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NICKELOAN MANGANOAN SUBCALCIC ACTINOLITE IN A METACHERT FROM THE MINEOKA BELT, CENTRAL JAPAN

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ABSTRACT

Nickeloan manganoan subcalcic actinolite occurs in a metachert of epidote amphibolite facies of the Mineoka belt, Japan. Ni varies inversely to Mg + total Fe; it occurs at the *M*(1,2,3) positions. The subcalcic character of the amphibole is largely due to the tirodite–dannemorite component and, subordinately, to an alkali amphibole component.

Keywords: nickeloan manganoan subcalcic actinolite, metachert, epidote amphibolite facies, Mineoka belt, Japan.

SOMMAIRE

Une actinote déficiente en Ca, nickeleuse et manganeuse, se présente dans un métachert à facies amphibolite à épidote de la ceinture Mineoka, au Japon. La teneur en Ni varie en proportion inverse de la somme des teneurs en Mg + Fe total; le Ni occupe les positions *M*(1,2,3). La déficience de l'amphibole en Ca est due, principalement, au constituant tirodite–dannemorite et, subsidiairement, à un constituant d'amphibole alcaline.

(Traduit par la Rédaction)

Mots-clés: actinote hypocalcique à teneur en Ni et Mn, métachert, facies amphibolite à épidote, ceinture Mineoka, Japon.

INTRODUCTION

Subcalcic actinolite of unusual composition was found in a metachert of the epidote amphibolite facies from the Mineoka belt, central Japan. The amphibole contains appreciable amounts of Ni and Mn; its compositional variation is described here to examine the behavior of Ni^{2+}, whose distribution in amphiboles is not well characterized (Chigareva *et al.* 1969, Hawthorne 1983). Ni-bearing amphibole has not been reported, except for a synthetic nickel-fluor-richterite [= sodian nickel-magnesio-cummingtonite according to Leake (1978)] (Fedoseev *et al.* 1970).

GEOLOGICAL SETTING AND PETROLOGICAL ASSOCIATION

The Mineoka belt, located on the Boso Peninsula, near Tokyo, is a Cenozoic tectonic belt mainly composed of serpentinite *mélange*, which contains blocks of various kinds of igneous, metamorphic and sedimentary rocks (*e.g.*, Arai *et al.* 1983). Metachert and metasandstone occur as deformed lenses in a metabasite block (several metres across) at Kamogawa harbor, at the eastern end of the Mineoka belt (Kanehira *et al.* 1968). The metamorphic rocks constituting the block are severely crushed and have the appearance of breccia or even sandstone. However, the original prominent schistosity can be observed in the uncrushed parts. The K–Ar age of muscovite in a metasandstone lens is 38 Ma (Yoshida 1974).

The metabasite contains hornblende, epidote, oligoclase (An_{27}), titanite and pyrite, and belongs to

TABLE 1. CHEMICAL COMPOSITION** OF Ni–Mn SUBCALCIC ACTINOLITE FROM THE MINEOKA BELT, JAPAN

No.	1	2	3	4	5	6	7
SiO_2	53.67	54.00	54.77	53.03	55.51	54.01	56.76
TiO_2	0.00	0.03	0.00	0.00	0.01	0.00	0.01
Al_2O_3	2.03	1.91	2.77	2.67	2.73	2.86	1.29
Cr_2O_3	0.02	0.00	0.04	0.03	0.01	0.00	0.00
FeO*	6.02	7.21	6.81	6.70	6.48	7.22	6.56
MnO	6.84	6.41	3.90	4.13	5.93	4.99	3.58
MgO	16.61	15.55	16.49	16.22	17.71	16.66	17.95
CaO	6.51	6.35	8.87	8.85	6.61	7.55	9.77
Na_2O	2.11	1.45	1.78	1.93	2.46	2.69	1.05
K_2O	0.11	0.07	0.12	0.13	0.14	0.14	0.03
NiO	2.09	2.07	2.01	2.00	0.95	0.86	0.60
Total	96.02	95.06	97.57	95.69	98.54	96.99	97.60
Cations on the basis of 23 oxygen atoms							
Si	7.846	7.962	7.824	7.761	7.831	7.780	8.005
Al	0.154	0.038	0.176	0.239	0.169	0.220	0.000
Al	0.196	0.294	0.290	0.222	0.285	0.266	0.214
Ti	0.000	0.004	0.000	0.000	0.001	0.000	0.001
Cr	0.002	0.000	0.005	0.004	0.001	0.000	0.000
Fe*	0.736	0.889	0.813	0.820	0.795	0.870	0.774
Mg	3.620	3.419	3.512	3.540	3.724	3.578	3.775
Ni	0.246	0.246	0.231	0.235	0.107	0.100	0.068
Mn	0.200	0.149	0.148	0.184	0.116	0.186	0.169
Mn	0.648	0.652	0.324	0.329	0.592	0.422	0.259
Ca	1.020	1.003	1.358	1.388	0.999	1.166	1.477
Na	0.332	0.346	0.318	0.283	0.409	0.412	0.264
Na	0.268	0.069	0.176	0.264	0.263	0.340	0.024
K	0.020	0.014	0.023	0.024	0.026	0.025	0.006

FeO* and Fe*: total iron as FeO and Fe, respectively.
** determined by electron-microprobe analysis.

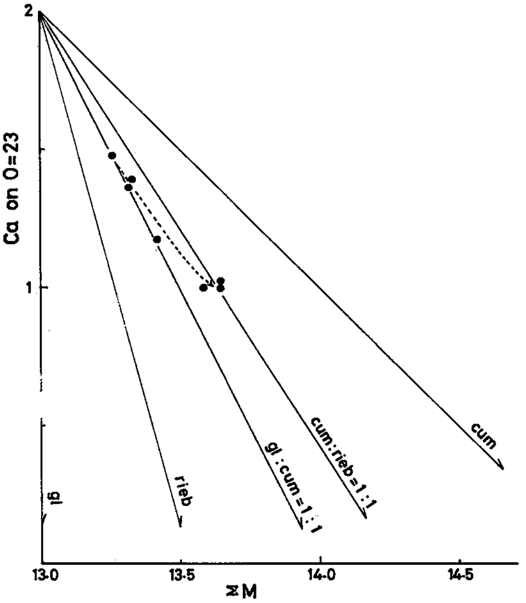

FIG. 1. Extent of the solution of alkali amphibole and Mg–Mn–Fe amphibole in subcalcic actinolite (Arai & Hirai 1985). ΣM, number of atoms of Mg + Fe* + Mn + Ni + Al + Ti based on 23 oxygen atoms. Symbols: cum Mg–Mn–Fe amphibole, rieb riebeckite, gl glaucophane. Fe* refers to total iron.

the epidote amphibolite facies. The metasandstone consists of quartz, oligoclase (An_{11}), K-feldspar, biotite, muscovite, epidote and hematite (Arai & Hirai 1985). The metachert is greyish rose-pink in hand specimen, and the original bedding plane is preserved in the uncrushed part. It is composed of quartz, spessartine, hematite, allanite and amphibole; the latter occurs as minute ($<100 \times 20$ μm) prisms and is very pale green in thin section.

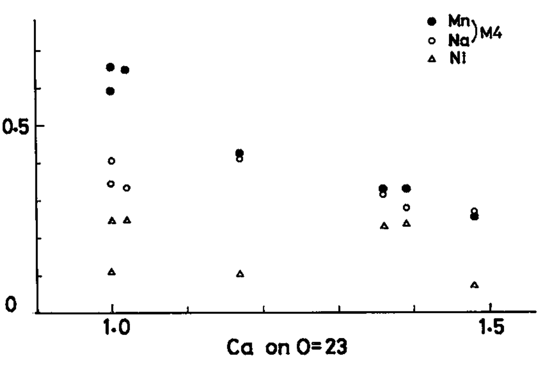

FIG. 2. Relationships between Ca and Mn ($M4$), Na($M4$) and Ni in subcalcic actinolite.

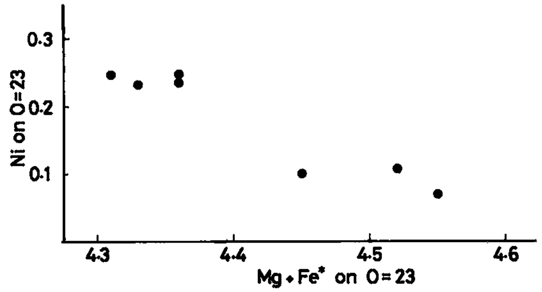

FIG. 3. Relationship between Ni and Mg + Fe* in subcalcic actinolite. Fe* refers to total iron.

CHEMISTRY AND CRYSTAL DATA

The chemical composition of the amphibole prisms was determined by electron microprobe (Table 1). The amphibole is nickeloan manganoan subcalcic actinolite according to Leake (1978), although there is significant grain-to-grain chemical heterogeneity (Table 1). The ratio of alkali amphibole to Mg–Mn–Fe amphibole components is roughly unity in the subcalcic actinolite (Fig. 1). The Fe^{3+} contents are expected to be low, and thus iron is treated as Fe^{2+}.

Ni shows a poor correlation with Ca (Fig. 2) but has a clear negative correlation with Mg + Fe* (Fe* total iron; Fig. 3). Mn and Na at the $M(4)$ position, show, respectively, strong and weak antipathetic variations with Ca (Fig. 2). Mn at the $M(4)$ position correlates positively with Mg + Fe* + Ni − 2.5Ca (= Mg + Fe* + Ni, constituting the components other than tremolite–ferroactinolite at $M(1,2,3)$ positions; Fig. 4).

A single crystal of the amphibole (No. 7 of Table 1) was removed from the thin section, and unit-cell parameters were measured by four-circle diffractometer using Mo$K\alpha$ radiation (50 kV, 160 mA) as follows; a 9.95(2), b 18.04(2), c 5.29 (1) Å, β

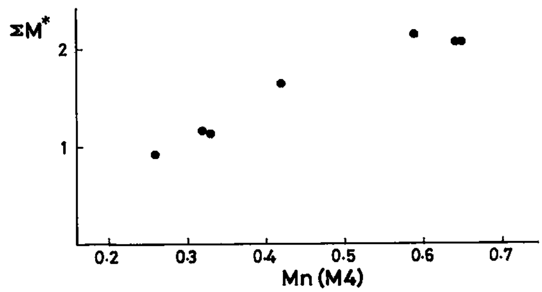

FIG. 4. Relationship between Mn ($M4$) and ΣM^* (= Mg + Fe* + Ni − 2.5Ca) in subcalcic actinolite. Mg + Fe* + Ni − 2.5Ca approximates the sum of cations at the $M(1,2,3)$ positions constituting the Mg–Fe–Mn amphibole component.

104.1(3)°. Other crystals were found to be too small to handle for single-crystal work.

DISCUSSION

Figure 3 clearly suggests that Ni is substituting for Mg + Fe* in these amphiboles. As Mg and Fe* are the predominant constituents of the *M*(1,2,3) positions in amphibole of this general type (Hawthorne 1981), this would indicate that Ni occupies the *M*(1,2,3) positions. The subcalcic character of the amphibole is attributed largely to the substitution of $Mn_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$ (tirodite–dannemorite) (Fig. 4) and, subordinately, to that of alkali amphibole (Fig. 2). This tendency is prominent in the strongly subcalcic ($Ca \simeq 1$ for 23 oxygen atoms) actinolite compositions (Figs. 1, 2).

The unusual composition of the present amphibole is mainly due to the composition of the source chert, enriched in Mn and Ni relative to Ca, Al, Mg and Fe. Ni is one of the most common heavy-metal elements coprecipitating with Mn and Fe in modern oceanic hydrogenous metalliferous deposits (Bonatti *et al.* 1976). Ni is also concentrated in deposits of bedded manganese ore associated with chert (Watanabe *et al.* 1970).

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