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An occurrence of gaspéite and pecoraite in the Nullagine region of Western Australia

GASPÉITE (NiCO_3) and PECORAITE ($\text{Ni}_3\text{Si}_2\text{O}_5(\text{OH})_4$) are rare secondary nickel minerals. Gaspéite was first defined by Kohls and Rodda (1966) as the nickel end-member of a MgCO_3 - NiCO_3 solid-solution series, although they, themselves, did not actually discover pure gaspéite. The mineral from Quebec that they described was, instead, a magnesian gaspéite with a composition corresponding to $\text{Ni}_{0.98}\text{Mg}_{0.86}\text{Fe}_{0.16}(\text{CO}_3)_2$. Magnesian gaspéite and nickeloan magnesites have subsequently been reported from several localities in Western Australia (Morris and Pepper, 1968), but the only relatively pure gaspéite reported to date was found at Pafuri in the Transvaal province of South Africa (Mariano *et al.*, 1969).

Pecoraite was defined by Faust *et al.* (1969) as the nickel analogue of chrysotile. It was found as fracture fillings in the Wolf Creek meteorite of Western Australia, and no other occurrences have been reported to date.

Description of samples. The gaspéite and pecoraite described here are from a nickel prospect [Claim no. MC-517-L (Lionel)] near Spinnaway in the Nullagine district of Western Australia. The samples were obtained from Mr. P. J. Bridge of Perth, W.A., who in turn had received them from a prospector by the name of C. Otway. The occurrence will here be referred to as the Otway prospect.

The samples in which the gaspéite and pecoraite occur contain some sulphide minerals, notably millerite and polydymite, with the textures clearly indicating the partial replacement of millerite by polydymite. The sulphides are veined and encrusted by green carbonates and silicates, which include the gaspéite and pecoraite. Other minerals found in the samples include magnésite, siderite, chrysotile, antigorite, and magnetite. The carbonates and silicates in this assemblage are extremely fine-grained and are obviously of secondary origin. The gaspéite and pecoraite are generally in intimate intergrowth suggestive of co-precipitation, and it was only with some difficulty

that areas relatively free of contamination by the other phase could be found for analysis.

The *gaspéite* has a bright grass-green colour where it occurs in compact masses, and lighter in colour where it occurs as loosely aggregated grains. Under the microscope in transmitted light it is seen to be cryptocrystalline, with a maximum grain size of about two microns. As a result, the mineral is nearly opaque in oil immersion mounts except in the very thinnest fragments.

The extremely small grain size made the accurate measurement of refractive indices very difficult, and in fact, only the ω index was measured. The value obtained was $\omega = 1.84$, which is appreciably below the value of 1.930 given by Isaacs (1963) for

TABLE I. *Chemical data for gaspéite and pecoraite*

	Gaspéite		Pecoraite		
	Nullagine	Theor.	Nullagine	Wolf Creek*	Theor.
Ni ²⁺	43.6	49.45	44.0	40.5	46.31
Mg ²⁺	1.6	—	0.6	0.3	—
Ca ²⁺	0.2	—	—	0.3	—
Fe ²⁺	0.1	—	0.1	0.5	—
Al ³⁺	—	—	—	0.7	—
Si ⁴⁺	0.4†	—	12.5	14.5	14.77
CO ₃ ²⁻	48.9‡	50.55	—	—	—
O ²⁻	—	—	20.7‡	18.3	21.03
OH ⁻	—	—	17.6‡	20.1	17.89
H ₂ O—	n.d.	—	n.d.	4.1§	—
Sum	94.8	100.00	95.5	99.3	100.00

* Recalculated from Faust *et al.*, 1969.

† SiO₂.

‡ Calculated from cation percentages.

§ H₂O+ calculated as OH⁻.

pure synthetic NiCO₃. It is unlikely that the small amounts of impurities shown by the analysis (table I) would fully account for this discrepancy, so that other causes should be looked for. Possibly the mineral contains some adsorbed water or hydrated silica, as indicated below, which might affect the refractive index measurements, but indisputable evidence of this was not obtained.

An electron-probe analysis of the *gaspéite*, made by an M.A.C. probe, using metals and oxides as standards, and correcting the raw results by the MAGIC computer programme (Colby, 1968), is shown in table I. The analysis shows that the mineral is nearly pure NiCO₃. The Mg, Ca, and Fe are probably in solid solution, whereas the Si is probably extraneous, possibly in the form of *pecoraite*, with which the *gaspéite* is closely associated, or as hydrated silica. The shortfall from 100 % can probably be attributed to adsorbed water.

The X-ray powder diffraction pattern of the *gaspéite* is very similar to that reported by Graf (1961) for synthetic NiCO₃. The unit-cell dimensions calculated from eight lines of a Guinier diffraction pattern, with thoria as an internal calibration standard, are a 4.608 (± 0.004) Å and c 14.805 (± 0.027) Å. These values are somewhat higher

than those cited by Graf (1961) for pure synthetic NiCO_3 (a 4.5975, c 14.723) but are relatively close to the maximum values reported by Isaacs (1963) for hydrothermally synthesized NiCO_3 (a 4.609, c 14.737). These high values seem to be due to bound water in the carbonate (Isaacs, 1963), and this explanation might equally well apply to the Otway gaspéite.

Pecoraite. The pecoraite is bright green in colour, and is distinguished in hand specimen from the associated gaspéite by its relatively clear vitreous appearance in contrast to the 'frosted' appearance of the gaspéite. It is weakly birefringent, with a refractive index of 1.63. This is appreciably higher than the range reported by Faust *et al.* (1969), and indicates that the Otway sample probably contains less adsorbed water.

The composition of the pecoraite, as determined by electron microprobe, is given in table I. The analysis is reasonably close to that of Faust's pecoraite and corresponds quite well with $\text{Ni}_6\text{Si}_4\text{O}_{10}(\text{OH})_8$, the nickel analogue of chrysotile. The X-ray powder diffraction pattern is very diffuse, indicating poor crystallinity. Only five lines are discernible, and these agree with the strongest lines reported for the original pecoraite (Faust *et al.*, 1969). The shortfall from 100 % can probably be ascribed largely to adsorbed water, as is the case with the Wolf Creek pecoraite.

Conclusions. The precise conditions that enable the nickel liberated from the decomposed sulphides to be fixed in the intimately associated gaspéite and pecoraite are not known in detail, although studies currently in progress in these laboratories will hopefully shed some light on this problem. Nevertheless, it would be reasonable to assume that the necessary conditions would include an alkaline environment and relatively arid climatic conditions. In this connection, it is relevant to note that the original pecoraite was found in an arid environment, in the northern part of the Great Sandy Desert of Western Australia.

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Division of Mineralogy,

ERNEST H. NICKEL

Commonwealth Scientific and Industrial Research Organization,

Private Bag, P.O.,

Wembley, Western Australia, Australia, 6014

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