

## Desautelsite, a new mineral of the pyroaurite group

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### Abstract

Desautelsite,  $\text{Mg}_6\text{Mn}_2^{3+}(\text{CO}_3)(\text{OH})_{16}\cdot 4\text{H}_2\text{O}$ , is the trivalent manganese analog of pyroaurite. The mineral occurs at two localities in San Benito County, California, and at the type locality, the Cedar Hill quarry, Lancaster County, Pennsylvania. At both localities it is associated with altered serpentines. Desautelsite is hexagonal, space group  $R\bar{3}m$  or  $R\bar{3}m$  with  $a = 3.114(1)$  and  $c = 23.39(2)\text{Å}$ ,  $V = 196.4\text{Å}^3$ ,  $Z = 3/8$ . The strongest lines in the X-ray diffraction pattern ( $d$ , in Å; intensity;  $hkl$ ) are: 7.76 100 0003, 3.88 60 0006, 2.332 60 01 $\bar{1}$ 5, 1.981 60 01 $\bar{1}$ 8 and 2.622 50 01 $\bar{1}$ 2.

Desautelsite is bright orange in color and is the last mineral to form in the paragenesis. Optically, it is uniaxial (–) with  $\epsilon = 1.547$  and  $\omega = 1.569$ . The density is  $2.13\text{ g/cm}^3$ , in excellent agreement with the theoretical value of  $2.10\text{ g/cm}^3$ . Morphologically, desautelsite forms simple hexagonal crystals, tabular along [0001], and shows the forms {0001} and {10 $\bar{1}$ 0}. Microchemical tests provide a ready means for distinguishing between desautelsite and pyroaurite.

### Introduction

This new mineral was initially noted on specimens from San Benito County, California, by one of the authors (TDP), who correctly assumed that it belonged to the pyroaurite group and noted that it contained little iron and appreciable manganese. Subsequent investigation indicated that it is the trivalent manganese analog of pyroaurite, a new mineral species.

We take pleasure in naming this new species desautelsite in honor of Paul E. Desautels, curator of the mineral and gem collections of the National Museum of Natural History at the Smithsonian Institution. His efforts in expanding the collection and assuring its pre-eminence have been very successful. The new mineral and the name were both approved by the Commission on New Minerals and Mineral Names,

IMA, prior to publication. The holotype specimen, from Lancaster County, Pennsylvania, is deposited in the mineral collection of the Smithsonian Institution under catalog #120219. Metatype specimens have been deposited in the Mineralogical Museum at Harvard University, Cambridge, Massachusetts. The new mineral name is pronounced DESS'-ah-tell-site.

### Occurrence

Desautelsite has been found at four localities and may well be found at a much larger number of localities as its existence and properties become known to the scientific and collector communities. The mineral occurs at the Cedar Hill quarry in Lancaster County, Pennsylvania, at an undisclosed locality in Japan (Akira Kato, personal communication), and abundantly at two localities in San Benito County, California.

At the type locality, the Cedar Hill quarry, desautelsite occurs sparsely as small orange crystals imbedded in colorless brucite and as isolated euhedra in vugs as the last mineral to crystallize. The mineral must be considered rare at the type locality, but the best crystals we found were from this deposit and the description is based entirely on material from this occurrence. The related phase, pyroaurite, has also been found at Cedar Hill by Lapham and Geyer (1965), and Lapham (1965) also noted the occurrence of a nickeliferous magnesium hydroxide, presumably also a member of the pyroaurite group.

Desautelsite occurs abundantly at two localities in San Benito County, California, in the vicinity of the New Idria mining district. This district is located at the southern end of the Diablo range, in a region consisting in part of highly sheared and serpentized rock masses containing antigorite, chrysotile, and talc. Mercury and chromium ores have been mined in the area for many years, and chrysotile asbestos is currently being mined at two locations. The New Idria mining district is noted for its extensive suite of rare and unusual minerals including a number of species first described from the area: benitoite, joaquinite, jonesite (Wise *et al.*, 1977), and coalingite. The geology and mineralogy of the area have been described by Wise and Gill (1977) and others. Because desautelsite is common at both California localities, it may be found at many others of similar paragenesis. The mineral has probably been overlooked until now because of its similarity to locally abundant coalingite and pyroaurite.

The first California occurrence, where the mineral was first observed by one of us (TDP), is at the Coalinga asbestos mine in San Benito County. Additional field work resulted in the discovery of a second California occurrence at the Herman Akers Claim, a surface asbestos prospect located four miles south of New Idria. This location is geologically characteristic of the general area, including the Coalinga asbestos mine, and consists of highly fractured serpentine. Extensive open spaces in the serpentine breccia are often filled with secondary magnesium minerals such as artinite, talc, brucite, and desautelsite. At the Herman Akers Claim, desautelsite forms bright orange coatings and encrustations on the serpentine fragments and on the other minerals which form in the interstices. Artinite is the most abundant of these interstitial fillings and frequently entirely fills the spaces in the breccia, and lines fractures with crusts of acicular crystals and spherical aggregates. Desautelsite is always the last mineral to form and is char-

acteristically bright orange in color. The crystals are very small, seldom exceeding 0.2mm, and the thin coatings of microcrystals on serpentine frequently resemble coatings of yellow mustard. Such coatings of desautelsite occur irregularly through the brecciated serpentine but appear to be more common in and adjacent to water-laden faults that traverse the serpentine outcrops.

#### X-ray crystallography

Single crystals were studied with the precession and Weissenberg techniques. These showed that it has space group  $R\bar{3}m$  or  $R3m$  and is twinned by rotation of  $180^\circ$  about [0001]. The lattice parameters obtained from the single-crystal studies were refined by least-squares from powder-diffraction data measured from a Gandolfi pattern which was obtained with Si as an internal standard. The lattice parameters are  $a = 3.114(1)$  and  $c = 23.39(2)$ Å. The powder-diffraction data are listed in Table 1.

The diffraction, chemical-analytical, and physical-property data are all consistent with desautelsite being isostructural with pyroaurite. Pyroaurite and other minerals of this group are known to occur in other stacking modifications. For example, sjögrenite is the 2H polytype of pyroaurite. Although the diffraction patterns were carefully examined for evidence of the occurrence of the 2H-equivalent of desautelsite, none was observed. Powder diffractometry does not permit a distinction between pyroaurite and desautelsite.

The unit-cell contents are  $Z = 3/8$  for the formula  $Mg_6Mn_2^{3+}(CO_3)(OH)_{16}\cdot 4H_2O$ . This value of  $Z$  requires that Mn and Mg be disordered, as has been shown to be the case for  $Fe^{3+}$  and Mg in pyroaurite by Ingram and Taylor (1967) and Allman (1968). Taylor (1969) found that pyroaurite and sjögrenite may have superlattice reflections which require that the  $a$  translation be either  $\sqrt{3}A$  or  $\sqrt{13}A$ , where  $A$  is the substructure translation. These reflections are consistent with ordering of Mg and Fe in pyroaurite, and Taylor showed that the two superstructures correspond to Mg:Fe ratios of 2:1 and 12:1 respectively. Octahedral coordination of the  $Mn^{3+}$  ion, as required by the pyroaurite-type structure, invariably leads to a Jahn-Teller distortion of the polyhedron. This, coupled with the high probability, based on ionic charge and radius considerations, of Mg-Mn ordering suggests that Mg and Mn should be ordered in desautelsite. We therefore carefully examined the single-crystal diffraction photographs for the occurrence of superstructure reflections, but none were

observed. The highly probable Mg-Mn ordering must therefore be short-range in nature. It is also possible, however, that we were simply not able to observe weak superstructure reflections, due to the poor quality of the available crystals.

### Morphology

Desautelsite occurs as simple hexagonal crystals, tabular along [0001]. The only forms are {0001} and {10 $\bar{1}$ 0}. Examination of many crystals with the scanning electron microscope did not reveal the existence of any other modifying forms. The crystals from the Cedar Hill quarry in Pennsylvania are slightly resorbed (Fig. 1), but the crystals from both California occurrences are sharp and euhedral.

### Physical and optical properties

Desautelsite is bright orange in color, and the streak is light orange. The hardness (Mohs) is approximately 2. There is one perfect cleavage on {0001}. The density, measured with heavy-liquid techniques, is 2.13(2) g/cm<sup>3</sup>, in excellent agreement with the theoretical value of 2.10 g/cm<sup>3</sup>. Optically, desautelsite is uniaxial (-) with  $\epsilon = 1.547$ ,  $\omega = 1.569$  (both  $\pm 0.003$ ). The mineral is strongly pleochroic with  $\omega =$  deep orange and  $\epsilon =$  light orange. Desautelsite does not fluoresce in ultraviolet radiation.

Table 1. Powder-diffraction data for desautelsite (114.6mm-diameter Gandolfi camera, NBS Si internal standard, CuK $\alpha$  radiation, Ni filter, intensities visually estimated)

d(obs)	D(calc)	hkl	I/I <sub>0</sub>
7.76	7.80	0003	100
3.88	3.90	0006	60
2.622	2.628	01 $\bar{1}$ 2	50
2.332	2.336	01 $\bar{1}$ 5	60
1.981	1.982	01 $\bar{1}$ 8	60
1.768	1.767	10 $\bar{1}$ .10	20
1.670	1.670	01 $\bar{1}$ .11	20
1.557	1.557	11 $\bar{1}$ 0	20
	1.559	000.15	
1.527	1.527	11 $\bar{2}$ 3	30
1.498	1.497	10 $\bar{1}$ .13	20
1.446	1.446	11 $\bar{2}$ 6	10
1.421	1.420	01 $\bar{1}$ .14	5
1.297	1.296	20 $\bar{2}$ 5	10
	1.299	000.18	
1.286	1.285	10 $\bar{1}$ .16	10
1.226	1.225	01 $\bar{1}$ .17	5
	1.224	20 $\bar{2}$ 8	
1.141	1.139	20 $\bar{2}$ .11	1
0.9973	0.9975	11 $\bar{2}$ .18	1

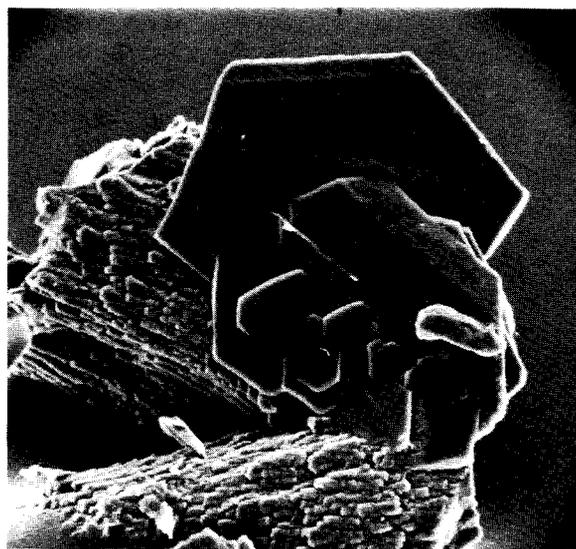


Fig. 1. Scanning electron photomicrograph of desautelsite from the Cedar Hill quarry, Lancaster County, Pennsylvania (250 $\times$ ).

### Chemistry

Crystals of desautelsite were chemically analyzed with an ARL-SEMQ electron microprobe, utilizing an operating voltage of 15 kV and a beam current of 0.15  $\mu$ A. The standards used were manganite for Mn, and hornblende for Mg, Fe, Ca, and Al. A wavelength-dispersive scan indicated the absence of any other elements with atomic number greater than nine. There was insufficient material for the direct determination of water or carbon, but carbonate was detected by effervescence of a pure fragment in HCl, and the sum of water and carbonate by difference is in good agreement with the theoretical composition. The resultant analysis yielded: (in weight percent) Mn<sub>2</sub>O<sub>3</sub> 23.04, MgO 35.88, Fe<sub>2</sub>O<sub>3</sub> trace, compared with the theoretical values of Mn<sub>2</sub>O<sub>3</sub> 23.92, MgO 36.65. Manganese was assigned to the trivalent state on the basis of the isostructural relationship of desautelsite to pyroaurite. By analogy with pyroaurite, the formula of desautelsite is Mg<sub>6</sub>Mn<sup>3+</sup>(CO<sub>3</sub>)(OH)<sub>16</sub>·4H<sub>2</sub>O.

Desautelsite is readily soluble in hydrochloric acid, and this solubility assists in distinguishing the mineral from pyroaurite. Desautelsite is much more reactive with hydrochloric acid than pyroaurite and actually dissolves in the presence of hydrochloric acid vapor (fumes) without direct contact between mineral and liquid acid. Pyroaurite, on the other hand, is not nearly as sensitive and dissolves only when in contact with liquid acid.

The solution of desautelsite in 1:1 hydrochloric

acid is deep brown, whereas pyroaurite imparts a light greenish-yellow color to the solution. In addition, a very simple microchemical test serves to distinguish between the species. After dissolution of the mineral in hydrochloric acid, a drop of a solution of potassium ferrocyanide gives a dark blue solution if  $\text{Fe}^{3+}$  is present and no reaction for  $\text{Mn}^{3+}$ . Hence, the lack of any blue solution indicates the mineral being tested is not pyroaurite. Although hydrotalcite also responds negatively to this iron test, the X-ray powder diffraction pattern is sufficiently different to permit its identification.

### Acknowledgments

The authors are indebted to Mr. Martin Anne of Wrightsville, Pennsylvania and Mr. Donald Schmerling of York, Pennsylvania for providing samples of the Cedar Hill desautelsite. Both men, affiliated with the Pennsylvania Friends of Mineralogy, were extremely cooperative and provided critical samples at the outset of this investigation. We also thank Mr. Richard Johnson and Mr. Grover Moreland of the Smithsonian Institution for the prepara-

tion of polished sections, Mr. Charles Obermeyer for assistance with the microprobe, and Ms. Mary Jacque Mann for assistance with the scanning electron microscope.

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*Manuscript received, July 12, 1978;*  
*accepted for publication, September 15, 1978.*