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MINERALOGICAL NOTES

PREHNITE FROM THE CONTACT METAMORPHIC AUREOLE OF THE WHIN SILL INTRUSION, NORTHERN ENGLAND

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Abstract

Prehnite is recorded for the first time from the contact aureole of the Whin Sill intrusion in Teesdale, northern England. An electron microprobe study of the prehnite has shown an overall range of Fe_2O_3 (total iron) from below the detection limit to 8.3 percent and from 0.3 to 7.0 percent within an individual crystal. Substitution of Fe^{3+} for Al extends, therefore, to over 21 mole percent. Optical properties are given for the two most iron-rich crystals.

Introduction

Prehnite has been well documented from low-grade regional metamorphic regimes but data available for material from contact metamorphic areas appears to be minimal. Prehnite has been recorded for the first time during the present investigation in a number of samples from the contact aureole of the Whin Sill, a quartz–dolerite intrusion of late Carboniferous age. The sill is intruded mainly into Lower Carboniferous sediments consisting dominantly of limestone with sandstone and shale horizons (Dunham, 1948). The prehnite is found in the impure limestones and calcareous shales, up to 5.5 m from the upper contact of the sill, which is 73 m thick in the area of study.

Optical Properties and Chemistry

The prehnite occurs commonly as xenoblastic crystals forming the matrix to small (0.5 mm) pockets and lenses, which are surrounded by and embedded with sub–idioblastic grossular. A characteristic feature of the prehnite is its undulose extinction, with crystals displaying anomolous first order blue interference colors. Most of the crystals showing these optical anomalies have fine twin lamellae present.

Partial electron microprobe analyses have been undertaken following the techniques of Sweatman and Long (1969), the raw data being processed using the programme EMPADR (Rucklidge and Gasparrini, 1969). The recalculated CaO, Al_2O_3 and Fe_2O_3 (total iron) values of twelve analyses of four crystals, in three samples are shown in Figure 1. A substantial departure from the ideal composition of prehnite, $[Ca_2Al_2Si_3O_{10}(OH)_2]$, shown by the arrow on the CaO–Al_2O_3 join in Figure 1, is indicated by the CaO:Al_2O_3:Fe_2O_3 ratio of 48.7:36.0:15.3 in an analysis from sample 43/3 (Fig. 1). A large variation is also seen within a single crystal from sample 35/4, the CaO:Al_2O_3:Fe_2O_3 ratios varying from 53.1: 46.3:0.6 to 50.0:36.6:13.4 (Fig. 1).

Assuming total iron as ferric and (OH) as 4.00, the atomic proportions of some of the analyses have been recalculated on the basis of twenty–two oxygen equivalents. Based on the above assumptions the analysis showing the highest Fe_2O_3 content (8.3 per-

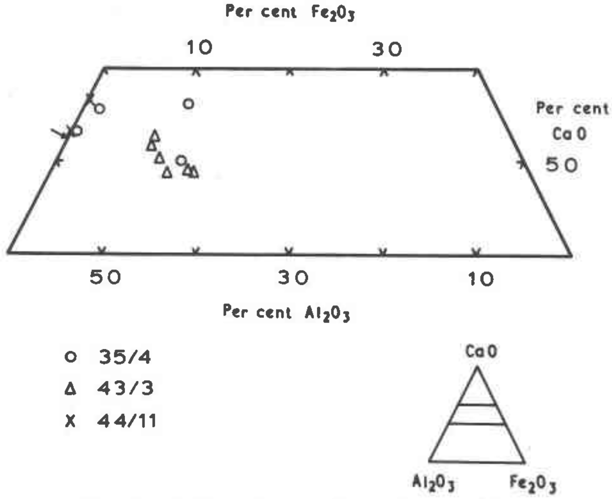

FIG. 1. Distribution of prehnite analyses with respect to CaO, Al_2O_3 and Fe_2O_3 (total iron) weight percent. The arrow on the CaO–Al_2O_3 join indicates the ideal composition of prehnite $[Ca_2Al_2Si_3O_{10}(OH)_2]$.

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cent) represents over 21 percent substitution of Fe^{3+} for Al in the series $Ca_2Al_2Si_3O_{10}(OH)_2$–$Ca_2Fe_2Si_3O_{10}(OH)_2$. The average analyses of the two most iron–rich crystals (Table 1A) show between 16 and 18 percent substitution of Fe^{3+} for Al (Table 1B).

The extent of $Fe^{3+} \rightleftharpoons Al$ substitution recorded in the present study is much larger than recorded by Hasimoto (1964), who suggested that less than 10 percent substitution is usually found in natural prehnites. The Fe_2O_3 values recorded here are similar to those recorded by Surdam (1969) for prehnite from a low–grade regional metamorphic environment. He recorded a maximum average Fe_2O_3 content of 8.2 percent, while his most iron–rich analysis was indicative of some 30 percent $Fe^{3+} \rightleftharpoons Al$ substitution.

The optical properties of the two crystals analyzed from sample 43/3 are given in Table 1C. The refractive indices, which show a small increase with increase of iron substitution, correspond reasonably with the calibration curves given by Hasimoto (1964) for the variation in refractive indices of prehnite with iron substitution.

As relatively few analyses are available, no particular variation in composition of the prehnite can be correlated with distance from the intrusive contact. It is worthy to note, however, that eight of the ten point analyses from samples 35/4 and 43/3, within 0.1 m of the contact, show appreciable substitution, while the two analyses of sample 44/11, 5.5 m from the contact, show virtually no substitution (Fig. 1).

TABLE 1. PARTIAL ELECTRON MICROPROBE ANALYSES, ATOMIC PROPORTIONS, AND OPTICAL PROPERTIES OF TWO PREHNITE CRYSTALS

A. Partial electron microprobe analyses			B. No. of ions on the basis of 24(O,OH)			C. Optical Properties		
Sample no.	43/3-1	43/3-2		43/3-1	43/3-2		43/3-1	43/3-2
SiO_2	43.2	41.8	Si	6.09	5.90	α	1.632	1.637
Al_2O_3	19.8	20.2	Al	3.29 } 3.93	3.36 } 4.11	β	1.639	1.647
$^*Fe_2O_3$	6.0	7.1	Fe^{3+}	0.64	0.75	γ†	1.654	1.668
CaO	26.1	26.7	Ca	3.94	4.04	$2V_z$	67	65
Subtotal	95.1	95.8	**(OH)	4.00	4.00			
Range of $^*Fe_2O_3$	4.7-7.9	5.9-8.3	$100Fe^{3+}/Fe^{3+}+Al$	16.2	18.3			

* *Total iron as Fe_2O_3.*
** *(OH) is taken as 4.00, and the formula calculated on the basis of 22 oxygen equivalents.*
† *Estimated using Mertie chart.*

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