INDERITE AND GERSTLEYITE FROM THE KRAMER BORATE DISTRICT, KERN COUNTY, CALIFORNIA*

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ABSTRACT

A mineral tentatively identified as inderite, and identical with a mineral described by Heinrich (1946) from a different locality, has been found in the Baker and Jenifer mines in the Kramer district, California, Analyses of material from these mines correspond closely to $Mg_2B_6O_{11}\cdot 15H_2O$. Biaxial negative, with *n*X 1.490, *n*Y 1.511, *n*Z 1.520; 2V moderate, $r>v$. Sp. gr. 1.861.

The new species gerstleyite occurs in the Baker mine as cinnabar-red, platy-fibrous spherules in clay. Composition $(Na, Li)_4As_2Sb_8S_{17}\cdot 6H_2O$, from the analysis Na 4.65, Li 0.15, As 8.02, Sb 51.91, S 29.33, H_2O 5.94; total 100 after deduction of 8 per cent gangue. Sp. gr. 3.62, hardness 2½. Biaxial, with indices over 2.01; X salmon-red, Y and Z deep blood-red. Probably monoclinic, with perfect cleavages on (010) and (100) and a poor cleavage on (001).

INDERITE (?)

The borate deposits of the Kramer district in the Mohave desert, Kern County, California, consist of extensive beds of kernite and massive borax associated with minor amounts of probertite, colemanite, ulexite, and tincalconite. The borates are interstratified with a greenish clay shale, and apparently were formed in a shallow lake or playa. The deposit has been somewhat faulted, tilted, and buried beneath several hundred feet of sandy alluvium. The mineralogy and geology of the deposit have been described by Schaller (1930) and by Gale (1946).

A mineral tentatively identified as inderite recently has been found at two mines in the Kramer district. It was first noted in a core from an exploratory drill hole in the hanging wall of the Baker mine. Later, a small find of irregular masses and rough crystals was made in the Jenifer mine. The mineral occurs here with borax, ulexite, orpiment, realgar, and a new monoclinic polymorph of inderite that is being described elsewhere. These minerals were encountered in the clay fill of a buried erosional valley in the upper portion of the borate beds.

The inderite(?) is colorless and transparent, with a weak vitreous luster. The hardness is 2½, and the specific gravity is 1.861. The *x*-ray powder pattern is identical with that of the natural and synthetic material described and referred with some doubt to inderite by Heinrich (1946). The mineral has a perfect cleavage on (010) and an indistinct

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cleavage on $(1\bar{1}0)$, with a cleavage angle of about 70° in the triclinic description of Heinrich (1946). Optically biaxial negative, with nX 1.490, nY 1.511, nZ 1.520 (all ±.002); 2V moderate, $r>v$. Chemical analyses, cited below, closely conform to the formula $Mg_2B_6O_{11} \cdot 15H_2O$.

	1	2	3
MgO	14.43	14.42	14.41
B_2O_3	36.89	37.31	37.32
H_2O	48.69	48.12	48.27
Total	100.01	100.07	100.00

1. Inderite (?). Baker mine, Kramer district, California. V. Morgan, analyst.
2. Inderite (?). Jenifer mine, Kramer district, California. V. Morgan, analyst. Includes 0.22 per cent insoluble.
3. Theoretical weight percentages $Mg_2B_6O_{11} \cdot 15H_2O$.

Inderite originally was described from the Inder borate deposits in western Kazakstan by Boldyreva (1937). A new occurrence of what probably is the same mineral later was fully described by Heinrich (1946). The exact locality of this mineral is not known. It is stated as "America" by Heinrich (1946), as California in Dana (1951), as not from California by the original donor of the specimen,[1] and as very likely in Argentina.[2] It definitely is not from the Kramer district. Heinrich (1946) thoroughly discussed the problem of the identity of his mineral with the original, rather ill-defined Russian inderite. He concluded that the weight of the evidence, chiefly the identity in chemical composition of the two natural minerals, and the apparent identity of his natural and synthetic material with the synthetic substance described as inderite by Feigelson *et al.* (1939), indicated that the two minerals were the same species. Discrepancies still remain in the descriptions of the two minerals, however, particularly with regard to the rather unsatisfactory *x*-ray powder data given for the Russian material. In any case, the mineral from the Kramer district here described is completely identical with the mineral described by Heinrich (1946).

GERSTLEYITE

Gerstleyite, a new alkali sulfantimonite-sulfarsenite, was first noticed in 1945 in workings of the Baker mine in the Kramer district. It occurs chiefly as cinnabar-red to blackish red spherules, up to an inch in diameter, with a crudely radial fibrous structure. It also occurs as fine-granular aggregates and as groups of small, thick plates with rough sur-

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[1] Personal communication, M. Vonsen to V. Morgan, 1948.

[2] Personal communication, W. T. Schaller to C. Frondel, 1956.

faces. The individual crystals of the aggregates are warped and show a subparallel or slightly divergent to almost feathery intergrowth of subindividuals. There are two perfect cleavages at right angles to each other and a third poor cleavage, best seen in crushed grains under the microscope, that is inclined at 80° to 90° to the other two. The powder is bright cinnabar-red, darkening on long exposure, and the luster is weakly adamantine. The hardness is $2\frac{1}{2}$ and the specific gravity is 3.62. In transmitted light, gerstleyite is deep blood-red to nearly opaque in small grains, and orange-red in very small particles. The indices of refraction are over 2.01, and the birefringence is high. Biaxial, probably with large 2V. Weakly pleochroic, with X salmon-red, Y and Z deep blood-red. The extinction is parallel against one of the cleavage intersections and is either parallel or at most makes a small angle against the other two cleavage intersections.

Efforts to obtain single-crystal *x*-ray photographs met with small success, due to the composite nature of the crystals and to strong absorption. Disoriented rotation photographs obtained about the intersection direction of the two perfect cleavages, taken as the *c*-axis, indicated a period of about 10 Å. Zero-layer photographs about this axis were virtually useless, but a spacing of about 7.4 Å was obtained for one of the principal lattice directions. Rational rotation photographs could not be obtained about the perpendicular to one of the two perfect cleavages; this cleavage corresponded to (100) in the monoclinic interpretation suggested below. Very inferior rotation photographs obtained about the perpendicular to the second perfect cleavage, taken as the *b*-axis, indicated a period of 22 to 23 Å. A Weissenberg resolution of the 0-layer about this axis showed localized sets of spots belonging to several misoriented individuals; when projected, these reflections indicated an oblique cell with β $97 \pm 3°$ and with axial spacings of approximately 4.9 Å (presumably along *c*) and 5.6 Å (then along *a*). The mineral may be monoclinic. It did not prove possible to index the *x*-ray powder spacing data (Table 1) from these data, although a number of the spacings are related to the single-crystal measurements.

A chemical analysis of gerstleyite is cited below. The Sb and As were found to be present in the trivalent state. The low summation of the analysis is due to the presence of gangue material, which unfortunately was partly lost during its determination. The ratios of the analysis are very close to the formula $(Na,Li)_4As_2Sb_8S_{17} \cdot 6H_2O$.

Gerstleyite fuses at about 2. It is completely soluble in dilute alkalies, and is decomposed by dilute HCl with the evolution of H_2S and the separation of a yellow residue. A large number of synthetic compounds of this general composition are known. Summary accounts of their

TABLE 1. *X*-RAY POWDER SPACING DATA FOR GERSTLEYITE
Copper radiation, nickel filter, in Angstrom units

I	*d*	*I*	*d*	*I*	*d*
10	11.85	3	2.492	2	1.693
7	5.64	½	2.432	1	1.656
7	4.03	2	2.346	½	1.640
1	3.96	2	2.272	1	1.593
2	3.76	2	2.162	1	1.575
3	3.56	2	2.091	½	1.568
2	3.38	2	2.011	½	1.526
3	3.20	4	1.934	3	1.404
9	3.05	½	1.874	2	1.177
5	2.81	1	1.828	2	1.137
4	2.739	2	1.788	1	1.081
3	2.573	2	1.734		

	1	2	3	Molec. quot.	
Na	4.48	4.65	4.28	0.186	2.07
Li	0.14	0.15	0.135	0.019	
As	8.04	8.02	7.38	0.099	1
Sb	52.28	51.91	47.80	0.393	3.97
S	29.26	29.33	27.01	0.842	8.51
H_2O	5.80	5.94	5.47	0.304	3.07
gangue			n.d.		
Total	100.00	100.00	92.07		

1. Theoretical weight percentages, $(Na, Li)_4As_2Sb_8S_{17}\cdot 6H_2O$ with Na:Li=9.8:1.
2. Analysis 3 recalculated to 100.
3. Gerstleyite. Baker mine, Kramer district, California. V. Morgan, analyst.

preparation and properties are given by Mellor (1929) and Gmelin (1950, 1952). Among those with ratios approaching those of gerstleyite may be mentioned $Na_2Sb_4S_7\cdot 2H_2O$, $Li_2Sb_4S_7\cdot 3H_2O$, $Na_2As_4S_7\cdot 6H_2O$, $NaAs_3S_5\cdot 4H_2O$, and the oxysulfarsenite $Na_8As_{18}S_{24}O_7\cdot 30H_2O$. It is of interest to note, since gerstleyite contains lithium, that a number of lithium compounds with sulfur and either trivalent or pentavalent arsenic or antimony are known.

Gerstleyite has been observed chiefly in the footwall of the Baker mine as spherules embedded in gray-green clay. It also has been found embedded in massive borax and, in one instance, in a crystal of kernite. The mineral generally is associated with probertite, tincalconite, realgar, and spherules of stibnite. Gerstleyite is named after Mr. J. M. Gerstley, President of the Pacific Coast Borax Company.

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