SHORT COMMUNICATION

PYROXENE EXSOLUTION TEXTURES IN PLUTONIC BASIC IGNEOUS ROCKS FROM KANDRA IGNEOUS COMPLEX, NELLORE SCHIST BELT, ANDHRA PRADESH

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The pyroxenes in the mineral assemblage of gabbros and norites of the Kandra Igneous Complex (KIC), Nellore Schist Belt, Andhra Pradesh show fascinating exsolution phenomenon. An attempt has been made herein to characterize the pyroxenes chemically and to estimate their temperatures of crystallization.

Introduction

The region around Kandra (Lat.l4°2'20"N: Long. 79°47'30"E) has attained importance due to the occurrence of basic igneous rocks in association with granitic gneisses, schists and mica pegmatites. These basic igneous rocks were referred to as 'Kandra volcanics' (Roy, 1944), 'Kandra ophiolites' (Leelanandam, 1990) and 'Kandra Igneous Complex' (Rao, 1992) The stratigraphic sequence proposed by Rao (1992) is given below:

Youngei basic igneous rocks	Dolentes and quartz-dolentes
Gi amies and pegmatites	Mica bearing pegmatites and metasomatic biottte granodiontes Pink miciocltne granites
	Replacement migmatites Lit par lit injections and leplacement dykes of leucocratic granitic rocks into the amphibohtes and basic igneous locks
Migmatites	Recrystalhsed migmatites Segregated banded para- and ortho-amphiboJites and development of hornblende granodiontes
	Hypabyssal basic igneous rocks Dolentes, porphyntic dolentes, olivine dolentes
Oldei basic igneous rocks	Plutonic basic igneous rocks TioctoJites, olivine nontes, oh vine gabbros, nontes and gabbros Oitho-metamorphics (Kandia volcanics) Amygdaloidal amphibohtes and amphibohtes
Metamorphics	Para-metamorphics. Quartzites, mica schists, garnet-mica schists, garnet-staurohte-kyanite-nuca schists, grey mica granite, schistose amphibohtes, garnet amphibohtes

The plutonic basic igneous rocks represented by the troctolites, olivine norites, olivine gabbros. norites and gabbros are well exposed around Arimanipadu in KIC. These are in general, medium to coarse grained, hard and compact rocks characterised by cumulus textures The pyroxenes in the mineral assemblage of gabbros and norites show fascinating exsolution lamellae. An attempt is made to present the chemical compositions of pyroxene phases and estimate their temperatures of crystallisation Pyroxene exsolution textures are found to be ubiquitous in gabbros and nontes exposed in Arimanipadu-Vendodu hill range in KIC. Electron micro-probe analysis has been carried out on the pyroxenes and the temperature estimates are reported.

Methodology

Mineral analyses were performed at the Institute of Experimental Mineralogy (I.E.M.), Chernogolovka, Russia by the senior author using a CAMEBAX-MBX Probe with energy dispersive spectrometers following the standard procedures established in those Laboratories Electron beam energy was set at 20 KV for both wave dispersive and energy dispersive modes with current beam, 30 nA (under wave dispersive) and 1 nA (under energy dispersive). The ZAF correction was applied with CAMEBAX - MICROBEAM and Link 860-500 software.

Petrography **and** Exsolved Features

The plutonic basic igneous rocks (troctolites, olivine norites, olivine gabbros, norites and gabbros) in KIC are dark grey coarse grained rocks essentially made up of plagioclase, olivine, ortho- and clinopyroxenes and opaque minerals and apatite as accessories.

The microtexture is commonly hypidiomorphic inequigranular, consisting of lath shaped plagioclase ($An_{60\pm5}$) inequi-dimensional olivine (Fo_{70_54} Fa_{3046}) and subophitic orthopyroxene and clinopyroxene. Both ortho- and clinopyroxenes occur as coarse subhedral plates, ranging

in length from 0.5 to 3.0 mm and breadth 0.5 to 2.5 mm, enclosing olivine and more often rimming partially the olivine crystals. Pyroxenes also occur as subhedral plates interstitial to plagioclase laths.

The orthopyroxene, hypersthene shows abundant coarse lamellae (Figs. 1 and 2) and blebs of augite regularly oriented parallel to (001) normally and occasionally with narrow lamellae of augite parallel to (100). The coarse augite lamellae parallel to (001) range in thickness from 0.006 mm to 0.016 mm with exceptional lamellae up to 0.02 mm; they are spaced from 0.03 to 0.06mm apart and constitute about 15 to 25% of each crystal. The narrow lamellae range in thickness from 0.0005 to 0.0004 mm and are widely spaced and constitute a minor part of each crystal.

Electron-Probe Data and Temperature Estimate

Quantitative analyses of orthopyroxene host and clinopyroxene lamellae from gabbros and norites of KIC are listed in Table 1. The temperatures of formation of coexisting orthopyroxene host and augite lamellae using

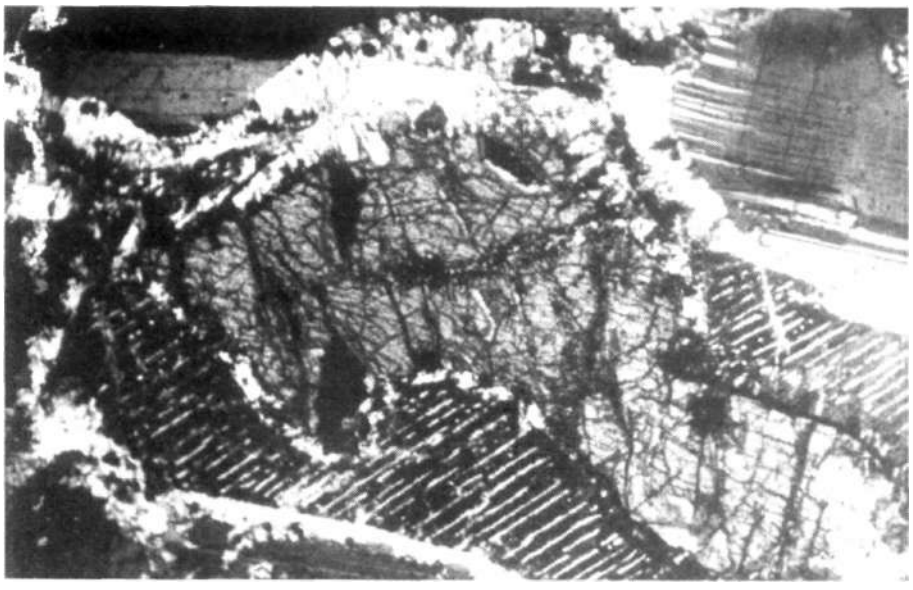

Fig.l. Photomicrograph of olivine rimmed by Opx with exsolved Cp\ lamellae; Crossed Nicols, **May n \ 10.**

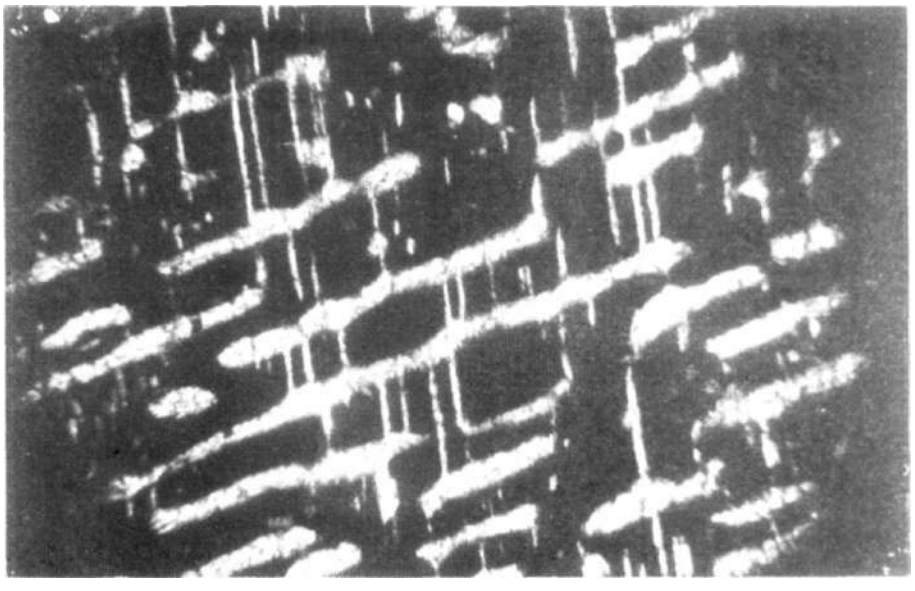

Fig.2. Photomicrograph of two sets (coarse lamellae parallel lo 001: narrow lamellae pai.tllel to **100) lamellae in Opx host: Crossed Nicols. Magn. x 50.**

Table 1. Electron Micro-Piobe data of chemical composition foi host Opx and exsolved Cpx lamellae in KIC, Nellore Schist Bell Andhra Pradesh

Rock types	Olivine nonte 9		Olivine nonte 19		Nonte 10		Olivine gabbro 7		Gabbro 1 1	
	Opx	Cpx	Opx	Cpx	Opx	Cpx	Opx	Cpx	Opx	Cpx
SiO_2	52 16	50 69	51 56	51 13	52,49	51 39	52 00	51 05	54 21	51 19
TiO,	021	0 38	0 25	0 37	0 22	0 37	0 17	0 43	01 1	0 42
Alp,	0 98	150	0 97	1,67	100	156	106	158	1 36	182
0,0,	0 00	0 10	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 00
FeO*	23 99	12 80	24 82	10 83	25 05	10 63	24 30	10 90	21 01	1160
MnO	0 47	0 24	0 56	0 20	0 52	0 18	0 37	0 19	0 38	0 26
MgO	21 03	1501	19 59	14 10	20 23	14 34	21 11	13 79	20 20	1381
CaO	142	18 47	2 05	19 80	113	20 35	1 33	20 20	3 53	19 78
Total	100 26	99 19	99 80	98 10	100 64	98 82	100 34	98 14	100 80	98 88
Foimula quantities Number of ions on the basis of 6 (0)										
Si	196	J 92	1,96	195	196	194	1 95	1 95	!99	194
Ti	0 00	001	0 00	001	0 00	001	0 00	001	0 00	001
At	0 04	0 06	0 04	0 07	0 04	0 07	0 04	0 07	0 05	0 08
Fe^2	0 75	0 40	0 78	0 34	0 78	0 33	0 76	0 34	0 64	0 36
Mn	001	0 00	0 05	0 00	001	0 00	0 01	0 00	0 01	0 00
Mg	1 17	0 85	1 11	0 80	1 13	081	1 18	0 78	1 11	0 78
Ca	0 05	0 75	0 08	081	0 04	0 82	0 05	0 82	0 13	0 80

* Total Fe as FeO

Table 2. Geothermometry (Temperatures in degrees C) of coexisting pyroxenes from Kandra Igneous Complex, Nellore Schist Bell, Andhra Pradesh

Metliod	Olivine nonte 9	Olivine nonte 19	Nonte 10	Olivine Gabbro 7	Gabbro 11
Wood and Bano (1973)	998	946	938	927	973
Henry and Medans (1976) A	982	916	896	866	937
Henry and Medans (1976) B	1153	1053	1021	971	1075
Wells (1977)	1086	1031	1015	991	1050
Powell (1978)*	1011,1026 & 1041	1213, 1224 & 1235	998, 1006 & 1014	1036, 1044 & 1052	1506 1519 & 1532
Kiucpin (1979)	1155	797	782	985	1536
Kretz(I982) A	—	1024	1001	970	1016
Kretz(1982)B	1147	851	837	1010	1299
Fonrev and Grapchikov (1982)*	881, 880 & 879	767, 766 & 766	746, 745 & 744	796, 795 & 794	921, 920 *A* 919
Slavinsky(1983) A	872	725	697	816	1055
Slavmsky (1983)B*	873 & 877	717&720	686 & 688	812 & 815	958 & 962
Finnety and Boyd (1984)*	880, 890, 896	722	690	818	966
Nickel et at (1985)*	1237, 1243 & 1249	1169, 1175 & 1181	1132, 1138 & 1144	1133, 1139 & 1145	1195 1201 & 1207
Fonrev and Grapchikov (1991)(A 2px)*	947, 952 & 956	—	—	—	996, 1001 & 1006
Fonrev and Grapchikov (1991) (B 2px)*	—	761, 764 & 768	742, 744 & 747	801, 805 & 809	—
Fonrev and Grapchikov (I991)(C 2px)*	—	729, 732 & 735	702,705 & 707	—	—
Fonrev and Grapchikov (1991)(D Cpx)*	959, 963 & 968	896, 902 & 907	888, 894 & 900	882 888 & 893	898, 903 & 908
Sen and Jones (1989) A	1417	1325	1283	1211	1307
Sen and Jones (1989 }B	1095	1167	1997	1054	1358

* Temperatures calculated assuming piessure 3, 5 & 7 kb,

A, B, C & D versions are used in temperature calculations by different authors

various pyroxene thermometers are presented in Table 2 Different methods have indicated scattering of results. However, the method of Fonarev and Grapchikov (1991) includes practically all available experimental data and is found to be highly calibrated This method has shown that in comparison with versions of other authors two pyroxene thermometry, most satisfactorily describes all known experimental data Testing (Fonarev and Grapchikov, 1991) has confirmed high reliability of this thermometer in a wide range of compositions and P-T conditions

Estimates of temperatures based on 2px calculations for Cpx lamellae in Opx host in the plutonic basic igneous rocks of KIC reveal a broad range of 700°-1000° C The higher temperature estimate of about 1000° C is recorded only for two samples: olivine nonte 9 and gabbro 11 and where as in the other samples ohvine gabbro 7, nonte 10, olivine nonte 19 the temperatures of formation is observed to be 750°±50° C In the samples olivine nonte 9 and gabbi o i l, herringbone structure characteristic of inverted pigeomte has been observed in a few pyroxene grains, suppoiting higher temperature of formation of about 1000° C for the exsolved Cpx in the host Opx, surrounding olivine Orthopyroxenes interstial to plagioclase in the mincial assemblage suggests its late paragenetic sequence and temperature of formation aiound 750°±50 °C

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