

Saltonseaites, $K_3NaMn^{2+}Cl_6$, the Mn analogue of rinneite from the Salton Sea, California

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ABSTRACT

Saltonseaites, $K_3NaMn^{2+}Cl_6$, is a new mineral from the Salton Sea, Imperial County, California, U.S.A., which formed as the result of the evaporation of geothermal (hydrothermal) brines enriched in K, Na, Mn, and Cl. It occurs as lozenge-shaped and bladed crystals to about 10 cm that are composites of parallel-grown {012} rhombohedra. It is associated with large, well-formed crystals of sylvite and halite. Crystals are transparent and colorless, but appear light orange due to inclusions of akaganéite. The streak is white and the luster is vitreous to oily, the latter being due to deliquescence. The Mohs hardness is about 2½, the tenacity is brittle, the fracture is irregular, and crystals exhibit one very good cleavage on {110}. The mineral has an astringent taste and is markedly hygroscopic. The measured and calculated densities are 2.26(1) and 2.297 g/cm³, respectively. Saltonseaites is soluble in water at room temperature and crystallizes from solution above 52 °C. Optically, saltonseaites is uniaxial positive, with $\omega = 1.577(1)$ and $\epsilon = 1.578(1)$ (white light) and is non-pleochroic. Energy-dispersive spectroscopic analyses (average of 5) provided: K 28.79, Na 5.35, Mn 13.48, Fe 0.24, Cl 52.19, total 100.05 wt%. The empirical formula (based on 6 Cl atoms) is: $K_{3.00}Na_{0.95}Mn_{1.00}Fe_{0.02}^{2+}Cl_6$. Saltonseaites is trigonal, $R\bar{3}c$, with cell parameters $a = 12.0966(5)$, $c = 13.9555(10)$ Å, $V = 1768.48(16)$ Å³, and $Z = 6$. The nine strongest lines in the X-ray powder diffraction pattern are [d_{obs} in Å(hkl)]: 5.83(61) (012); 3.498(25)(300); 2.851(68)(131); 2.689(32)(312); 2.625(62)(214); 2.542(100)(223); 1.983(32) (324); 1.749(20)(600), and 1.384(22)(multiple). The structure of saltonseaites ($R_1 = 1.08\%$ for 558 $F_o > 4\sigma F$) contains face-sharing chains of alternating $Mn^{2+}Cl_6$ octahedra and $NaCl_6$ polyhedra along c . The chains are joined via bonds to eight-coordinated K atoms. Saltonseaites is isostructural with rinneite, $K_3NaFe^{2+}Cl_6$, and very similar in structure with chlormanganokalite, $K_4Mn^{2+}Cl_6$. Existing chemical analyses for saltonseaites and rinneite fail to confirm a solid-solution series between them; experimental studies are needed.

Keywords: Saltonseaites, new mineral, crystal structure, rinneite, chlormanganokalite, evaporite, geothermal brine, Salton Sea, California