# HAIWEEITE, A NEW URANIUM MINERAL FROM CALIFORNIA

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### Abstract

A hydrous calcium uranium silicate, found near the Haiwee Reservoir in the Coso Mountains, California, has been determined as a new mineral and named haiweeite, from the locality.

It occurs as spherulitic aggregates, or single flake-like grains, on fracture surfaces in granite and in voids of the adjacent lake bed deposits. It is pale yellow to greenish yellow in color; hardness 3.5; specific gravity 3.35; luster pearly. A chemical analysis gives it the the following formula: $CaO \cdot 2UO_3 \cdot 6SiO_2 \cdot 5H_2O$. Optically it is biaxial negative, with 2V about 15°; the acute bisectrix is nearly normal to the broad surface of the blade-like grains {100}. Dispersion is strong, with $r \rightarrow v$. The spherules from the granite are in general made up of two components, of which the inner has higher indices of refraction, and may be considered to be meta-haiweeite. The outer shell is made up of haiweeite, with indices $\alpha$ 1.571, $\beta$ 1.575, $\gamma$ 1.578.

X-ray study of minute flakes shows that the mineral is monoclinic(?) with the following (approximate) cell-dimensions:

$$a_0 = 15.4 \text{ Å} \qquad b_0 = 7.05 \text{ Å} \qquad c_0 = 7.10 \text{ Å} \qquad \beta = 107°52'$$

Space is probably $P2/c—C_{2h}^4$.

Haiweeite was found in the Coso Mountains, California, just above the Haiwee Reservoir, for which it has been named. It occurs as a sparse coating of spherulites either on fracture surfaces of granite, or in voids of the neighboring loosely consolidated lake bed deposits. In the granite occurrence there is locally an additional coating, associated with the spherulites, of minute crystalline flakes. The spherulites show the usual radial structure, made up of minute, blade-like grains, with pearly luster on the broad surfaces. In color haiweeite is pale yellow to greenish yellow, fluorescing weakly to dull green. Hardness 3.5; specific gravity, determined in Clerici solution, close to 3.35; cleavage good on {100}.

Optically, haiweeite is biaxial negative, a nearly centered acute bisectrix figure on {100} (the broad faces) showing a 2V of about 15°; dispersion is strong, with $r > v;$ not visibly pleochroic; extinction appears to be essentially parallel to elongation ($c$), on the {100} face.

Examination shows that the spherulites from the granite are made up of two minerals, one composing the center, the other the outer border. The inner has considerably higher indices than the outer. The two are too intimately intergrown for any separation to be made, but on igniting the mineral from the lake beds at a low red heat, its indices are raised to the value of the inner mineral, whereas they were originally identical

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TABLE 1. REFRACTIVE INDICES OF HAIWEEITE AND
"META-HAIWEEITE"

| From granite | | From lake beds | |
|---|---|---|---|
| Inside of spherule (meta-haiweeite) | Outside of spherule | Fresh | Ignited |
| $\alpha$ 1.611 | 1.571 | 1.571 | 1.611 |
| $\beta$ 1.620 | 1.575 | 1.575 | 1.620 |
| $\gamma$ 1.645 | 1.578 | 1.578 | 1.645 |

with those of the outer portion. The respective indices of refraction for the two minerals, and for the ignited part, are given in Table 1.

This change in index values for the ignited material, to agreement with the inner mineral, would indicate a difference in water content, and suggest a relationship between the two like that between torbernite and metatorbernite, for instance. This inner mineral may thus be tentatively considered to be meta-haiweeite.

The chemical analysis is the average of four determinations, adjusted to 100% after deduction of insolubles, mainly quartz. The formula, as calculated from this analysis, as nearly as may be comes out as follows:

$$CaO \cdot 2UO_3 \cdot 6SiO_2 \cdot 5H_2O$$
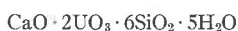
In Table 2 are shown the average analysis, and the percentages as calculated from the proposed formula. Spectroscopic analysis was used to check the details of the chemical analysis. Spectroscopic traces of Na, K, Al, Fe, Ti, Mg, and Ba, were noted, but none in sufficient amount to require consideration in the calculation of the analysis.

## X-RAY STUDY

$X$-ray powder photographs have been taken of both occurrences of

TABLE 2. CHEMICAL ANALYSIS OF HAIWEEITE

|  | I | II |
|---|---|---|
| CaO | 5.4 | 5.2 |
| $UO_3$ | 52.8 | 53.0 |
| $SiO_3$ | 33.1 | 33.4 |
| $H_2O$ | 8.7 | 8.4 |

I. Average of four analyses, adjusted to 100% after deduction of insoluble, mainly quartz. T. C. McBurney, analyst.

II. $CaO.2UO_3.6SiO_2.5H_2O$.

haiweeite, and of the ignited mineral from the lake beds, with the following results:

Patterns of the two types of occurrence, not ignited, show essentially identical spacings and intensities, indicating that the core mineral with higher indices, was not present, at least in the sample selected, in amount enough to produce a visible overlay of another pattern. The ignited material, however, with identical indices to those of the core, produced a definitely different pattern. The three patterns are shown in the accompanying Table 3. The ignited pattern shows essentially the same type of differences from the others as those between torbernite and metatorbernite.

A small sliver from one of the spherulites was carefully selected and mounted with its elongation, taken as the $c$ direction, as the axis of rotation. About this axis were taken a rotation photograph and Weissenberg photographs of the equator and first layer. The rotation photographs showed a fair alignment, but with indication of multiple crystals, even in the small flake selected, though with essentially parallel orientations in the $c$ direction. The spacing in this direction has an average value of 7.1 Å for $c_0$, with very good agreement between values for three layer lines.

Weissenberg photographs, equator and first layer, involved very long exposures and were, even so, much less satisfactory, though showing a fair grouping of orientation of the multiple crystals about $b$. The spots on the film were elongated streaks fading in intensity in either direction. By taking readings on the points of greatest intensity in these streaks, it was possible to make a construction showing a fairly consistent pattern, rectangular or nearly so, with a measurable offset on the first layer. The symmetry is probably monoclinic, but may be triclinic. The value of $b_0$ was calculated from several orders of $\{0k0\}$, and $a_0$ was estimated by scaling off the position of $\{h00\}$. Beta was calculated from the offset of the pattern on the first layer. The cell dimensions thus calculated, and beta are as follows:

$$a_0 = 15.44 \text{ Å} \qquad b_0 = 7.05 \text{ Å} \qquad c_0 = 7.10 \text{ Å} \qquad \beta = 107°52'$$

The value of $c_0$ may be considered as fairly good, but $b_0$ is an approximation and $a_0$ even less reliable. Beta should be reasonably good. Observed extinction is $h0l$ with $l$ odd, so that the space group is probably $P2/c$ $(C_{2h}^4)$. Other possibilities are $P2/m$, $P2_1/m$, $P2$.

No crystals were developed enough to show even observable faces, except that the broad faces are apparently $\{100\}$.

TABLE 3. X-RAY POWER PATTERNS OF HAIWEEITE AND "META-HAIWEEITE"
Copper radiation, Ni filter, $CuK_\alpha$ 1.5418 Å

| Haiweeite | | | | Lake bed mineral ignited (meta-haiweeite) | |
|---|---|---|---|---|---|
| from granite | | from lake bed | | | |
| $d$ | I | $d$ | I | $d$ | I |
| 9.14 | 10 | 9.26 | 10 | 8.81 | 5 |
| 8.05 | 2 | 7.97 | 2 | 7.97 | $\frac{1}{2}$ |
| 7.05 | 4 | 7.09 | 3 | 7.31 | $\frac{1}{2}$ |
| 5.53 | 2 | 5.54 | 2 | 6.98 | 10 |
| 5.06 | 1 | 5.06 | 1 | 5.85 | 5 |
| 4.90 | $\frac{1}{2}$ | — | | 4.54 | 4 |
| 4.556 | 6 | 4.53 | 8 | 3.81 | 2 |
| 4.42 | 6 | 4.41 | 5 | 3.52 | 5 |
| 3.82 | 2 | 3.80 | 1 | 3.28 | 4 |
| — | | 3.64 | $\frac{1}{2}$ | 3.16 | 5 |
| 3.54 | 4 | 3.54 | 3 | 3.00 | 3 |
| 3.30 | 3 | 3.30 | 3 | 2.90 | 5 |
| 3.19 | 5 | 3.18 | 4 | 2.78 | $\frac{1}{2}$ |
| 3.106 | 5 | 3.00 | 3 | 2.38 | 2 |
| 2.905 | 3 | 2.904 | 2 | 2.36 | 2 |
| 2.81 | 1 | 2.808 | $\frac{1}{2}$ | 2.268 | 1 |
| 2.62 | 2 | 2.616 | 3 | 2.22 | $\frac{1}{2}$ |
| 2.506 | $\frac{1}{2}$ | 2.503 | $\frac{1}{2}$ | 2.18 | $\frac{1}{2}$ |
| 2.393 | 2 | 2.386 | 2 | 2.11 | $\frac{1}{2}$ |
| 2.28 | 2 | 2.28 | 2 | 2.08 | $\frac{1}{2}$ |
| 2.21 | 1 | 2.22 | 2 | 1.982 | $\frac{1}{2}$ |
| — | | 2.188 | 2 | 1.963 | $\frac{1}{2}$ |
| 2.11 | 1 | 2.12 | $\frac{1}{2}$ | 1.892 | $\frac{1}{2}$ |
| | | 2.096 | 1 | 1.772 | 1 |
| — | | 2.07 | $\frac{1}{2}$ | 1.721 | 1 |
| 1.979 | 1 | 2.01 | 1 | 1.680 | $\frac{1}{2}$ |
| 1.923 | 1 | 1.923 | 1 | 1.648 | $\frac{1}{2}$ |
| 1.898 | 1 | 1.892 | 1 | 1.585 | $\frac{1}{2}$ |
| 1.854 | $\frac{1}{2}$ | 1.852 | 1 | 1.546 | 1 |
| 1.829 | 1 | 1.825 | 1 | | |
| 1.781 | 1 | 1.781 | 1 | | |
| 1.732 | 1 | 1.736 | 1 | | |
| 1.686 | 1 | 1.679 | 1 | | |
| 1.659 | $\frac{1}{2}$ | 1.650 | 1 | | |
| 1.628 | $\frac{1}{2}$ | 1.626 | $\frac{1}{2}$ | | |
| 1.598 | 1 | 1.592 | 1 | | |
| 1.559 | 1 | 1.558 | 1 | | |
| — | | 1.526 | $\frac{1}{2}$ | | |
| 1.492 | $\frac{1}{2}$ | 1.493 | $\frac{1}{2}$ | | |
| 1.454 | $\frac{1}{2}$ | 1.454 | $\frac{1}{2}$ | | |

and for suggestions as to the adjustment of the formula to Dr. Michael Fleischer, U. S. Geological Survey, Washington, D. C. Elimination of the chance that this mineral might be an earlier known one was made by comparison with the manuscript of a publication by Clifford Frondel and others: "X-ray powder pattern data of uranium and thorium minerals."