

FALCONDOITE, NICKEL ANALOGUE OF SEPIOLITE

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ABSTRACT

Falcondoite, a new mineral from the Dominican Republic, is a hydrous nickel silicate of the sepiolite group containing 26.7% NiO, 8.5% MgO, 45.9% SiO₂ and 15% H₂O. It is orthorhombic with cell parameters *a* 13.5, *b* 29.9, *c* 5.24Å. Dehydration occurs in four steps at 180, 360, 540 and 840°C. Conversion to an orthopyroxene takes place on heating to above 850°C.

SOMMAIRE

La falcondoïte, nouveau minéral provenant de la République dominicaine, est un silicate de nickel hydraté appartenant au groupe de la sépiolite et contenant 26.7% NiO, 8.5% MgO, 45.9% SiO₂ et 15% H₂O. La falcondoïte est orthorhombique avec *a* 13.5, *b* 29.9, *c* 5.24Å. La déshydratation se produit en quatre étapes, soit à 180, 360, 540 et 840°C. La transformation en orthopyroxène se produit au-dessus de 850°C.

(Traduit par la Rédaction)

INTRODUCTION

Sepiolites are common constituents of garnierite deposits. They occur together with talc and serpentine-type minerals and are frequently nickel-bearing. Caillère (1936) described a sepiolite from New Caledonia in which the atomic nickel-to-magnesium ratio is 1:4. Hotz (1964) gave 1.46% Ni for a sepiolite occurring at Nickel Mountain, Oregon. Maksimovic (1969) mentions nickeliferous sepiolite with 6.65% Ni from Goles, Yugoslavia.

Adopting $\{Mg_x(H_2O)_x(OH)_4[Si_{12}O_{30}]\} \cdot (H_2O)_z$ as the formula for sepiolite (Brauner & Preisinger 1956), and assuming that all Mg is replaced by Ni, a nickel content of 29.9% can be calculated; replacement of 50% of the Mg would result in a nickel content of 16.4%. Natural material averaging 21% Ni and with the structural characteristics of sepiolite has been found and is described in the following. As the nickel content exceeds the magnesium content in terms of atomic proportions, the mineral is considered a new species for which the name falcondoite is proposed. The name has been approved by the Commission on New Minerals and Mineral

Names, IMA. Type material is preserved at the Royal Ontario Museum under specimen number M 34324.

OCCURRENCE

The new mineral occurs near the town of Bonao, Dominican Republic, in an extensive laterite deposit mined by Falconbridge Dominicana C. por A. (Falcondo). The deposit is part of a serpentinized harzburgite massif and is composed of serpentinitic and limonitic ore. Conspicuous green to greenish white veins dissect the orebody and consist of garnierites of the types described in previous work (Springer 1974). Sepiolitic material is enriched in certain parts of the veins. The examined specimen was taken from a fissure, 2 cm wide, exposed during mining at a depth of about 3 m in an area of the deposit called Loma Peguera. Serpentine is closely associated.

MINERAL DESCRIPTION

The hand sample is whitish green, slightly schistose, soft and friable. Hardness is 2-3 on the Mohs scale. The density, measured by a hydrostatic method, is 1.9 ± 0.1 g/cm³. Clear to translucent tangled aggregates of fibrous particles can be discerned under the microscope. The fibrous particles are smaller than 10 μm and have a refractive index of less than 1.55. Birefringence is about 0.01 to 0.02. Extinction is parallel or nearly parallel, with positive elongation.

Powder X-ray diffraction analysis gave a pattern similar to that described by Brindley (1959) for sepiolite from Little Cottonwood, Utah (Table 1). The peaks are somewhat broadened, presumably due to poor crystallinity so that very accurate readings of *d*-values could not be obtained. The main reflections of hydrated talc and of quartz, at 9.8 and 3.33Å, respectively, could be observed. As shown in Table 1 the spacings can be indexed on the basis of orthorhombic symmetry. The unit-cell dimensions, calculated from the powder data using a least-squares refinement program, were found to be

TABLE 1. X-RAY DIFFRACTION DATA FOR FALCONDOITE

<i>hkl</i>	<i>d</i> _{calc} (Å)	<i>d</i> _{meas} (Å)	<i>I</i>
110	12.07	12.2	100
-	-	9.8	<5 (talc)
130	7.47	7.5	5
060	4.48	4.53	10
131	4.29	4.30	15
260	3.73	3.75	10
080	3.36	3.33	30 (+quartz)
331	3.19	3.19	25
261	3.04	3.03	<5
081	2.83	2.80	5
441, 281	2.61	2.62	30
530	2.59		
022	2.57	2.58	35 (broad)
371, 191	2.55		
202, 042	2.44	2.44	30
222, 461	2.40	2.39	20
062, 312	2.26	2.26	20
640, 2.12.0	2.13	2.12	5
082, 601	2.07	2.07	15
		1.95	<5
		1.87	<5

Diffractometer, Co/Fe radiation.

a 13.5, *b* 26.9, and *c* 5.24 Å. The unit-cell volume is 1903 Å³. Assuming that there are 2 molecules of (Ni,Mg)₈Si₁₂O₃₀•(H₂O)₄•(OH)₄•(H₂O)₈ in one unit cell, analogous to sepiolite, a density of 2.54 g/cm³ can be derived. The considerably lower measured density seems to be due to the porous nature of the material.

A bulk wet-chemical analysis for NiO, and X-ray fluorescence analyses for FeO, CoO, SiO₂, Al₂O₃, Cr₂O₃ and MnO are given in Table 2. Weight loss on ignition was determined by heating a sample to 950°C.

Examination of a section by electron probe analysis revealed zoning with regard to the

TABLE 2. BULK CHEMICAL AND ELECTRON PROBE ANALYSES

Chem.*	Electron Probe				
	A	B	C	D	Average
NiO	26.7	18.2	23.1	25.1	28.1
FeO	1.99	<0.03	<0.03	<0.03	<0.03
MgO	8.46	12.87	9.98	7.86	6.36
SiO ₂	45.93	50.3	49.8	47.1	49.6
LOI**	15.0	18.6	17.1	20.0	16.0

* Also contains 0.39% Al₂O₃; 0.45% Cr₂O₃; <0.01 MnO; <0.01 CoO.

** Loss on ignition, or difference from 100% in case of electron probe results.

Formulae to basis of 16 non-hydrated oxygens:

Chem.:
4.44 (Ni_{0.80}Mg_{0.35}Fe_{0.05})O•0.05(Al_{0.57}Cr_{0.43})₂O₃•5.71 SiO₂•6.22 H₂O

Probe:

A: 4.02 (Ni_{0.43}Mg_{0.57})O•5.99 SiO₂•7.43 H₂O
 B: 4.02 (Ni_{0.56}Mg_{0.44})O•5.99 SiO₂•6.85 H₂O
 C: 4.05 (Ni_{0.63}Mg_{0.37})O•5.98 SiO₂•8.46 H₂O
 D: 3.91 (Ni_{0.70}Mg_{0.30})O•6.04 SiO₂•6.52 H₂O
 av. 4.00 (Ni_{0.58}Mg_{0.42})O•6.00 SiO₂•7.30 H₂O

Mg/Ni ratio. Some scatter in the (Ni+Mg)/Si ratio about the value of 2:3 was observed, suggesting that the small amounts of talc and quartz indicated by X-ray diffraction occur as micron-size particles intimately intergrown with sepiolitic material. Table 2 lists four point analyses marking the spread of the electron probe results. The average of these results gives a (Ni+Mg)/Si ratio very close to the ideal ratio of 2:3. The determinations of the total water content reveal that there are 14 molecules of H₂O in a half unit-cell in accordance with the structural model of Brauner & Preisinger (1956). The formula for a half-cell, resulting from this model for an average composition, is therefore { (Ni_{0.58}Mg_{0.42})₈•(H₂O)₄•(OH)₄[Si₁₂O₃₀] }•(H₂O)₈. This gives 8 molecules or 9.9 wt. % of zeolitic water, 4 molecules or 4.9 wt. % of bound water, and 4 molecules of OH or 2.5 wt. % of water derived from these hydroxyl groups.

The ion-exchange capacity is small. Treatment of 100 mg of the material in 50 ml of a molar MgCl₂ solution for 3 weeks at 60-70°C resulted in the dissolution of 0.24% Ni which is 1.14% of the total nickel content.

The thermal characteristics of the new mineral were established by differential thermal and thermogravimetric analysis. The thermograms were found to be similar to those of sepiolite (Caillière & Hénin 1959; Nagata *et al.* 1974). Important features are summarized in Table 3, together with interpretations derived from the work of the earlier authors. Considering the somewhat impure nature of the falcon-

TABLE 3. THERMAL CHARACTERISTICS

DTA* endotherm. peaks, °C	TGA* °C	% wt. loss	calc. wt. loss	Interpretation
				Mechanism
180	25-200	7.0	9.9	zeolitic water lost
360	200-370	3.1	4.9	bound water lost in two steps
540	370-600	2.3		
840	600-850	2.7	2.5	hydroxyl water lost
	Totals	15.1	17.3	

*Average heating rates of 8 °C/min

doite samples, the agreement between the weight losses observed and calculated from the Brauner-Preisinger formula is not unreasonable.

The X-ray diffraction pattern of material heated to about 1000°C shows only reflections due to an orthopyroxene. The peaks are broad and of low intensity, indicating that the majority of the reaction product is amorphous or has a poorly ordered structure. Enstatite is formed when sepiolite is heated above 900°C (Kulbicki 1959); accordingly, an exothermal peak at about

850°C, which follows the endothermal dehydration peaks in both the sepiolite and the falcondoite cases, may be assigned to mark the crystallization of orthopyroxene.

DISCUSSION

The new mineral belongs to the sepiolite group together with sepiolite, ferri-sepiolite and loughlinitite. Because of the similar ionic radii of Mg and Ni, the existence of the new species is not surprising and follows the pattern established for serpentines, (e.g., lizardite-nepouite, clinochrysotile-pecoraite), for talc-willemseite, and for chlorites-nimite (Brindley & Maksimovic 1974). Although the present analyses do not include that of the pure nickel analogue of sepiolite, it is very probable that it exists in nature, and will eventually be found. The mineral described above is magnesian falcondoite. It is the end member for which the new name falcondoite is intended.

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