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FASSAITE FROM A CALC-SILICATE SKARN VEIN NEAR GONDIVALASA, ORISSA, INDIA

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ABSTRACT

Fassaite from a calc-silicate vein occurring in the limestones of the khondalite group of Eastern Ghats near Gondivalasa is described. The high proportion of $CaAl_2SiO_6$ pyroxene component in fassaite indicates that the amount of $CaAl_2SiO_6$ in pyroxenes probably depends on the relative availability (chemical potentials of Al and Si) as well as temperature and pressure. The temperature of formation high as 650°C for the fassaite-plagioclase assemblage of calc-silicate vein is suggested.

Introduction

Fassaite is the name applied to diopsidic pyroxene relatively high in alumina and ferric oxide, poor in alkalies and with a content of calcium oxide essentially that of the ideal diopside (Tilley, 1938). The balancing of the electric charge in fassaite is accomplished by substitution of aluminum for silicon and of aluminum and ferric iron for magnesium. A diopside, with aluminum replacing tetrahedrally co-ordinated silicon and octahedrally co-ordinated magnesium occurs in a calc-silicate vein 1.6 km southwest of Gondivalasa (Long. 82°59′ N and Lat. 18°24′39″ E). This is apparently the first such occurrence described in the Eastern Ghats of India. The various rock types observed in the area are quarz-orthoclase-sillimanite-graphite gneisses, quartzites, garnetiferous quartzites, limestones and calc-granulites of the khondalite group and associated granites, pegmatites and quartz veins. Thin skarn veins occur frequently in the limestones near Gondivalasa. The average chemical composition of limestone in weight percent is SiO_2 0.35, R_2O_3 1.74, CaO 50.38, MgO 4.0, loss on ignition 43.52. The sketch (Fig. 1) shows the fassaite bearing skarn vein which consists of plagioclase and fassaite as essential constituents and sphene and calcite as accessories. Near the contact of skarn vein with the limestone the calcite is often recrytallized in relatively large grains. Coarse flaky graphite is intimately associated with the coarse recrystallized calcite along the margins of skarn vein contact. All the features described suggest a metasomatic skarn vein formation in the limestones by the influx of hydrothermal solutions enriched in silica, alumina, magnesium, iron and water. The source of these elements may be a later intrusive granite.

Mineralogy

Fassaite is granular in habit, pale yellowish in color and nonpleochroic and shows prominent prismatic cleavage in thin sections. Fassaite often

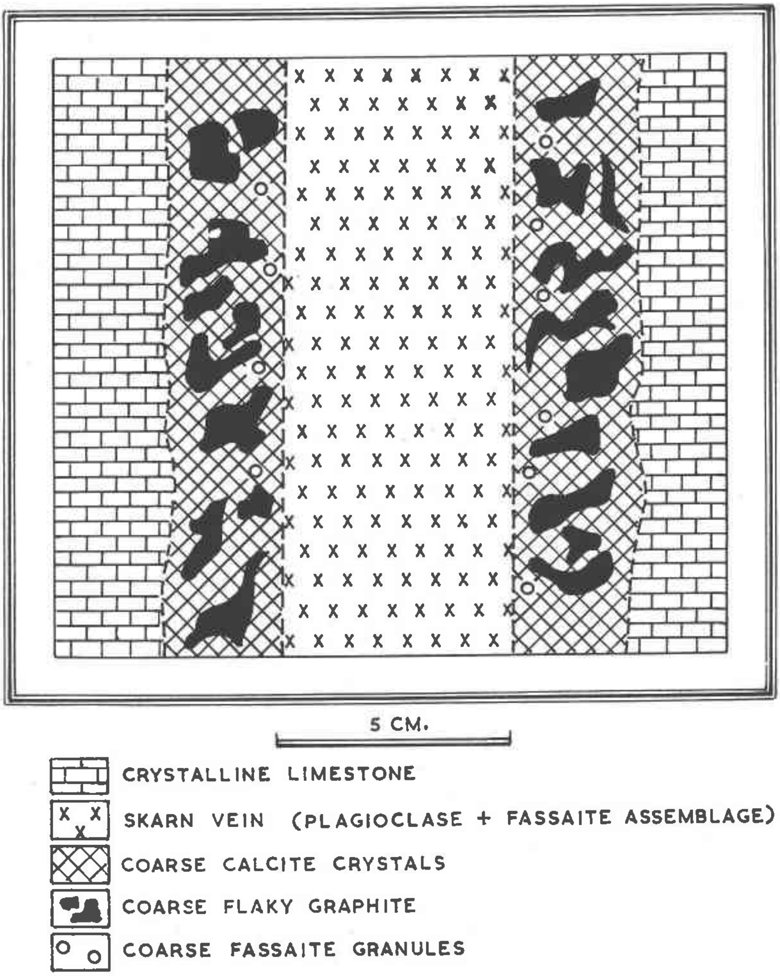

FIG. 1. Sketch of Calc-silicate skarn vein near Gondivalasa.

encloses plagioclase (An_{75-80}) in a poikiloblastic manner. The chemical, optical and X-ray data of fassaite are given in Tables 1 and 2. A comparison with aluminous augite in the pyroxenite of the ultrabasic members of the charnockite rocks is also presented. The proportions of pyroxene components of fassaite and aluminous augite are given in Table 3.

The Gondivalasa fassaite shows a reduction in the *a* and *b* parameters and an increase in the *c* parameter (Table 2) when compared with natural clinopyroxenes containing lesser amounts of aluminum. A similar decrease in the cell dimensions of *a*, *b*, *a* sin β and *V* and an increase in *c* is reported from a study of synthetic aluminous diopsides (Sakata, 1957; Clark *et al.*, 1962; and Coleman, 1963). Natural aluminous clinopyroxenes with minor Fe^{3+} and Ti show a decrease in the cell dimensions *a* sin β and *b* and an increase in the *c* parameter (Lewis, 1967). The replacement of Mg (0.66 Å) and Si (0.40 Å) by Al (0.51 Å) results in a decrease of *a* and *b* parameters and an increase of *c* parameter. The observed reduction in *a*, *b* and *a* sin β cell dimensions is possibly due to the higher amount of octahedral Al in fassaite. The increase in *c* parameter in aluminous augite, compared to that of fassaite under study is due to higher amount of tetrahedral Al in it.

TABLE 1. CHEMICAL ANALYSIS OF FASSAITE WITH COMPARISON OF ALUMINOUS AUGITE

Oxide	Wt%		Number of ions per six oxygen atoms				
	1	2		1		2	
SiO_2	47.04	45.48	Si	1.721	2.000	1.693	2.000
TiO_2	0.28	1.64	Al^{iv}	0.279		0.307	
Al_2O_3	12.43	11.06	Al^{vi}	0.257	2.009	0.178	2.008
Fe_2O_3	0.63	2.03	Ti	0.009		0.046	
FeO	1.23	5.08	Fe^{3+}	0.018		0.056	
MnO	0.24	0.35	Fe^{2+}	0.037		0.158	
Cr_2O_3	—	0.03	Mn	0.006		0.011	
MgO	12.80	11.08	Mg	0.697		0.615	
CaO	24.34	23.13	Ca	0.954		0.922	
Na_2O	0.32	0.21	Na	0.022		0.018	
K_2O	0.19	0.11	K	0.009		0.004	
H_2O^+	0.50	0.31	Ca	55.9		52.3	
H_2O^-	0.06	0.13	Mg	40.9		34.9	
Total	100.06	100.64	Fe	3.2		12.8	

1. Fassaite, Calc-silicate skarn vein, Gondivalasa.
2. Aluminous augite (Sriramadas et al, 1969).

DISCUSSION

The discovery of aluminous augite (Sriramadas *et al.*, 1969) in the pyroxenite of the charnockite rocks of Eastern Ghats of Visakhapatnam district corroborates the concept that normally the clinopyroxenes can take considerable Al_2O_3 in solid solution at higher pressures (Hess, 1960; Kushiro, 1962; and Clark *et al.*, 1962). The presence of pyroxene compo-

TABLE 2. OPTICAL AND X-RAY DATA

	1	2
$2V\gamma$	52–56°	47–49°
γ:c	43–45°	42–46°
α	1.683	1.720
β	1.691	1.728
γ	1.710	1.741
$\gamma-\alpha$	0.027	0.021
Pleochroism		
α	—	Light pink
β	—	Dark pink
γ	—	Pinkish pale green
Cell parameters		
a Å	9.716	9.731
b Å	8.865	8.872
c Å	5.268	5.274
β	74°3′	74°5′
$a \sin \beta$	9.344	9.358

1. Fassaite
2. Aluminous augite

nents of compositions $(Na,K)Fe^{3+}Si_2O_6$ and $CaFe^{3+}AlSiO_6$ in aluminous augite (Table 3) with the consumption of all the available Fe^{3+} indicates igneous character of clinopyroxenes according to Kushiro (1962). The absence of $CaFe^{3+}AlSiO_6$ in the fassaite might indicate a distinct en-

TABLE 3. PROPORTIONS OF PYROXENE COMPONENTS ACCORDING TO THE METHOD OF KUSHIRO (1962) (MOLECULAR PERCENT)

Pyroxene components	1	2
$(Na, K)Fe^{3+}Si_2O_6$	0.525	1.16
$NaAlSi_2O_6$	0.760	—
$CaTiAl_2O_6$	0.525	2.67
$CaFe^{3+}AlSiO_6$	—	2.09
$CaAl_2SiO_6$	14.720	10.37
$CaFe^{3+}Si_2O_6$	—	—
$CaSiO_3$	40.350	38.30
$MgSiO_3$	40.610	35.63
$FeSiO_3$	2.510	9.79

1. Fassaite
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vironment of formation. The high $CaAl_2SiO_6$ proportion in the fassaite of the skarn vein is possibly related to the metasomatic process rather than high pressures. The fassaite from the skarn vein taken jointly with the occurrence of fassaite in metamorphosed limestones indicates that the amount of $CaAl_2SiO_6$ in pyroxenes probably depends on the relative availability (chemical potentials of Al and Si) as well as temperature and pressure.

Graphite occurs sporadically within the limestones. During the metasomatic formation of plagioclase and fassaite assemblage CO_2 is released. In addition CO_2 is also liberated from the reaction of carbon within the limestones and water from the granitic source, resulting in an increase of CO_2 concentration and consequent formation of coarse flakes of graphite from the following reaction as outlined by Winchell (1924).

$$C + 2H_2O \rightleftharpoons CO_2 + 2H_2$$

Pitcher (1950) has reported similar piling-up of graphite near the skarn vein contacts at a temperature higher than 550°C. It is inferred that the plagioclase and fassaite assemblage from the present study might indicate crystallization above 550°C. Studies on the assemblage fluor-apatite and phlogopite in the skarn vein contacts around Gondivalasa have also indicated a probable temperature of formation about 600°C (manuscripts Rao, *et al.*; and Rao and Acharyulu). Thus the plagioclase and fassaite assemblage in the inner skarn vein might have formed at a temperature high as 650°C.

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References

Clark, S. P., J. F. Schairer, and J. de Neufville (1962) Phase relations in the system $CaMgSi_2O_6$-$CaAl_2SiO_6$-SiO_2 at low and high pressure. *Carnegie Inst. Wash. Year Book* **61,** 59–68.

Coleman, C. L. (1962) Effect of ionic substitution on the unit-cell dimensions of synthetic diopside. *Geol. Soc. Amer. Buddington Volume* 429–446.

Hess, H. H. (1960) Stillwater igneous complex, Montana. *Geol. Soc. Amer. Mem.* **80,** 225 p.

Kushiro, I. (1962) Clinopyroxene solid solutions. Pt. 1. $CaAl_2SiO_6$ component. *Jap. J. Geol. Geogr.* **33,** 213–220.

Lewis, F. J. (1967) Unit-cell dimensions of some aluminous natural clinopyroxenes. *Amer. Mineral.* **52,** 42–54.

Pitcher, S. W. (1950) Calc-silicate skarn veins in the limestone of Lough Anure, Co. Donegal. *Mineral. Mag.* **29,** 126–141.

SAKATA, Y. (1957) Unit-cell dimensions of synthetic aluminium diopsides. *Jap. J. Geol. Geogr.* **28,** 161–168.

SRIRAMADAS, A., K. S. R. RAO, AND A. T. RAO (1969) Aluminous augite in the pyroxenite of the charnockite rocks of Visakhapatnam district, Andhra Pradesh. *Proc. Indian Acad. Sci.* **70,** 15–27.

TILLEY, C. E. (1938) Aluminous pyroxenes in metamorphosed limestones. *Geol. Mag.* **75,** 81–86.

WINCHELL, A. N. (1924) Petrographic studies of limestone alterations at Bingham. *Trans. Amer. Inst. Mining Met. Eng.* **70,** 884–903.

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