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メタデータ	言語: eng
	出版者:
	公開日: 2008-01-25
	キーワード (Ja):
	キーワード (En):
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URL	https://doi.org/10.14945/00000309

静岡大学地球科学研究報告 20 (1994年3月) 1頁～4頁
Geosci. Repts. Shizuoka Univ., 20 (Mar., 1994), 1-4

Ferroaxinite and datolite from Mt. Nio, Shizuoka city, central Japan

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Abstract Ferroaxinite and datolite occur in veins in a dolerite sheet cutting metabasite of the Setogawa Group. The chemical analysis of ferroaxinite is SiO_2 42.40, Al_2O_3 18.30, Fe_2O_3 0.09, TiO_2 0.13, FeO 9.05, MgO 1.51, MnO 0.77, CaO 19.20, B_2O_3 6.37, H_2O^+ 1.33, H_2O^- 0.06, total 99.21% corresponding to $(Ca_{1.94}Mn_{0.06})_{\Sigma 2.00}(Fe^{2+}_{0.71}Mg_{0.21}Al_{0.04}Fe^{3+}_{0.01}Ti_{0.01})_{\Sigma 0.98}Al_{2.00}B_{1.04}Si_{4.00}O_{16}H_{0.84}$ on the basis of total O = 16. The empirical formula of datolite, derived from the chemical analysis, is very close to the ideal formula $CaBSiO_5(OH)$ with a slight H_2O excess. Idiomorphic forms of the minerals are exclusively found in voids in veins, although partially developed forms of ferroaxinite are common. Ferroaxinite is tabular with larger r(011) and b(010). Datolite idiomorphs are short prisms with m(110) and s(102) dominant. Associated minerals within and adjacent to veins are quartz, calcite, albite, adularia, chlorite, and bannisterite, together with pumpellyite. In veins ferroaxinite always preceeds datolite in the crystallisation sequence. This is similar to the relationship between manganaxinite and datolite in skarns from some pyrometasomatic ore deposits in Kyushu. Some veins lack ferroaxinite and have pumpellyite instead, drawing attention to the fact that, leaving aside minor differences in H_2O content, subtraction of $HBO_2 + SiO_2$ from the ferroaxinite formula yields pumpellyite-(Fe^{2+}).

Key words: ferroaxinite, datolite, pumpellyite, Setogawa Group

INTRODUCTION

It is well-known that some basic rocks like gabbro, dolerite, and greenstone contain hydrous borosilicates such as dravite, ferroaxinite and datolite in their pegmatitic phases or in veins cutting them. These are in all cases the late products of formation of the parental bodies in which boron is frequently concentrated. The studied materials occur in veins cutting a dolerite sheet, which is the likely source of boron. In these veins ferroaxinite always crystallised before datolite; this sequence corresponds to that observed for manganaxinite in skarns from some pyrometasomatic ore deposits in Kyushu (Ko 1902; Ozaki 1969).

A few veins in the Mt Niô locality are devoid of ferroaxinite and contain instead a green pumpellyite (suffixed with-(Fe^{2+})). Its ideal chemical formula, $Ca_2Fe^{2+}Al_2[BO_3]Si_4O_{12}(OH)$ is convertible to that of ferroaxinite by subtraction of $HBO_2 + SiO_2$ and addition of H_2O, suggesting that the pumpellyite-(Fe^{2+}) corresponds to a boron-free alternate of ferroaxinite, the former crystallising under boron deficient conditions during the vein formation.

OCCURRENCE

The dolerite sheet is exposed in the eastern side of Mt. Nio which is located about 17 km northwest of Shizuoka Station, Eastern Japan Railway Company Ltd. (Fig. 1). The dolerite sheet intersects metabasite of the Palaeocene Setogawa Group. The sheet is cut in many places by veins, which have quartz, calcite, albite, ferroaxinite and datolite as their macroscopic constituents together with minor adularia, bannisterite, pumpellyite and chlorite. The dolerite sheet adjacent to the veins is converted into deep to light green aureole which consists exclusively of chlorite with minor albite. The veins exceed 30 cm in width, enabling pure grains of ferroaxinite and datolite to be easily

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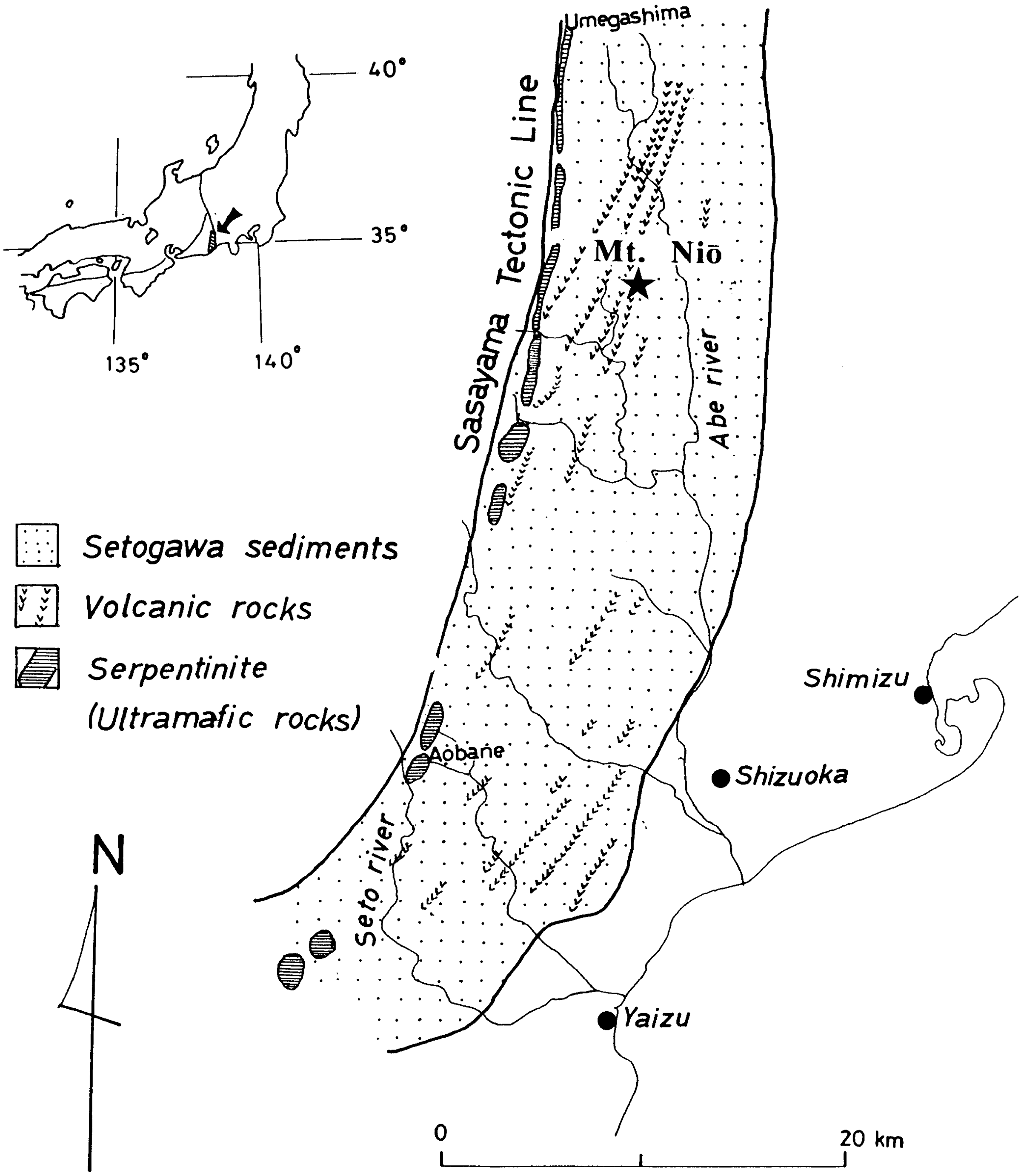

Fig. 1 Locality map for Mt. Niô, Shizuoka city, central Japan.

separated out and also clear observation of their idiomorphs from the voids therein. Mineral grains were then subjected to microprobe and wet chemical analyses.

Ferroaxinite has various shades of grey with or without purplish tint and is rather coarse-grained as known from the cleavage plane, or millimeter order size. Faint colour bandings are observed even in a single vein. The grains are minutely fractured along cleavages, especially in materials subjected to prolonged exposure. Under the microscope the most representative feature of ferroaxinite is sheaflike aggregates of milli- to centimeter order size.

Datolite occurs at least in two forms: one thinner veins cutting aggregates of ferroaxinite within the larger veins, and the other as material interstitial to the quartz or ferroaxinite aggregates. It is colourless to white and rather turbid if there is neighbouring quartz. Those with crystal faces are exclusively found in voids and are rather transparent. Under the microscope aggregates of datolite

Table 1 Chemical analysis of ferroaxinite.

Weight percentages and molecular numbers (basis O=16)

	wt. %	mole nos.	ideal nos.
SiO_2	42.40	4.00	4
TiO_2	0.13	0.01	
Al_2O_3	18.30	2.04	2
Fe_2O_3	0.09	0.01	
FeO	9.05	0.71	1
MgO	1.51	0.21	
MnO	0.77	0.06	
CaO	19.20	1.94	2
B_2O_3	6.37	1.04	1
H_2O+	1.33	0.84	1
H_2O-	0.06		
Total	99.21		

Empirical formula:

$(Ca_{1.94}Mn_{0.06})_{\Sigma 2.00}(Fe^{2+}_{0.71}Mg_{0.21}Al_{0.04}Ti_{0.01}Fe^{3+}_{0.01})_{\Sigma 0.98}$
$Al_{2.00}B_{1.04}H_{0.84}Si_{4.00}O_{16.00}$

Table 2 Chemical analysis of datolite.

Weight percentages and molecular numbers (basis O=5)

	wt. %	mole nos.	ideal nos.
SiO_2	36.34	0.98	1
Al_2O_3	0.11	0.00	
Fe_2O_3	0.34	0.01	
FeO	0.16	0.00	
MgO	0.01	0.00	
CaO	34.68	1.00	1
Na_2O	0.51	0.03	
K_2O	0.04	0.00	
B_2O_3	21.05	0.98	1
H_2O+	6.02	1.08	1
H_2O-	0.23		
Total	99.49		

Empirical formula:

$(Ca_{1.00}Na_{0.03})_{\Sigma 1.03}B_{0.98}H_{1.08}(Si_{0.98}Fe^{3+}_{0.01})_{\Sigma 0.99}O_{5.00}$

consist of rather equigranular grains of millimeter order size or less with linear boundaries to adjacent grains without any regular orientation. There are both datolite-free and ferroaxinite-free veins. The relative quantity of quartz in the veins is variable but it seems that the datolite-free veins contain more quartz than the ferroaxinite-free veins.

Some ferroaxinite veins without datolite are mantled by grey white walls composed of fine-grained aggregates of albite with minor adularia between veins and the chlorite aureole.

CHEMICAL ANALYSES

The chemical analyses of ferroaxinite and datolite are given in Tables 1 and 2, respectively. The former is characterized by partial substitution of Mg for Fe^{2+}. The latter is very close to the ideal $CaBSiO_4OH$, except for a slight H_2O excess, which is known in the botryoidal variety.

MORPHOLOGY AND PHYSICAL PROPERTIES

Ferroaxinite is tabular with well developed r(011) and b(010) forms after the new orientation. Datolite forms short prismatic crystals with dominant m(110) and s(102). Their refractive indices, optic axial angles, and specific gravities were measured: ferroaxinite --- $\alpha = 1.676$, $\beta = 1.682$, $\gamma = 1.685$, $(-)2V = 75°$, specific gravity = 3.29; datolite --- $\alpha = 1.627$, $\beta = 1.650$, $\gamma = 1.670$, $(-)2V = 74°$, specific gravity = 2.96. All of the data are coincident with those recorded for the minerals in the literature.

An X-ray powder diffraction study was made of the minerals and the patterns obtained are essentially identical with those given in JCPDS Card Nos. 27-76 and 36-429, for ferroaxinite and datolite respectively.

THE RELATION OF FERROAXINITE TO PUMPELLYITE-(Fe^{2+})

Among veins from the same mode of occurrence as the studied materials, there are ferroaxinite-free veins, in which the mineral association consists of datolite, calcite and quartz with a small amount of microscopic pumpellyite. Pumpellyite has a green colour in thin section corresponding to that of pumpellyite-(Fe^{2+}). The close chemical relationship between ferroaxinite and pumpellyite-(Fe^{2+}) is shown by the following equation

$$Ca_2Al_2Fe^{2+}[(OH)_2[SiO_4]Si_2O_7] \cdot H_2O + BO_2 + SiO_2$$
pumpellyite$-(Fe^{2+})$
$$= Ca_2Fe^{2+}Al_2B[OH[O](Si_2O_7)_2] + 2H_2O$$
ferroaxinite

Except for B_2O_3, the components in ferroaxinite are the same as those in pumpellyite$-(Fe^{2+})$, which is interpreted as the boron-free alternate to ferroaxinite. Minor minerals of the axinite series are also reported in skarns from some pyrometasomatic ore deposits in Kyushu (Ko 1902). These Kyushu localities are famous for the occurrence of well-developed crystals of "axinite", which is actually manganaxinite (Ozaki 1969), and some of them accompany datolite. In all the skarns containing these minerals "axinite" preceeds datolite in the crystallisation sequence. This antecedence also takes place under the conditions of skarn formation. The vicarious availability of Mn^{2+} to Fe^{2+} does not influence the paragenetic sequence of the minerals.

ACKNOWLEDGEMENTS

The authors thank Drs. Akira Kato and Kazumi Yokoyama, Department of Geology, National Science Museum for their help in preparing the text for publication, and for the identification of the bannisterite collected by Mr. Ryoichi Yamamoto, Mumeikai Group, to whom the authors are also grateful,

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