

Radtkeite, $\text{Hg}_3\text{S}_2\text{Cl}_2$, a new mineral from the McDermitt mercury deposit, Humboldt County, Nevada

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ABSTRACT

Radtkeite, $\text{Hg}_3\text{S}_2\text{Cl}_2$, is a new mineral that occurs in small amounts with cinnabar and corderoite at one locality in the McDermitt mercury mine, Humboldt County, Nevada. The mineral occurs mostly as 2- μm grains and as finely dispersed grains, coatings, and prismatic crystals as long as 30 μm , some of which are hollow, in altered tuffaceous sediments. Radtkeite is orthorhombic, with possible space groups *Fmmm*, *F222*, or *Fmm2*; $a = 16.85(1)$ Å, $b = 20.27(2)$ Å, and $c = 9.133(2)$ Å; $V = 3119.4(5)$ Å³; and $Z = 16$. The four strongest lines in the X-ray powder diffraction pattern of synthetic material are (d Å, I/I_0 , hkl) 2.54, 100, 080; 2.65, 85, 313; 3.89, 48, 420; 2.71, 44, 620. Radtkeite is opaque in thick sections but translucent in thin grains. The mineral and streak are yellow-orange, and both blacken on exposure to sunlight. Luster is almost adamantine. Hardness is 2–3. Cleavages are: pinacoidal {010} perfect, {001} and {100} very good; prismatic {0kl}, {h0l}, and {hk0} good. Fracture is splintery, conchoidal, and hackly. $D_{\text{meas}} = 7.0 \pm 0.1$ g/cm³, and $D_{\text{calc}} = 7.05 \pm 0.1$ g/cm³. Preliminary optical measurements indicate that the mineral is biaxial (+), with $2V_z$ approximately 35°. Refractive indices are greater than 2.0. Pleochroism of thin plates is orange, orange with red tint, and orange with green tint. Reflected light properties of natural and synthetic radtkeite are: medium reflectance, slightly lower than cinnabar; color pale gray with yellow cast; strong anisotropism commonly masked by abundant canary yellow internal reflections. The polishing hardness is less than that of cinnabar; VHN = 65–75. Radtkeite formed during late stages of mineralization by reaction of cinnabar and corderoite with halide-rich hydrothermal solutions in a surface-dominated environment; it exists in several textures as a result of fluctuating saturation levels.

INTRODUCTION

Radtkeite, $\text{Hg}_3\text{S}_2\text{Cl}_2$, occurs in the McDermitt mercury deposit in north-central Nevada, about 7 miles southwest of the town of McDermitt, Nevada-Oregon. The McDermitt mine is adjacent to the inactive Cordero, Crofoot, Lenway, and Ruja underground mercury mines (Yates, 1942; Bailey and Phoenix, 1944; Curry, 1960; Fisk, 1968). Radtkeite was found in one location in the present open pit. The major ore minerals at the McDermitt mine are cinnabar and corderoite, $\text{Hg}_3\text{S}_2\text{Cl}_2$, which was discovered first at the McDermitt mine, remarkably constituting as much as 25% of the ore (Foord et al., 1974). Corderoite has been since reported at three additional localities (Vasil'yev and Grechishchev, 1979; Krupp et al., 1985; John et al., 1989).

Radtkeite is named for Arthur S. Radtke, Palo Alto, California, in recognition of his outstanding work on the mineralogy, geology, and geochemistry of epithermal ore deposits, especially the Carlin-type disseminated gold deposits (see Radtke, 1985). In addition to numerous publications on Carlin-type deposits, he described six new minerals from Nevada, five of which were from the Carlin deposit.

Radtkeite is pronounced “rad” as in radish, “ke” as in

key, and “ite” as in white. The mineral and name were approved in advance of publication by the Commission on New Minerals and Mineral Names of the International Mineralogical Association. Representative samples of radtkeite are deposited in the Smithsonian Institution, Washington, DC (cat. no. NMNH 168450), and the W. M. Keck Minerals Museum of the Mackay School of Mines, University of Nevada, Reno.

OCCURRENCE

Radtkeite formed during reaction of hydrothermal solutions with lake sediments in the McDermitt caldera complex, which is a system of nested Miocene calderas approximately 50 km in diameter (McKee, 1976; Speer, 1977; Rytuba and Conrad, 1981; Rytuba and McKee, 1984). Rhyolitic tuffaceous sediments accumulated in an ancient lake; those sediments are now strongly altered in places to mixtures of montmorillonite, kaolinite, adularia, opal, cristobalite, and clinoptilolite (Glanzman and Rytuba, 1979; Hetherington, 1983; Hetherington and Cheney, 1985; Giraud, 1986; McCormack, 1986). Radtkeite was found closely associated with quartz, cinnabar, and corderoite at one location on the south margin of the present open pit. Compositions of important sulfide min-

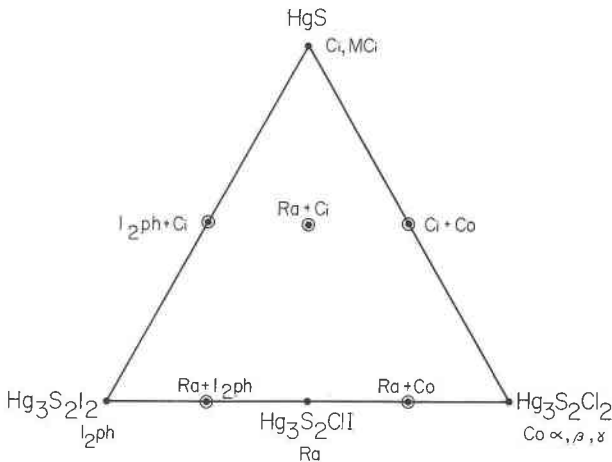


Fig. 1. Mineral and solid phase compositions plotted in the system $\text{HgS-Hg}_3\text{S}_2\text{Cl}_2\text{-Hg}_3\text{S}_2\text{I}_2$. Dots are bulk compositions; dots enclosed by circles are two-phase compositions. Ra = radtkeite, Co = corderoite, Ci = cinnabar, MCi = metacinnabar, I_2ph = iodide end-member phase, and α , β , and γ Co = polymorphs of corderoite.

erals at the McDermitt mine and of other solid phases in the system $\text{HgS-Hg}_3\text{S}_2\text{Cl}_2\text{-Hg}_3\text{S}_2\text{I}_2$ are plotted in Figure 1. Other rare mercury minerals that occur at the McDermitt mine are calomel, kleinite, eglestonite, native mercury, and possibly mosessite (Foord et al., 1974; McCormack, 1986). Radtkeite occurs as submicrometer grains, irregular masses, finely dispersed grains in the silica-clay matrix, coatings on cinnabar and corderoite, and euhedral crystals of several habits, up to $10\ \mu\text{m}$ wide and $30\ \mu\text{m}$ long. Most commonly, crystals are tabular prismatic, showing combinations of orthorhombic pinacoids and prisms that give rise to a characteristic habit (Fig. 2).

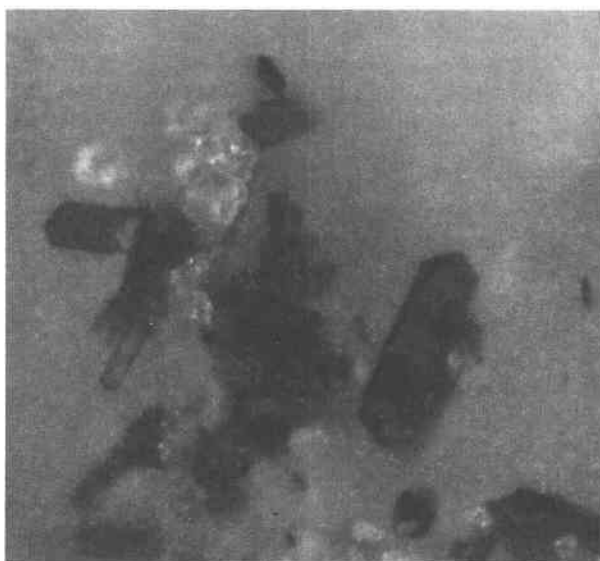


Fig. 2. Radtkeite crystals showing characteristic morphology within quartz; reflected light, crossed polars, magnification $\times 1000$.

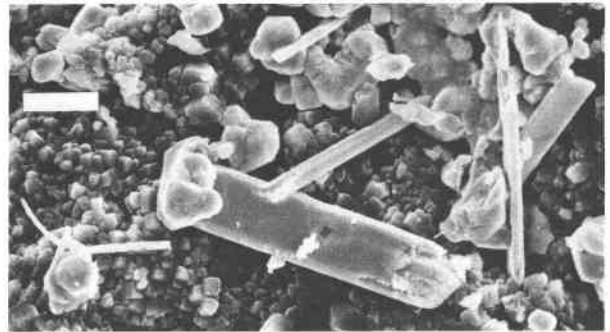


Fig. 3. SEM photomicrograph of prismatic radtkeite crystals and equant corderoite crystals on quartz matrix. A fluted radtkeite crystal is near the right margin. Hollow crystals of radtkeite overlie other minerals and quartz matrix. Note curved and tapered radtkeite tubular crystal on left, bottom margin. Bar scale = $10\ \mu\text{m}$.

The genesis of the mineral assemblages has been studied by many workers (Foord et al., 1974; Roper, 1976; Rytuba, 1976; Rytuba and Glanzman, 1979; Rytuba et al., 1979; McCormack, 1986). McCormack (1986) showed that the sequence of deposition of sulfides began with early pyrite with stibnite, followed by cinnabar. Corderoite was formed when dilute solutions with relatively low Cl and S contents reacted with cinnabar. Some corderoite replaced cinnabar volume for volume (McCormack, 1986). The radtkeite may have formed by the reaction of chloride-iodide solutions with cinnabar, but some was by reaction of iodine with corderoite as indicated by the common occurrence of radtkeite with corderoite (Fig. 3).

LABORATORY SYNTHESIS

Radtkeite forms sintered, wholly crystalline powders when correct proportions of HgS , HgI_2 , and HgCl_2 are reacted in evacuated sealed glass tubes at elevated temperatures. The reaction is complete after several days at $100\ ^\circ\text{C}$ or overnight at $200\ ^\circ\text{C}$ and above. Some reactants left for weeks in ordinary drying ovens at about $130\ ^\circ\text{C}$ produced excellent crystals. Crystals of radtkeite formed on cooler parts of the glass tubes, separated from the main charge; evidently the vapor pressure of radtkeite is sufficient to accommodate gaseous transport. Although charges having the precise radtkeite composition reacted rapidly to produce fine-grained radtkeite, subsequent growth of crystals was slow. Small excesses of HgCl_2 and HgI_2 quickened crystal growth. The slight departure from stoichiometry did not affect the bulk composition of the main charge, because the excess formed a compound of Hg, Cl, and I, presumably HgClI (Losana, 1926; Ansari, personal communication), which being more volatile than radtkeite, moved to cooler parts of the glass tubes. No melting of radtkeite was observed even at temperatures as high as $400\ ^\circ\text{C}$.

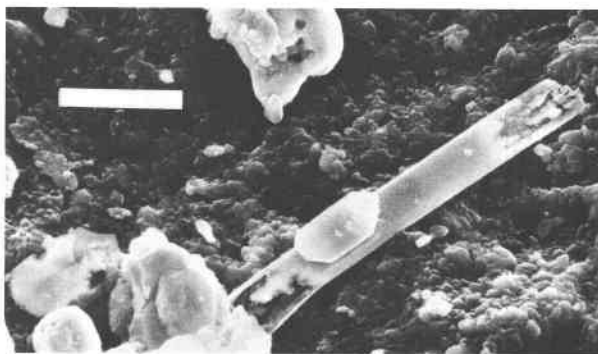


Fig. 4. SEM photomicrograph of prismatic radtkeite crystal with perched gypsum crystal, showing dissolution cavities coated by secondary, tiny crystals of radtkeite accompanied by equant white corderoite crystals on quartz groundmass. Bar scale = 10 μm .

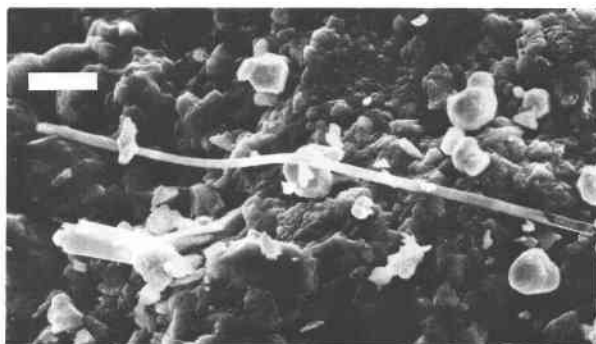


Fig. 5. SEM photomicrograph of tubular radtkeite crystal, capped on left end, on quartz matrix with equant white corderoite and prismatic radtkeite. Bar scale = 10 μm .

PHYSICAL AND OPTICAL PROPERTIES

The scanning electron microscope (SEM) was essential to the study of the natural materials because nearly all of the mineral grains were exceedingly small, 2 μm or less, and intimately intergrown with other minerals. Some prismatic crystals are fluted (Fig. 3) with hollow terminations (Figs. 3 and 4) as was noted for perrouditite, the mercury silver sulf-bromide-chloride-iodide (Sarp et al., 1987). Some extraordinary crystals are extremely long relative to their diameters, and hollow (Figs. 3 and 5); crystal forms bound their external surfaces; some are straight and others bend gently, draping like euhedral hoses over the groundmass minerals.

On freshly broken surfaces, radtkeite ranges from bright yellow-orange to a dull orange in color; the streak is yellow-orange. The mineral is highly sensitive to sunlight, and during exposure it darkens within minutes through shades of yellow-brown to black. Coarsely crystalline synthetic radtkeite shows the following characteristics: a very bright, almost adamantine luster; Mohs hardness of 2–3; fractures that are splintery, hackly, and conchoidal; many cleavages: pinacoidal {010} perfect, {001} and {100} very good; prismatic {0kl}, {h0l}, and {hk0} good; and $D_{\text{meas}} = 7.0 \pm 0.1 \text{ g/cm}^3$ by air comparison pycnometer on synthetic material, $D_{\text{calc}} = 7.05 \pm 0.1 \text{ g/cm}^3$ for natural samples. Transmitted light optical properties could be determined only partially because of high indices of refraction, deep color, and tendency to dissolve in high-index oils. In thick grains, the mineral is opaque; thin grains are translucent. Very thin grains display distinct pleochroic colors in transmitted light: bright orange, bright orange with a rosy tint, and bright orange with a greenish tint. The refractive indices are greater than 2.00 as measured by Becke line test in Cargille's 2.00 RI oil (AsBr₃). Preliminary optical measurements indicate that the mineral is biaxial (+), with $2V_z$ near 35°.

In reflected light, radtkeite has medium reflectance, slightly less than that of cinnabar and much greater than

that of quartz. Its color in a quartz matrix next to cinnabar is pale gray with distinct yellow cast. Radtkeite displays abundant internal reflections that are canary yellow in color. The polishing hardness of radtkeite is less than that of cinnabar. Six measurements of the Vickers hardness number (VHN) ranged from 65 to 75. The exceedingly small grain size, softness, and multiple cleavages of the mineral made polishing difficult and twinning, pleochroism, and cleavages nonobservable. Synthetic radtkeite shows strong optical anisotropism that is commonly masked by the abundant internal reflections.

Radtkeite is exceedingly fine grained and tightly cemented by matrix minerals, and special methods were required to prepare material suitable for study. As mentioned earlier, radtkeite powder and crystals, successfully synthesized in the laboratory, served some purposes. We resorted to leaching the natural material with acid after attempts to free radtkeite by physical means produced low yields. Concentrates with lower levels of cinnabar and quartz were obtained by leaching away silicate minerals with strong HF in a fume hood. Radtkeite also reacts with strong acids but, fortunately, more slowly. The radtkeite mineral sample used for X-ray analysis, for which data are given in Table 1, was freed by this procedure. Excellent agreement of the d values of the mineral with those of synthetic material was obtained except for some differences in intensity resulting from the preferred orientation of the synthetic material.

CRYSTALLOGRAPHIC RELATIONS

Radtkeite is orthorhombic, diffraction symbol $F---$. Using unfiltered Mo radiation, single-crystal precession photographs of synthetic radtkeite showed Laue symmetry mmm with extinctions: hkl , all odd or all even; $h00$, h even; $0k0$, k even; $00l$, l even. Thus, the possible space groups are $Fmmm$, $F222$, or $Fmm2$. Unit-cell parameters determined from the photographs are (\AA) $a = 16.85(1)$, $b = 20.27(2)$, and $c = 9.133(2)$ with $V = 3119.4(5) \text{ \AA}^3$ and $Z = 16$ (R. C. Erd, personal communication). The cell volume is large compared with volumes of most related minerals and solid phases (Puff et

TABLE 1. Powder X-ray diffraction data for natural and synthetic radtkeite

// l_0 syn.	d_{obs} (Å) syn.	d_{calc} (Å)	hkl	// l_0 mineral	d_{obs} (Å) mineral
3	10.10	10.134	020	1	10.11
2	7.46	7.465	111	1	7.50
13	6.47	6.479	220	8	6.49
3	5.16	5.169	131		
3	5.06	5.067	040		
11	4.65	4.657	311	6	4.66
7	4.34	4.343	240	4	4.34
15	4.16	4.163	022	18	4.15
48	3.89	3.891	420	41	3.90
17	3.73	3.733	222	22	3.73
5	3.62	3.619	151	4	3.65
22	3.38	3.378	060	9	3.38
4	3.15	3.147	242	6	3.15
14	3.10	3.097	402	7	3.10
17	2.96	2.961	422	24	2.96
44	2.71	2.707	620	44	2.71
85	2.65	2.653	313	100	2.64
13	2.59	2.585	262	29	2.58
100	2.54	2.533	080	28	2.53
4	2.474	2.477	371	5	2.482
6	2.428	2.426	280	4	2.423
4	2.408	2.409	153		
2	2.314	2.313	711		
16	2.282	2.283	462	26	2.281
2	2.200	2.201	731		
10	2.169	2.169	191	10	2.164
7	2.142	2.143	533	7	2.144
17	2.109	2.107	800	18	2.107
2	2.082	2.082	173	3	2.072
3	2.037	2.038	391		
3	2.021	2.021	244	3	2.024
10	1.965	1.965	373	13	1.962
2	1.912	1.913	802	4	1.916
10	1.880	1.880	822	11	1.880
3	1.852	1.853	0, 10, 2		
18	1.827	1.827	911	12	1.827
3	1.800	1.800	193		
3	1.787	1.788	860	8	1.789
7	1.745	1.745	624	12	1.751
4	1.723	1.723	393		
22	1.697	1.696	084	21	1.695
4	1.682	1.682	335		
9	1.665	1.665	862	14	1.660
3	1.643	1.644	6, 10, 0		
3	1.622	1.620	880	11	1.622
7	1.617	1.619	791		
4	1.596	1.597	355		
3	1.581	1.581	10, 0, 2	9	1.583
3	1.563	1.562	535	12	1.565
7	1.549	1.550	971	13	1.550

Note: Calculated d values and hkl values calculated by use of least-squares unit-cell refinement program, North Dakota State University, after Appleman and Evans (1973).

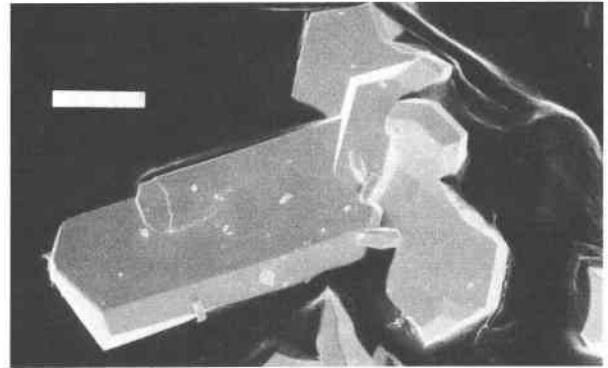


Fig. 6. SEM photomicrograph of synthetic radtkeite crystals, showing typical forms. Bar scale = 100 μm .

RADTKEITE CRYSTAL SHAPES AND IMPLICATIONS

Radtkeite from the McDermitt mine occurs in several shapes, each of which is a record of somewhat different genetic conditions. Most radtkeite from the McDermitt mine is in the shape of grains less than 2 μm in diameter embedded in groundmass minerals. At least three shapes of larger crystals occur in quartz-filled fractures and small cavities. The most common were relatively large, tabular crystals, with well-developed prisms and pinacoids, forms seen also in synthetic material (Fig. 6). Other mineral grains of the same general size and appearance show fluted ends. Dissolution and redeposition are evidenced by comparatively large pits lined by smaller radtkeite crystals (Figs. 3 and 4). Most remarkable, however, are hollow crystals, capped at one end, that are extremely long, more than 30 μm , relative to their diameters of a few micrometers (Figs. 3 and 5).

The formation of hollow tubes by highly anisotropic solids (i.e., those that show contrasting strain responses to applied stress, particularly those with large unit cells such as radtkeite) has been treated theoretically by Frank (1951), Van der Hoek et al. (1982), and Nabarro (1984). Hollow crystals have been reported in natural materials (Zolensky and Mackinnon, 1986), and they have been made experimentally (Van der Hoek et al., 1982; Yager et al., 1988; Pool, 1990). Free energies of solids along stressed dislocation sites can be significantly higher than the bulk free energy. The magnitudes of free energies depend in part on thermal and elastic properties of the solids. Differences in free energies on faces lead to simultaneous growth and nongrowth, or dissolution, depending on the chemical potential of species in solution.

Radtkeite tubes probably formed by deposition from solution (or vapor) at times when the level of supersaturation (or vapor pressure) or kinetic factors were appropriate to the nucleation of tiny crystals; supersaturation evidently was not high enough to sustain growth on some dislocation zones. Textural features of radtkeite from the McDermitt mine provide evidence for varying growth conditions.

al., 1966). Unit-cell parameters calculated from the powder pattern of natural radtkeite are (\AA) $a = 16.92(2)$, $b = 20.25(2)$, $c = 9.110(3)$. X-ray patterns were obtained using a PW1700 automated powder diffractometer system using $\text{CuK}\alpha$ (1.54060 \AA) radiation. Internal standards were NBS SRM 675 (synthetic fluorophlogopite mica) and SRM 640 (Si metal). Interplanar spacings from X-ray powder diffraction studies of radtkeite and its synthetic analogue and calculated d values from the single-crystal photographs match well, with only a few weak reflections not present in the pattern of the mineral.

CHEMICAL COMPOSITION

A JEOL T300 scanning electron microscope equipped with a PGT energy-dispersive X-ray spectrometer operating at 20 kV and 0.15 nA, with HgS, PbCl₂, and HgI₂ as standards, was used for analysis. Chemical compositions for ten grains of natural radtkeite and two grains of synthetic material are given in Table 2 (Sjoberg, personal communication, 1990). The best-fit formula is Hg₃S₂ClI. A low operating voltage was used to minimize problems caused by volatility of the elements Hg, S, Cl, and I. Similar problems were encountered by Sarp et al. (1987) in their study of perroudite, a mineral containing variable concentrations of Ag₂S, HgS, Br, Cl, and I.

An important question is whether the formula for radtkeite would be better written as Hg₃S₂(Cl,I) to allow for the possibility of significant variations in Cl and I. The evidence available at the moment indicates that radtkeite is either stoichiometric or displays very limited solid solution. The situation is different for systems containing Br. Solid solutions have been reported for sulf-halides of Hg that contain both Br and Cl such as lavrentievite and arkazite, Hg₃S₂(Br,Cl) (Vasil'yev et al., 1984) or Br with Cl and I as in perroudite, ideal formula Hg₃Ag₃S₅(Cl,Br,I)₄ (Sarp et al., 1987), and grechischevite, Hg₃S₂(Br,Cl,I)₂ (Vasil'ev et al., 1989). Ionic radii of the halogens differ considerably (*CRC Handbook*, 1981–1982, p. F175). Br⁻ is intermediate in size, with a radius of 1.96 Å, Cl⁻ is smallest (1.81 Å) and I⁻ is largest (2.20 Å). Br⁻, being somewhat closer in radius to Cl⁻, would be expected to substitute more freely for Cl⁻ than for I⁻. Br was specifically sought in the microprobe studies of McDermitt mine materials but was not found.

No persuasive evidence supporting the existence of extensive solid solutions in radtkeite is revealed by the microprobe analyses shown in Table 2. The ten individual analyses were included, rather than an average analysis, to show the variability of each constituent. Considerable variations in reported values are shown by all elements, each of which presents special analytical difficulties in microprobe analysis. Mass and charge balances vary erratically, as do the raw data. The Cl contents are persistently low compared to I contents, but variations in Cl contents are not paralleled by variations in other constituents. Radtkeite and corderoite at the McDermitt mine formed in a Cl-rich environment, which would have favored Cl over I in any radtkeite solid solution but that was not observed. Homogeneous, crystalline radtkeite powder, synthesized under the conditions discussed earlier precisely on a one-to-one Cl to I molar ratio, gave rise to the same *d* values as the mineral. The X-ray diffraction data of radtkeite synthesized in the presence of corderoite differed little from data for natural and synthetic radtkeite.

CHEMISTRY AND PHASE RELATIONS

Radtkeite may result from a two-step reaction in which cinnabar is first converted to corderoite which then reacts

TABLE 2. Electron-microprobe analyses of radtkeite and structural formula

Grain No.	Wt%				Structural formulae
	Hg	S	Cl	I	
1	71.4	9.0	3.8	15.8	Hg ₃ S _{2.37} Cl _{0.90} I _{1.05}
2	71.7	9.6	4.3	14.4	Hg ₃ S _{2.51} Cl _{1.01} I _{0.96}
3	73.0	8.1	3.8	15.2	Hg ₃ S _{2.08} Cl _{0.88} I _{0.99}
4	75.3	7.2	3.2	14.3	Hg ₃ S _{1.79} Cl _{0.72} I _{0.90}
5	74.7	7.3	3.1	14.9	Hg ₃ S _{1.84} Cl _{0.70} I _{0.95}
6	73.9	8.7	3.4	14.0	Hg ₃ S _{2.22} Cl _{0.78} I _{0.90}
7	71.8	8.9	4.2	15.1	Hg ₃ S _{2.33} Cl _{0.99} I _{1.00}
8	73.8	8.3	3.3	14.6	Hg ₃ S _{2.11} Cl _{0.77} I _{0.94}
9	74.4	7.4	3.3	14.9	Hg ₃ S _{1.87} Cl _{0.75} I _{0.95}
10	74.4	7.4	3.3	14.9	Hg ₃ S _{1.87} Cl _{0.75} I _{0.95}
N	73.4	8.2	3.6	14.8	Hg ₃ S _{2.10} Cl _{0.82} I _{0.96}
Synthetic Hg₃S₂ClI					
1	73.9	7.3	4.3	15.5	Hg ₃ S _{1.87} Cl _{0.98} I _{0.93}
2	73.5	6.6	4.2	15.6	Hg ₃ S _{1.89} Cl _{0.98} I _{1.01}
N	73.7	7.0	4.3	15.1	Hg ₃ S _{1.78} Cl _{0.98} I _{0.97}

Note: Calculated on the basis of 3 Hg atoms. Ideal formula: Hg₃S₂ClI. Ideal composition: Hg = 72.66, S = 7.74, Cl = 4.28, I = 15.32 wt%. Analyses normalized to 100.0 wt%.

with I to form radtkeite: 3HgS^(C) + 2Cl⁻ = Hg₃S₂Cl₂^(Co) + S²⁻ and Hg₃S₂Cl₂^(Co) + I⁻ = Hg₃S₂ClI^(Ra) + Cl⁻. Radtkeite could also form directly by reaction with cinnabar: 3HgS^(C) + Cl⁻ + I⁻ = Hg₃S₂ClI^(Ra) + S²⁻. However, the solubility of cinnabar is quite low, and ordinarily very little cinnabar dissolves in neutral salt solutions. For appreciable radtkeite to form from cinnabar, some way of eliminating S²⁻ is required such as transport away in solution, oxidation to SO₄²⁻, or local precipitation of sulfides. This reaction may proceed slowly at room temperature as implied by a long-term experiment in which crystals of cinnabar were exposed to brine saturated with KCl and KI, kept in the dark and shaken occasionally, for 2 yr. The washed and dried, still bright red cinnabar turned black on exposure to sunlight within 1 h. Grinding, however, restored the original bright color, and no darkening of the material was observed thereafter on exposure to sunlight, even after days. The reaction evidently produced a vanishingly thin surface layer of radtkeite (or some other unknown compound). This may explain why cinnabar from some localities darkens in sunlight, while cinnabar from others does not (Dreyer, 1939). Possibly, a photosensitive coating forms when cinnabar contacts halides in low pH, oxygenated H₂O.

Radtkeite is a member of a group of sulf-halides of Hg that have some common characteristics. Sulfide minerals spatially and genetically most closely associated with radtkeite at the McDermitt mine are corderoite and cinnabar. Figure 1 is a plot of the compositions of solid phases in the system HgS-Hg₃S₂Cl₂-Hg₃S₂I₂. Radtkeite is similar in composition to corderoite, but it is orthorhombic rather than isometric. The crystal structures probably are similar in spite of the difference in symmetry. Crystal structures have been determined for cinnabar (Aurivillius, 1950), α-Hg₃S₂Cl₂ (corderoite) (Puff and Küster, 1962; Aurivillius, 1967), γ-Hg₃S₂Cl₂ (Durovic, 1968), and Hg₃S₂I₂ (Blachnik et al., 1986). Puff et al. (1966) sum-

marized the polymorphic relations of mercury sulf-halides.

Cinnabar has a structure with helical chains in which each S atom has two Hg atoms as nearest neighbors (Aurivillius, 1950). Sulf-halides of Hg can be derived from cinnabar by substituting two halide ions for one S^{2-} . Puff and Küster (1962), in their original description of the atomic structure of corderoite (α - $Hg_3S_2Cl_2$), pointed out that three Hg atoms were bonded to two S atoms by strong covalent bonds, creating a tightly bound $Hg_3S_2^+$ core group that in some ways behaves as a molecule. The group is tied laterally to halogens by weaker ionic bonds. This arrangement holds for the three sulf-halides of Hg for which the structures have been determined. By analogy, the structure of radtkeite should contain the same core group. The stability of Hg-S core groups in these structures is reminiscent of similarly strongly bonded atoms in the aqueous HgS_2^- complex anion (see Tunell, 1964, for review).

Systematic experimental studies of phase relationships in these systems are in progress at the University of Nevada. In addition, efforts are being made to synthesize crystals suitable for crystal structure determination by neutron diffraction.

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