has gone to tincalconite.

In 1954 we noted that one of the clear pieces of kernite, with borax attached at one end, started to split along its cleavages—a phenomenon also noted by Schaller (1930). Tincalconite and a small amount of borax occurred as a thin film along the cleavage planes. To see if such tincalconite is an alteration product of kernite, or of borax as we suspected, we cut a large thin section from a piece of kernite, which had part of a borax shell attached; the borax had altered superficially to tincalconite. As seen in the thin section, most of the attached borax had altered to tincalconite. The kernite within the borax shell is clear, but is cut by many linear, thin veins of borax-tincalconite. In places the veins are nearly all tincalconite; borax occurs only as irregularly shaped remnants within the finely crystalline tincalconite. Such veins grade into those that are mostly borax clouded by minute euhedral crystals of tincalconite. All contacts between the veins and the kernite are sharp and straight; the contact between the shell of borax-tincalconite and kernite is sharp but irregular, and the veins are apophyses from the shell. From these observations, and that of Gale that the borax shells are pseudomorphous after kernite, we deduce that: (1) the kernite hydrated along its edges to borax; (2) at the same time, water-borate solutions moved along the kernite cleavage planes and formed film-like borax veins (some of these veins may be nothing more than hydration products of the contiguous kernite); and (3) the tincalconite, which caused the kernite to fall apart along cleavage planes, formed from the borax of the veins, not from the kernite.

Lastly, we put into bottles two small cleavage fragments of clear kernite, one of which had a small piece of borax attached to it; the other was borax-free. Within the bottles, and attached to the caps, we put tissue paper soaked with water and then capped the bottles tightly. The air within the bottles was probably saturated with water vapor. After two months we took the fragments out of the bottles and powdered them. Immediate microscopic and x -ray study of the powders revealed only

borax. We conclude that all the kernite, both with and without attached borax, hydrated to borax.

The chemical and mineralogical work of Menzel, and others, the mine observations of Gale, and our own observations and experiments lead to the following conclusions: (1) kernite hydrates under unknown geologic conditions directly to borax; (2) kernite hydrates at room temperatures in water-saturated air directly to borax; (3) specimens of kernite that are altered probably contained undetected borax, which is really what dehydrated to form tinalconite; and (4) so far as we are aware kernite never hydrates directly to tinalconite.

Our findings differ from those of Schaller (1930), who reported that kernite hydrates to tinalconite "if any borax is attached to the kernite," rather than to borax, and that kernite without associated borax does not alter to tinalconite. Schaller made his observations in humid air in Washington, D. C., yet other writers—for example, Palache, Berman, and Frondel (1951)—have cited him and inferred that kernite in contact with borax normally alters to tinalconite. Schaller would probably have reached the same conclusions as we have, had he had the data available at the time of our study.

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