MINERAL COMPOSITIONS OF THE CHARNOCKITIC ROCKS FROM KONDAPALLI AND CORRELATIONS WITH THE WHOLE ROCK COMPOSITIONS

C Leelanandam
Department of Geology Osmania University Hyderabad – 500 007
Email: clcelanandam@rediffmail com

This communication is aimed at evaluating the compositional relationships between the minerals and host charnockitic rocks from Kondapalli and to demonstrate that the composition of any particular ferromagnesian mineral in the granulites is controlled not by the whole rock chemistry alone but by the amount and actual composition of all other coexisting ferromagnesian minerals and also of the ore minerals.

The results obtained from the chemical dissection of the charnockitic rocks from Kondapalli, by the classical methods in a clinical mode, are summarized in Table 1 The compositions of orthopyroxene (Opx), clinopyroxene (Cpx), hornblende (Hbl) and biotite (Bt), and also of their host rocks, expressed in terms of Fe^{2+}/Mg ratios and Mg# [$100Mg/(Mg+Fe^{2+})$], are provided SiO_2, FeO and MgO contents of the whole rocks (in wt%), and compositions of the constituent plagioclase (Pl) feldspar [100An/(An+Ab)] are also included for a greater appreciation of the chemical make up of the studied samples (Leelanandam, 1965)

The spatially associated ultramafic rocks (previously referred to as "ultrabasic charnockites") listed in Table 1 belong to varied groups of disparate paragenesis They are merely included here to represent wider chemical coverage of the specimens with alleged (now discredited) charnockitic lineage, and also to highlight their chemical distinctiveness They are genetically unrelated to the mafic and "felsic" granulites (previously referred to as basic and, "intermediate and acid" charnockites respectively) and hence are not further discussed in this communication

Mafic Granulites

The mafic granulites (excepting the sample A18) behave as an unusually coherent group with highly restricted compositional range (Mg# =55 60) In 5 out of the 8 mafic granulites, Fe^{2+}/Mg of the Opx is greater than that of the host rock, while the reverse is true in all the 5 felsic granulites The Mg# of Opx (given within the brackets) in the mafic granulite samples 28 (58 80), G17 (56 86), 220 (56 15), 474 (55 36) and 382 (51 51) are slightly higher than En^* contents ([$Mg/(Mg+Fe^{2+}+Fe^{3+}+Mn)$]) reported in Leelanandam (2002), the normative En values are enchantingly closer to Mg# than to En^* (*see* Table 1 in Leelanandam, 2002) However, in the samples P45 (53 90) and A18 (49 91), wherein En^* values are slightly higher than normative En values, the departure of the latter from Mg# (when compared to En^*) is marginally enhanced

In the mafic granulites, the Fe^{2+}/Mg of both Cpx and Bt is always significantly less (and of Hbl not so significantly less) than that of the host rock The sequence of minerals with decreasing order of Fe^{2+}/Mg ratio (or increasing order of Mg#) in these granulites is Opx-Hbl-Bt Cpx

The apparently elevated acidity values (as measured by SiO_2 contents) can be misleading in some cases The mafic granulite (lens) sample 382, with 62% SiO_2, contains a rather high amount of "introduced" quartz The other two mafic granulite lenses (samples 28 and 220) also contain minor "released" quartz, while the sample A18 (with 55 30% SiO_2) contains considerable amount of both introduced and released quartz The sample A18 [with the highest Fe^{2+}/Mg (1 01) and lowest Mg# (50) in this group] is exceptional on many counts (Leelanandam, 1967a), and such "specimens are equally as interesting as those that are well behaved" (*see* Kretz, 1990, p 504)

The two mafic granulites A18 (Fe^{2+}/Mg =1 01) and A7 (Fe^{2+}/Mg = 0 70) occur in the vicinity of pink granitic material in the field, and are rich in Hbl and Bt The Fe^{2+}/Mg ratios of the orthopyroxenes A18 and A7 are the highest (1 00) and lowest (0 56, from optics) in this group The specimen A18 was collected close to a local shear plane, the minerals exhibit aberrant chemical behaviour, and the plagioclase is strongly zoned ($An_{56\ 73}$) These two samples depart widely from other mafic granulites, which do not show sufficient spread in Fig 1

Amongst the mafic granulites, a poor positive correlation is perceptible between the rock Opx compositions (*see* Fig 2) If the data points for the two aberrant samples A18 and A7 are not considered, then the correlation becomes weak and ambiguous Figure 2 further shows that the patterns depicting the Fe^{2+}/Mg and Fe# distributions between the rock and Opx are identical Despite the paucity of data, a vague negative correlation between the rock-Cpx/Hbl compositions cannot be ruled out (*see* Fig 1)

Table 1. Compositions of the minerals and their host rocks from Kondapalli (Analyst C Leelanandam)

Sample No		Rock SiO$_2$ (wt%)	Rock FeO (wt%)	Rock MgO (wt%)	Fe^{2+}/Mg Rock	Fe^{2+}/Mg Opx	Fe^{2+}/Mg Cpx	Fe^{2+}/Mg Hbl	Fe^{2+}/Mg Bt	Mg # = 100Mg/(Mg+Fe^{2+}) Rock	Mg # Opx	Mg # Cpx	Mg # Hbl	Mg # Bt	Pl An%[!]
Ultramafic rocks															
48 [96243]		-	-	-	-	0 08	-	-	-	-	92	-	-	-	-
323 [96245]	(L)	53 28	9 64	27 03	0 20	0 22	0 12	-	-	83	82	89	-	-	-
472 [96249]	(D)	-	-	-	-	-	0 20	-	-	-	-	83	-	-	89[a]
G4 [96248]		-	-	-	-	(0 33)*	-	0 29	0 24	-	(75)*	-	78	81	77
J22 [96247]	(L)	40 75	11 85	17 85	0 37	0 34	-	0 23	-	73	74	-	81	-	92[a]
D14 [96242]		50 77	7 53	13 68	0 31	0 54	0 27	0 47	-	76	65	79	68	-	55
431 [96250][W]		45 10	9 62	13 00	0 42	0 58	-	0 31	0 16	71	64	-	77	86	85
Mafic granulites															
A7 [96253][W]		48 90	10 55	8 48	0 70	(0 56)*	-	0 52	0 45	59	(64)*		66	69	60
28 [96256]	(L)	51 89	9 14	6 92	0 74	0 70	0 40	0 63	-	57	59	72	61	-	84-88[a]
G17 [96258]	(HM)	49 14	9 65	7 89	0 69	0 76	0 41	0 68	-	59	57	71	59	-	57-61
220 [96252]	(L)	48 50	9 77	7 38	0 74	0 78	-	0 65	0 56	57	56	-	61	64	-
474 [96257]	(HM)	50 03	9 99	8 35	0 67	0 81	0 43	-	-	60	55	70	-	-	-
P45 [96259]	(D)[c]	47 09	10 38	7 12	0 82	0 86	-	-	0 55	55	54	-	-	64	81[a]
382 [96273]	(L)	62 00	6 47	4 58	0 79	0 94	-	-	0 48	56	52	-	-	68	55
A18 [96251]		55 30	11 00	6 12	1 01	1 00	0 43	0 79	0 69	50	50	70	56	59	56-73[b]
Felsic granulites															
62 [96275]		60 99	4 83	2 67	1 02	0 95	0 48	-	-	50	51	68	-	-	45
359 [96287][W]		62 80	3 27	2 23	0 82	-	-	-	0 71	55	-	-	-	58	-
M12 [96281]		68 52	6 94	1 51	2 58	1 05	-	-	-	28	49	-	-	-	38
B4 [96282][W]	(End)	65 90	3 35	1 59	1 18	1 17	-	-	-	46	46	-	-	-	44
S1 [96280]		67 39	4 48	1 49	1 69	1 26	-	-	0 71	37	44	-	-	58	40
322 [96293]	(End)	71 48	3 63	0 75	2 72	1 32	-	-	-	27	43	-	-		54

The five-digit numbers apply to the Harker Collection in the Department of Earth Sciences, Cambridge (England) For field relationships of the rock units, see Leelanandam (1969a) Data for rocks and plagioclase from Leelanandam(1965), rest from Leelanandam (1967a,1970)

[W]Rock SiO$_2$ and MgO from the analyses done by Dr K Govindaraju (CRPG, Nancy, France), [c]*see* Grasty and Leelanandam (1965), ! 100An/(An+Ab), [a] *see* Leelanandam (1967b)
[b] *see* Leelanandam (1968), *Determined from optics (see Leelanandam,1970) D = dyke L = lens. HM = hill mass. End = (unusual) enderbite (*see* Leelanandam, 1969b)

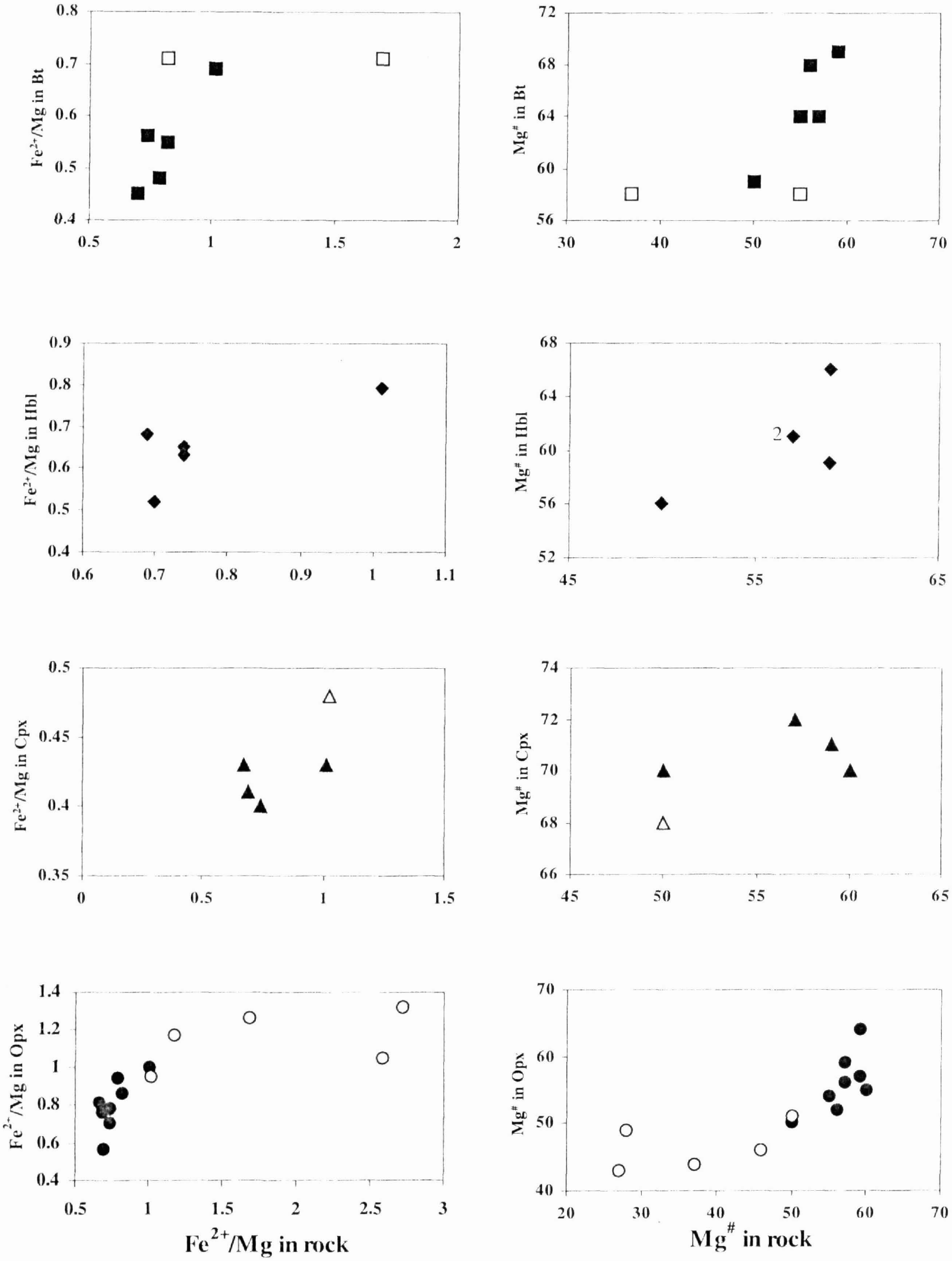

Fig.1. Relationships between the compositions of minerals and their host rocks. Solid symbols = mafic granulites; Open symbols = felsic granulites. For data *see* Table 1.

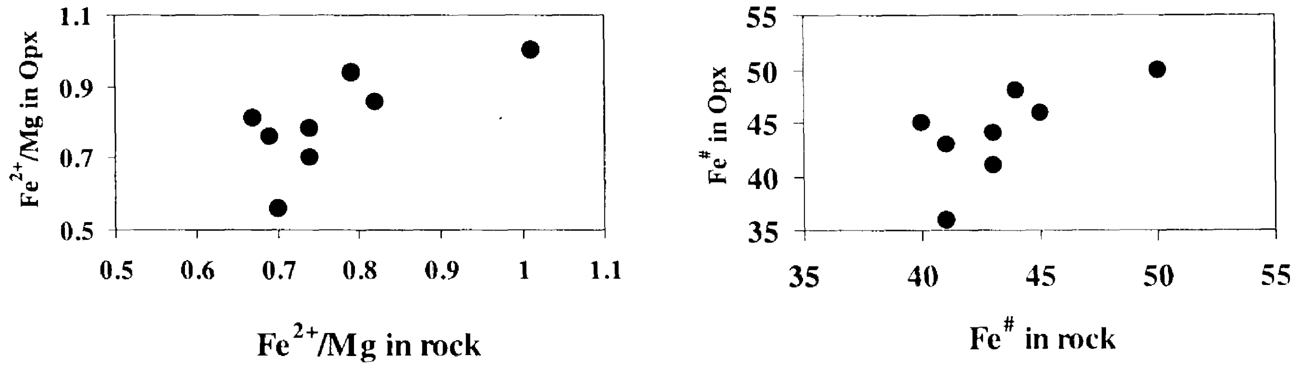

Fig.2. Orthopyroxene-rock (mafic granulite) compositional relationships. Fe# = 100 Fe^{2+} / (Fe^{2+}+Mg) = 100 - Mg#. For data *see* Table 1.

The plagioclase in the hill mass type of mafic granulite G17 (An_{57-61}) and that in the Bt-rich (atypical) mafic granulite lens 382 (An_{55}) are somewhat comparable. The plagioclase in the lens 28 (An_{84-88}) and Bt-rich dyke P45 (An_{81}) is unusually calcic and anomalously antiperthitic. Though Ca# of the Pl correlates reasonably well with Ca# of the host rock (*see* Table 2 and Fig. 3), drastic difference is expectedly encountered in the Cpx- and Hbl-rich mafic granulites G17 and A7 respectively.

Felsic Granulites

The felsic granulites (60.99-71.48% SiO_2) are characterized by the ubiquitous absence of Hbl and extreme rarity of Cpx. Though limited in number, they exhibit enormous compositional variation (Fe^{2+}/Mg = 1.02-2.72; Mg# = 50-27), which is curiously not reflected in the composition of the constituent Opx (Fe^{2+}/Mg = 0.95-1.32; Mg# = 51-43).

Increase in the Fe^{2+}/Mg of Opx is crudely correlatable, with the exception of M12, with an increase in the SiO_2 and Fe^{2+}/Mg of the host rock. It is queer that orthopyroxenes M12 and B4 with rather similar Fe^{2+}/Mg ratios (1.05 and 1.17 respectively) occur in rocks with highly dissimilar Fe^{2+}/Mg ratios (2.58 and 1.18 respectively). The Mg numbers magnify this anomaly. The rock M12 (68.52% SiO_2) with lower Mg# (28) contains Opx with higher Mg#(49), while the rock B4 (65.90% SiO_2) with higher Mg# (46) contains Opx with lower Mg# (46). Equally ironically, the biotite in the samples S1 (67.39% SiO_2) and 359 (62.80% SiO_2) has the same Fe^{2+}/Mg ratio (0.71), despite stupendous variation in the host rock Fe^{2+}/Mg ratios (1.69 and 0.82 respectively). Variable amounts of garnet and Fe-Ti oxides complicate the problem of correlation between the mineral and rock compositions. Furthermore, the acidic rocks (unusual enderbites) B4 (65.90% SiO_2) and 322 (71.48% SiO_2) contain plagioclase with 44% and 54% An respectively, which is singularly exceptional. All the Ca in felsic granulites (which are practically devoid of Ca-bearing femic minerals like Cpx and Hbl) is effectively locked up in the constituent Pl; the Ca contribution by garnet and apatite is negligible. Understandably the Ca# of plagioclase is often slightly less than that of the host rock (Table 2), and the anticipated nice correlation between them is quite remarkable (Fig. 3).

Table 2. Plagioclase and host rock compositions from Kondapalli (Analyst: C. Leelanandam)

Sample No.	Rock CaO (wt %)	Rock Na_2O (wt %)	Ca# = 100Ca/(Ca+Na) Rock	Ca# = 100Ca/(Ca+Na) Pl
		Mafic granulites		
28	10.47	0.75	88.57	87.70
P45	9.25	0.97	84.53	80.16
A18	7.22	2.01	66.66	67.23
G17	12.29	2.24	75.25	59.55
A7	8.78	2.19	69.02	58.65
382	5.90	2.59	56.14	53.80
		Felsic granulites		
322	4.74	2.33	53.16	52.97
62	6.20	3.80	47.41	45.04
B4	5.89	3.74	46.66	42.52
S1	3.08	2.69	38.57	38.41
J20	3.28	3.47	34.52	37.77
M12	2.52	2.06	40.00	36.51
P35	2.75	3.14	32.88	32.76
P60	4.21	4.69	33.33	32.75

The numbers given in the decimal places for the Ca# values have no significance.

Discussion

The two groups of Kondapalli granulites have distinctive mineral-chemical characteristics. As there is no strict correlation between the SiO_2 of the rock and FeO, MgO,

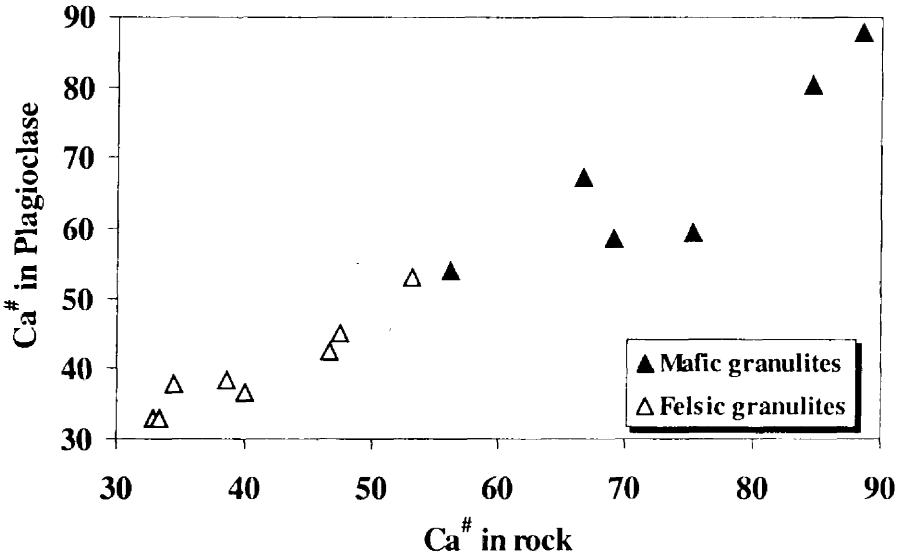

Fig.3. Plagioclase-rock compositional relationships. For data *see* Table 2.

Fe^{2+}/Mg or Mg# of the rock (Table 1), mafic and felsic granulites are not considered as one entity. Systematic correlations between the Fe^{2+}/Mg ratios of the host rocks and constituent minerals are absent; contrary to general expectations, the correlations are no better even when Mg numbers are considered (*see* Fig. 1). Though ill-defined positive correlations between the Opx and host rock compositions are noticeable, consistently regular (and straight line) relationships are not observed in either group. Rocks with minor or no garnet have indistinguishable chemistries. Garnet (which has grown at the expense of other minerals), when present in considerable amount, can cause drastic changes in the composition of other coexisting femics (and also plagioclase). Hence, petrogenetic appraisals based on the mineral compositional data alone are particularly vulnerable to misinterpretations.

The mineral compositions from the granulites of Kondapalli, as those of the type area near Pallavaram (Howie and Subramaniam, 1957), are not in tune with the accepted facts of mineral variation in a normal igneous differentiation series. As the rocks under study are reconstituted during metamorphic recrystallization under granulite facies conditions, simple rock-mineral chemical relationships are not expected.

The absence of stringent straightforward chemical relationships between granulite facies host rock and constituent minerals was primarily utilized as a criterion for delinking the genetic relationship between the mafic and felsic granulites of Madras (Subramaniam, 1959); by the same token, various members of the so-called differentiation series of the Madras "charnockite suite" (felsic granulites) also are to be viewed as genetically unrelated (Leelanandam, 1965). From the available data, the Kondapalli mafic granulites are construed as chemically consanguineous, with no apparent linkage with the felsic granulites; it is unclear whether or not there is consanguinity among the members of the felsic group. The present study demonstrably reaffirms the notion that the composition of any particular ferromagnesian mineral in the granulites is controlled not by the whole rock chemistry alone, but by the amount and actual composition of all other coexisting ferromagnesian minerals and also of the ore minerals.

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