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A Review of Petrography, Geochemistry and Genesis of High Magnesian Cumulate Ultramafics of Northwestern fringe of Chotanagpur Gneissic Terrain, Eastern India

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Abstract: In the northwestern fringe of Chotanagpur Gneissic Terrain (CGT) number of occurrences of high MgO ultramafic cumulates are recorded emplaced adjacent to Gondwana basin. The ultramafics occur as veins,lenses and tongue like bodies in metaultramafites and exhibit close spatial association with amphibolites. Mineralogically they are composed of olivine, clinopyroxene, orthopyroxene, magnetite±Cr spinel±phogopite±sphene and are lehrzolitic in composition. Chemically they are characterized by high MgO, Ni,Cr and low TiO_2,alkalies and silica and exhibit komatiitic signature. Major oxide, Trace element and Rare Earth Element ratios suggest their similarity with Al-undepleted Munro type komatiite. Al-undepleted nature together with flat HREE distribution pattern and different elemental ratios suggest absence of garnet in the melting residue. Depth of magma generation estimated on the basis of major oxide ratios suggests melting depth of 150 km at pressure 6-7 Gpa for komatiite magma. They are postulated to be derived from a plume tail or from the innermost part of a plume head.

Keywords: *Chotanagpur Gneissic Terrain, High MgO, Cumulates ,Al-undepleted Munro type Komatiite, Plume*

1. Introduction

The high grade gneissic terrain of Chotanagpur highland consisting dominantly of amphibolite to granulite facies rocks is juxtaposed between the two low grades metamorphic belts- the North Singhbhum Mobile Belt in the South and Mahakoshal Mobile Belt in the North; Roy and Devrajan [28]. It consists of basement gneisses with Supracrustal metasedimentary enclaves intruded by dykes swarms and plutons ranging in composition from ultramafic to acidic and sodic alkaline to ultrapotassic. The dykes swarms and plutons include grabboids, massive anorthosite, peraluminous granite plutons, rapakivi granite, leptynite, komatiite and tholeiitic sills/ dykes and flood basalts.

Five major intracontinental rift/shear zones largely control magmatism in the Chotanagpur Gneissic Terrain (CGT) designated as South Purulia Shear Zone, North Purulia Shear Zone, Damodar Graben, North Narmada South Fault and Rajmahal Basin; Ghose and Chatterjee [12]. In the northwestern fringe of CGT, which is situated adjacent to Damodar Graben rift zone, number of ultramafic to mafic dykes of various dimensions occurs in the form of komatiite to amphibolites and to some extend by dolerite. The ultramafic rocks of the study area, represented by high magnesian cumulate komatiites, have been recorded from Semra and adjoining areas (24^0 00’02” N: 83^0 58’ 40”E ;Bhattacharya et al [5]; Bhattacharya et al [6]; Prasad and Bhattacharya [26];Prasad and Bhattacharya [27]. Komatiites are ultramafic mantle derived extrusive volcanic rocks having MgO greater than 18% with low alkalis CaO and high content of Ni, Cr, Co. These rocks act as window to the upper mantle and occur predominantly in Arachean greenstone belts and are rare in Proterozoic and Phanerozoic. This paper embodies petrological and geochemical study of cumulate komatiite occurring in the area and an attempt has been made to assess the genesis of the rock based on major, trace and REE geochemistry together with their comparison with other important occurrences of the world.

2. Geological Setup

The Eastern Indian Shield consists mainly of Singhbhum Craton (including CGT) and Shillong plateau. The Singhbhum Craton is surrounded by Mahanadi rift in SW, Narmada- Son rift, Gangetic Alluvium and Mahakoshal- Satpura belt in NW, Eastern Ghat Belts in SW and Rajmahal Trap in N-NE. CGT records various crust forming events covering a period of over 2000 m.y. since Early Proterozoic- passing through different phases of tectonism, development of intracratonic basins in Proterozoic and Phanerozoic time, invasion of mantle and crustal derived rocks, polyphase metamorphism and migmatisation. The CGT comprises mainly of granite gneisses, migmatite, porphyritic granite and metasedimentary enclaves (Fig.1; Ghose[13]; Ghose[14]; Mahadevan[18]; Chatterjee and Ghose[9]. The gneisses and metasediments were metamorphosed and cofolded during the Satpura orogeny; Ghose et al [15]; Kumar and Ahmad[17]; Ghose and Chatterjee[12]. They trend in ENE- WSW to E-W following major structural trend, which probably existed since Arachean; Ghose and Chatterjee [12]; Bhattacharya et al[6]. There is no consensus on the nature of CGT and its relation with the Singhbhum Craton. There is debate over the nature of CGT; whether it is mobile belt or a cratonic block. Recently; Sharma [30] considers CGT to be a cratonic region of Arachen antiquity whose convergence with the Singhbhum Craton in the south gave rise to the Sighbhum Mobile belt they further states that medium grained enclaves of metasediments and basic rocks do not support its mobile belt nature. Occurrence of Komatiite; Bhattacharya et al [6] and potassic intrusive; Srivastava et al [32] also support cratonic nature of CGT. The present authors are also of the opinion that CGT should considered as a cratonic block however comprehensive study of the basement rocks with their radiometric ages are required to reach any conclusive remark.

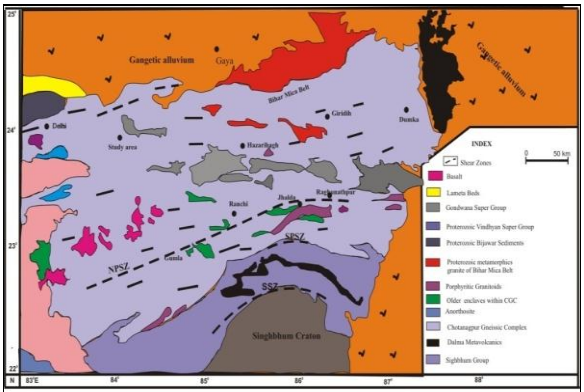

Fig.1 Regional geological map of Chotanagpur Gneissic Complex

3. Petrographic

Komatiites in the area occur as veins, lenses and tongue like bodies in metaultramafites and exihibt close spatial association with amphibolites. The metaultramafites represent pretectonic igneous activity and are represented by tremolite actinolite schist and talc tremolite schist and show concordant relationship (roughly E-W) with the country rock.These metaultramafites have been assigned tholeiitic parentage; Bhattacharya and Barla [4].

Megascopically these rocks are dark grayish black in colour and pale to dark brown on weathered. In the field a thin layer of spinifex zone is observed followed by comparatively thicker zone of cumulate textured rock. In the study area komatiites with cumulus texture are common. Texture of komatiite indicate the condition under which they crystallized, rapid cooling and high degree of super cooling for fine random spinfex moderate cooling for coarse spinifex texture and slow cooling rates for polyhedral cumulus texture of olivine. The investigated samples have textures of the cumulate komatiites range from orthocumulates through mesocumulates to adcumulates. In orthocumulates there is high proportion of crystallized intercumulus liquid and the cumulus crystals are subhedral to euhedral in form. Adcumulate komatiites exhibit no intercumulus material and are characterized by anhedral crystals with sharp mutual contact and triple point junctions. Mesocumulate varieties which exhibit extensive mutual boundary are rare in the area.

Mineralogically komatiites of the study area are composed of olivine (29-51 vol%), clinopyroxene (30-37 vol%), orthopyroxene (12-21 vol%), magnetite ± Cr spinel ± serpentine ± phlogopite ± sphene. Both olivine and pyroxenes occur as phenocrysts as well as equigranular groundmass. Olivine crystals (altered to serpentine /antigorite in varying degree) are of various shapes and sizes and are forsterite in composition. Though pyroxene is represented by both orthopyroxene and clinopyroxene, the dominance of former one over the other is noticed. Orthopyroxene ranges in composition from enstatite to hypersthene and bronzite. Bronzite is weakly pleochroic and occurs as coarse tabular crystal and is subhedral to euhedral in shape. Clinopyroxene is mainly represented by augite and to some extent by diopside.They occur as fine discrete crystal in the groundmass and show alteration. Phlogopite grains occur as irregular patches and at times occur along the prismatic cleavages of pyroxene. Spinel mostly occurs as subhedral to anhedral grains along intergranular spaces. The complete absence of plagioclase grains is a noticeable feature, denoting its formation beyond the stability field of this mineral. Presence of chrome spinel (pleonaste) support this contention.The sequence of crystallization of constituting minerals of this rock may be estabilised as olivine-orthopyroxene-clinopyroxene-spinel-magnetite. Mineralogically they are lehrzolitic in composition.

4. Chemistry

Major oxides, Trace elements and REE composition of ten samples of ultramafic rocks were determined at National Geophysical Research Institute (NGRI), Hyderabad using XRF and ICP-MS. International standards like JB.2 for major element and UB-N for trace and REE, were also run along with the samples to check precision and accuracy of results. Precision of analyses is within error limit of ± 2%. Major, trace and REE composition of ten samples from the study area are presented in Table 1, 2 and 3.

***Table 1**: Major oxide composition of the Komatiites of the study area and other occurrences of komatiite Average of Komatiites from different shield#*

Sample no.	JP1	JP2	JP3	JP4	JP5	JP6	JP7	JP8	JP9	JP10	11	12	13	14	15	16	17
SiO_2	40.43	41.31	38.11	37.14	34.21	36.43	40.25	39.13	35.8	34.01	43.56	47.4	49.2	45.6	46.8	45.9	47.2
TiO_2	0.48	0.56	0.42	0.33	0.31	0.4	0.52	0.44	0.31	0.36	0.69	0.46	0.43	0.4	0.33	0.41	0.38
Al_2O_3	6.91	6.92	6.8	6.61	6.06	6.71	6.91	6.8	6.12	6.01	8.17	6.76	3.76	7.95	3.42	7.97	4.09

Fe_2O_3	12.81	13.15	12.53	11.81	11.06	12.22	12.91	12.76	11.36	10.4	11.53	12.2	11	14.07*	12.51*	12.30*	13.35*
MgO	28.41	27.71	29.3	29.67	32.01	29.6	28.16	28.92	29.91	34.15	21.85	20.4	20	25	31.5	26.4	28
CaO	6.71	6.82	6.81	5.91	5.8	6.8	6.74	6.61	5.82	5.76	7.46	8.31	9.31	7.6	5.67	7.74	6.61
Na_2O	0.54	0.34	0.38	0.28	0.33	0.32	0.41	0.47	0.32	0.32	0.61	0.39	0.1	0.01	0.12	0.43	0.37
K_2O	0.32	0.42	0.44	0.43	0.46	0.27	0.47	0.33	0.47	0.33	0.08	0.06	0.02	0.02	0.08	0.09	0.04
P_2O_5	0.012	0.013	0.21	0.012	0.012	0.01	0.014	0.2	0.01	0.01	0.1						
LOI	5.02	4.02	5.76	7.07	8.88	6.98	4.98	5.42	8.12	8.78	5.71						
Mg#	85.23	84.605	85.73	86.49	87.92	85.97	85.02	85.4	86.97	89.16	Present data1 to 10 for Ultramafic of Study area, Palamau District,						
CaO/ Al_2O_3	1.029	1.014	0.998	1.118	1.044	0.986	1.025	0.972	1.051	1.043	# 11= Kunchia Ultra basics, East Singhbhum district. (Das et al. 2001),						
CaO/ TiO_2	14.4	12.36	16.19	20.03	19.55	16.76	15.7	16.19	19.74	20.03	14= Al-undepleted komatiite from Munro Township, Ontario. (Arndt and Nesbitt,						
Al_2O_3/ TiO_2	14.39583	12.3571	16.19	20.0303	19.548	16.775	13.288	15.455	19.74	16.69	1982), 15= Al-depleted komatiite from Barberton, SA (Smith and Erlank, 1982),						
											16= Average of 22 Al-undepleted komatiites.(Nesbitt et al. 1979); Arndt and						
											and Nesbitt, 1984; Cattell and Arndt, 1987; Nisbet et al. 1987) 17= Average of 18 Al-						
											depleted komatiites. (Nesbitt et al. 1979;Smith and Erlank,(1982)						

***Table 2**: Trace element composition and ratios of Komatiites of the Study area and other occurrences of world*

Sample no.	JP1	JP2	JP3	JP4	JP5	JP6	JP7	JP8	JP9	JP10					
Cr	2478	2143	2512	2615	2775	2563	2342	2452	2650	2800					
Ni	1485	1350	1775	1912	2185	1775	1415	1530	2075	2655					
V	83	69	120	128	153	127	78	114	152	170					
Sc	15.58	14.87	21.56	27.27	27.65	22.69	15.31	20.25	27.64	27.81					
Sr	12	12	14	12	11	13	15	16	12	18					
Ba	3	5	6	2	2	4	5	7	3	4					
Rb	5	3	4	7	2	4	5	6	4	5					
Cs	0.34	0.29	0.37	0.39	0.34	0.38	0.41	0.39	0.45	0.32					
Zr	47	52	46	33	31	35	51	48	32	30	Some alteration-resistant element ratios for chondrite and for				
Hf	0.29	0.2	0.4	0.43	0.61	0.42	0.28	0.39	0.59	0.63	spinifex-textured komatiites from Ghatti Hosahalli (Karnataka,India)				
Nb	0.36	0.5	0.47	0.61	0.29	0.44	0.47	0.34	0.47	0.33	Barberton(South Africa), Munro (Canada), and Yilgarn (Australia)				
Ti	2875.2	3354.4	2515.8	1976.7	1856.9	2396	3115	2635.6	1857	2165					
Y	7.73	8.07	6.26	5.77	3.63	5.97	7.83	6.28	5.18	3.54					
Ratios											Chondrite	Ghatti Hosahalli	Barberton	Munro	Yilgarn
Ti/Zr	61.17	64.5	54.69	59.9	59.9	68.45	61.07	54.9	58.02	72.18	102	57	121	117	111
Ti/Y	555.05	947.57	421.41	314.76	237.15	382.75	858.1	456.78	240.2	268.3	275	210	269	210	275
Ti/Sc	184.54	225.58	116.69	72.486	67.157	105.6	203.4	130.15	67.18	77.86	83	70	84	74	98
Ti/V	34.641	48.61	20.96	15.44	12.13	18.86	39.93	23.11	12.21	12.74	8.4	9.5	13	14	14
Zr/Y	9.07	14.68	7.7	5.25	3.95	5.59	14.05	8.31	4.13	3.71	2.5	3.6	2.8	1.9	2.4
Zr/Sc	3.01	3.49	2.13	1.21	1.12	1.54	3.33	2.37	1.15	1.07	0.7	1.2	1.2	0.8	0.9
Sc/Y	3	4.2	3.61	4.34	3.53	3.62	4.21	3.5	3.5	3.44	4.2	3	2.4	2.7	2.8
V/Zr	1.76	1.32	2.6	3.87	4.93	3.62	1.52	2.37	4.75	5.66	12	5.8	9.5	8.4	8
V/Sc	5.32	4.64	5.56	4.69	5.53	5.59	5.09	5.62	5.49	6.11	8	7.4	5.9	5.3	7
(La/Yb)n	0.98	0.93	0.91	0.96	1.09	0.97	0.92	0.92	1.62	0.87	Source of data for chondrite Ti/Zr, Ti/Sc, Ti/V, and V/Zr: Nesbitt and Sun				
(La/Sm)n	0.39	0.16	0.35	0.36	0.36	0.4	0.24	0.58	0.35	0.4	1976 quoted by Smith and Erlank (1982). Ti/ Y and V/Sc: Quoted by Arndt				
(Gd/Yb) n	0.98	0.94	0.91	0.96	1.1	1	0.97	0.92	1.62	0.87	and Nesbitt (1982). Zr/sc: Wanke et al.(1974).For Barberton: from Smith				
											and Erlank (1982). For Munro: Ti/Zr, Ti/Sc, Ti/V, Zr/Y and V/Zr: From Smith				
											and Erlank (1982). Ti/Y and V/Sc: from Smith and Erlank (1982).				

***Table 3:** Rare earth element concentration of Komatiites of the study areas*

Sample no.	JP1	JP2	JP3	JP4	JP5	JP6	JP7	JP8	JP9	JP10	Chondrite
La	0.17	0.1	0.26	0.32	0.33	0.3	0.16	0.26	0.32	0.39	0.237
Ce	1.13	1.39	1.39	1.02	1.12	1.32	1.32	1.08	1.08	1.13	0.613
Pr	0.1	0.2	0.25	0.16	0.08	0.23	0.19	0.17	0.16	0.1	0.093
Nd	0.94	0.48	1.02	1.12	1.22	1.08	0.65	0.89	1.22	1.32	0.457
Sm	0.27	0.4	0.46	0.56	0.57	0.47	0.42	0.28	0.57	0.6	0.148

Eu	0.11	0.12	0.19	0.2	0.22	0.19	0.1	0.12	0.2	0.23	0.056
Gd	0.68	0.45	0.73	0.88	1.15	0.87	0.47	0.72	0.2	1.12	0.199
Tb	0.13	0.08	0.15	0.17	0.21	0.16	0.09	0.14	1.02	0.22	0.036
Dy	0.62	0.62	0.99	1.11	1.24	1.02	0.69	0.95	0.18	1.3	0.246
Ho	0.2	0.13	0.21	0.22	0.24	0.21	0.15	0.21	1.14	0.27	0.055
Er	0.64	0.36	0.8	1	1.08	0.82	0.4	0.67	0.24	1.09	0.16
Tm	0.07	0.06	0.09	0.1	0.1	0.09	0.06	0.08	1.08	0.1	0.025
Yb	0.56	0.39	0.65	0.74	0.85	0.72	0.41	0.63	0.1	1.04	0.161
Lu	0.08	0.06	0.1	0.12	0.13	0.11	0.07	0.1	0.75	0.15	0.025
∑REE	5.68	4.88	7.31	7.73	8.52	7.55	5.21	6.95	7.66	8.91	2.511
∑LREE	3.4	3.14	4.3	4.26	4.69	4.46	3.31	3.52	3.75	4.89	1.411
∑HREE	2.3	1.7	2.99	3.46	3.85	3.13	1.87	2.78	4.51	4.17	0.386

Komatiites of the present area are typically characterised by high MgO content ranging from 27.71 to 34.2 wt% with an average of 29.78 wt% (n=10). The investigated rock plots exclusively in komatiite field in; Jensen [16] Al–(Fe+Ti)–Mg cation discrimination diagram (Fig. 2).The most important element in komatiites is aluminum and variations of Al_2O_3/TiO_2 or CaO/Al_2O_3 form important factors of all komatiite classifications; Arndt et al[1]. Al_2O_3 content of the ultramafics range between 6.01 and 6.92 wt% (Av. 6.59 wt%).The ratio of Al_2O_3/TiO_2 ratio varies from 12.36 to 20.03 wt% showing similarity with accepted chondritic value (Al_2O_3/TiO_2 = 20.4; Schmus and Hayes [29]; with "Munro type" Komatiites; Fan and Kerrich [11] and also with Al-undepleted komatiites of late-Arachean (~2.7 Ga) Abitibi greenstone belt; Fan and Kerrich[11]. The ultramafics show distinct Al-undepleted nature for these rocks particularly in terms of MgO vs Al_2O_3/TiO_2 plot (Fig.3). Similar conclusion can be drawn by (Gd/Yb)n vs Al_2O_3/TiO_2 diagram (Fig.4). The CaO/Al_2O_3 ratio of ultramafics varies from 0.98 to 1.11 wt% (Av.1.02 wt%), which is comparable with average Munro Township spinifex textured komatiite; Arndt et al [3], average Komatiite (2.7 Ga) of Newton Township, Canada;Cattel and Taylor [7]. The major oxide ratios like MgO/TiO_2, MgO/Al_2O_3 and Fe_2O_3/TiO_2 show near similarity with Munro type Komatiite. These rocks display high Mg# varying from 85.02 to 89.1, comparable to primitive upper mantle Mg# (89.8), suggesting their mantle derived source. The Cr ranges from 2143-2800 ppm, Ni(1350-2655 ppm), V(69-170 ppm), Sc(14.87-27.81 ppm), Sr(11-18 ppm), Ba(2-7 ppm), Rb(2-7 ppm) Zr(31-52 ppm) Ti(1856-3354 ppm) and Y(3.54-8.07 ppm). Fractionation trends of komatiites are exhibited by MgO vs TiO_2, Al_2O_3, Fe_2O_3, CaO, K_2O and Na_2O plots (Fig.5) and also by SiO_2 vs MgO, Y, Ni, Zr and Sc (Fig.6). Komatiites of the present area are characterized by a diagnostic convex upward REE profile in primitive mantle normalized diagram (normalization factor; McDonough and Sun, [19]). The total HREE ranges from 1.7 to 4.51 and LREE 3.14 to 4.89.Total REE ranging from 4.88 to 8.91 is 2 to 3 times the value of chrondrite.The normalized REE pattern display LREE depletion compared to HREE, which is similar to most of the other Arachean komatiites; Mitra and Bose [20].

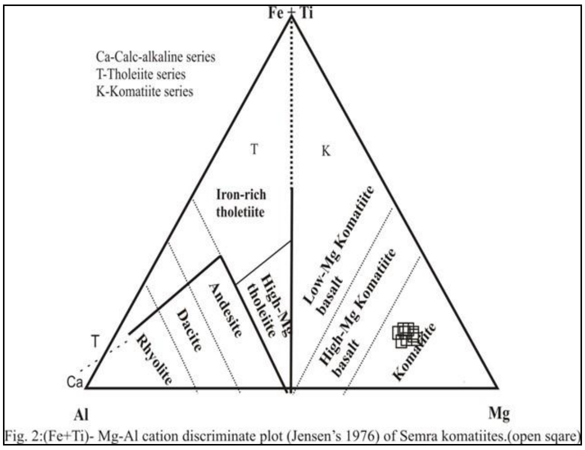

Fig. 2:(Fe+Ti)- Mg-Al cation discriminate plot (Jensen's 1976) of Semra komatiites.(open sqare)

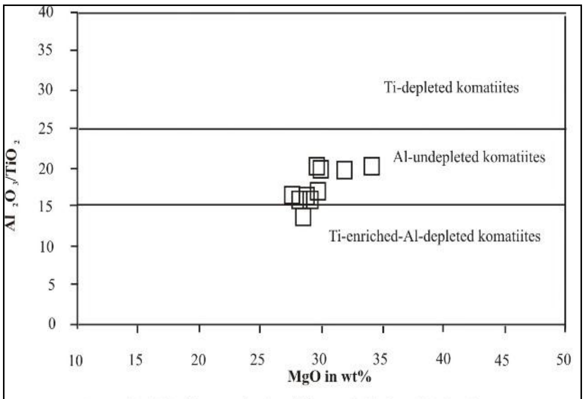

Fig.3 MgO vs Al_2O_3/TiO_2 diagram showing different fields for Al depleted, Al-undepleted,Ti enriched and Ti depleted komatiite.The komatiites of the present area fall mainly within Al- undepleted field.

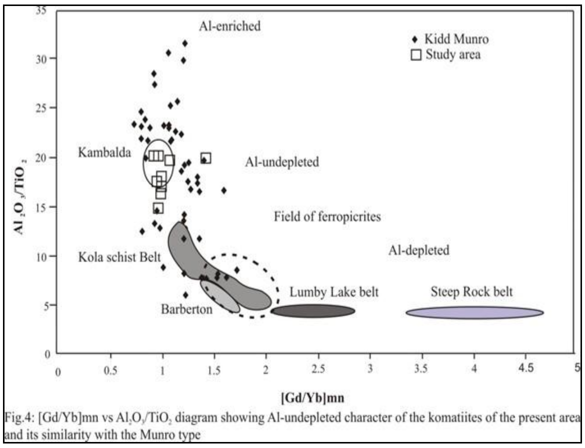

Fig.4: [Gd/Yb]mn vs Al_2O_3/TiO_2 diagram showing Al-undepleted character of the komatiites of the present area and its similarity with the Munro type

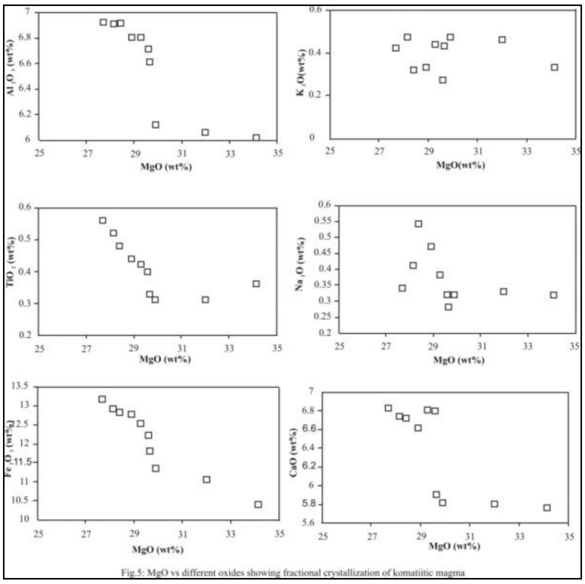

Fig.5: MgO vs different oxides showing fractional crystallization of komatiitic magma

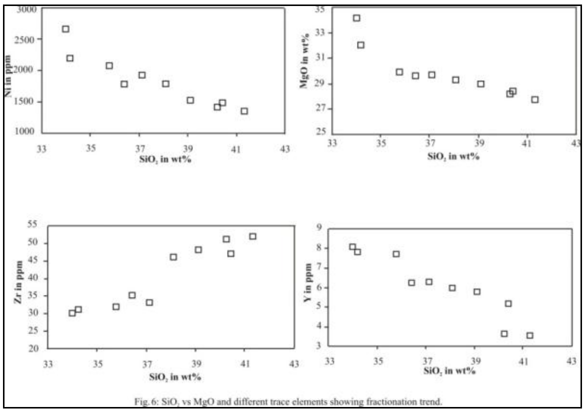

Fig. 6: SiO_2 vs MgO and different trace elements showing fractionation trend.

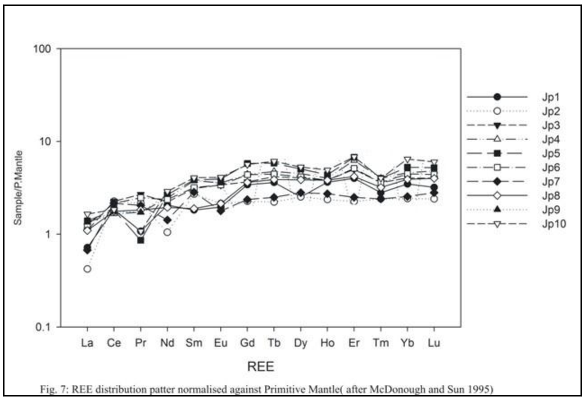

Fig. 7: REE distribution patter normalised against Primitive Mantle(after McDonough and Sun 1995)

5. Discussion

Many of the characteristic features of the CGT such as a broad linearity, monotony of high grade assemblages and gneisses, occurrence of massif type anorthosites, komatiite and potassic intrusives and marginal carbonatite activities demand adequate attention to determine the tectonic status and evolutionary history of the terrain. The discovery of high magnesian ultramafic rocks in the form of komatiites in the Northwestern fringe of CGT is unique of its kind and adds a new chapter in reveling the evolution of this part of Indian crust.

Komatiites in the area occur as veins, lenses and tongue like bodies in metaultramafites and exihibt close spatial association with amphibolites.The metaultramafites represent pretectonic igneous activity and are represented by tremolite actinolite schist and talc tremolite schist and show concordant relationship (roughly E-W) with the country rock.These metaultramafites have been assigned tholeiitic; Bhattacharya and Barla [4].

Megascopically these rocks are dark grayish black in colour and pale to dark brown on weathered. In the field a thin layer of spinifex zone is observed followed by comparatively thicker zone of cumulate textured rock. In the study area komatiites with cumulus texture are common. Texture of komatiite indicate the condition under which they crystallized, rapid cooling and high degree of super cooling for fine random spinifex moderate cooling for coarse spinifex texture and slow cooling rates for polyhedral cumulus texture of olivine. The investigated samples show cumulate texture ranging from orthocumulates through mesocumulates to adcumulates. In orthocumulates there is high proportion of crystallized intercumulus liquid and the cumulus crystals are subhedral to euhedral in form. Adcumulate komatiites exhibit no intercumulus material and are characterized by anhedral crystals with sharp mutual contact and triple point junction. Mesocumulate varieties which exhibit mutual boundary are rare in the area.

Mineralogically komatiites of the study area are composed of olivine (29-51 vol%), clinopyroxene (30-37 vol%), orthopyroxene (12-21 vol%), magnetite ± Cr spinel ± serpentine ± phlogopite ± sphene. Olivines are forsterite in composition. Pyroxene is represented by both orthopyroxene and clinopyroxene,the dominance of former one over the other is noticed. Orthopyroxene ranges in composition from enstatite to hypersthene and bronzite and clinopyroxene is mainly augite. Phlogopite grains occur as irregular patches and at times occur along the prismatic cleavages of pyroxene. Spinel mostly occurs as subhedral to anhedral grains along intergranular spaces. The complete absence of plagioclase denotes its formation beyond its stability field. Presence of chrome spinel (pleonaste) supports this contention. The sequence of crystallization of constituting minerals of this rock may be estabilised as olivine-orthopyroxene-clinopyroxene-spinel-magnetite and are lehrzolite in composition.

Chemically, the ultramafics are characterized by distinctly high MgO and poor in alkali contents. The high MgO and low TiO_2 and SiO_2 contents in these ultramafics are regarded as the result of primary partial melting of the mantle; and Sun [24]. The rock has distinctly low value of SiO_2 in comparison to many well-known komatiites of the world and may represent plume related magmatism for its generation; Parman [25]. Majority of the samples are characterised by typically high LOI values, possibly attributable to alteration/hydration of olivine and clinopyroxene into hydrous secondary phases viz serpentine and also due to presence of amphiboles.

The investigated rock plots exclusively in komatiite field in; Jensen [16] Al–(Fe+Ti)–Mg cation discrimination diagram. The ratio of Al_2O_3/TiO_2 (varying from 12.36 to 20.03 wt%) showing similarity with accepted chondritic value (Al_2O_3/TiO_2 = 20.4; Schmus and Hayes; [29]; with "Munro type" Komatiites; Fan and Kerrich[11] and also with Al-undepleted komatiites of late-Archean (~2.7 Ga) Abitibi greenstone belt; Fan and Kerrich [11]. The CaO/Al_2O_3 ratio of ultramafics varies from 0.98 to 1.11 wt% (Av.1.02 wt%), which is comparable with average Munro Township spinifex textured komatiite; Arndt et al [3], average Komatiite (2.7 Ga) of Newton Township, Canada; Cattel and Taylor [7]. The major oxide ratios like MgO/TiO_2, MgO/Al_2O_3 and Fe_2O_3/TiO_2 show near similarity with Munro type Komatiite. The ultramafics show distinct Al-undepleted nature for these rocks particularly in terms of MgO vs Al_2O_3/TiO_2 and by (Gd/Yb)n vs Al_2O_3/TiO_2 diagram. These rocks display high Mg# varying from 85.02 to 89.1, comparable to primitive upper mantle Mg# (89.8), suggesting their mantle derived source. Fractionation trends of komatiites are exhibited by MgO vs TiO_2, Al_2O_3, Fe_2O_3, CaO, K_2O and Na_2O plots and also by SiO_2 vs MgO, Y, Ni, Zr and Sc.The rock shows high Ni, Cr and poor in Ba, Cs Rb, Nb, Hf and Y contents. The Cr, Ni and V values increase with the value of MgO. Enrichment of Ni and Cr may have resulted in liquidous phases during magmatic evolution. Higher values of Zr concentration attributed to Zr-enriched mantle source and not due to crustal contamination. Komatiites of the present area are characterized by a diagnostic convex upward REE profile in primitive mantle normalized diagram (normalization factor after; McDonough and Sun [19]. The normalized REE pattern display LREE depletion compared to HREE, which is similar to most of the other Arachean komatiites; Mitra and Bose [20]. Depth of magma generation estimated on the basis of major oxide ratios suggests melting depth of 150km at pressure 6-7 Gpa for the komatiitic magma (Fig.8).

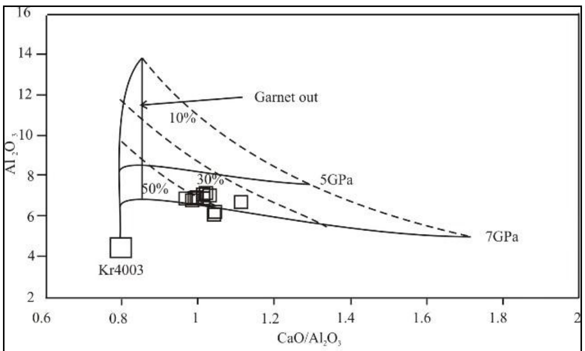

Fig. 8: CaO/Al_2O_3 vs Al_2O_3 plot showing age and pressure of generation of komatiitic magma.Fig also shows percent melting lines (thin dashed lines) and isobars (thin continous lines) garnet is stable in the residue to the right to the right of the bold continous line and is eliminated from the residue at a constant residue at a constant CaO/Al_2O_3 of ~ 0.86 (Walter 1987)

This is in conformity with; Arndt et al [1] view. They are postulated to be derived from a plume tail or from a innermost part of a plume head. Al undepleted nature of the rock with flat HREE and chrondritic values of Al_2O_3/ TiO_2 suggest absence of garnet in the melting residue. The petrographic and geochemical fingerprints of ultramafics together with its regional tectonic setting suggest that these rocks are derived by eruption of essentially unmodified primary magma; Nisbett and Chinner [23] from mantle source under extensional tectonic setup. Deep fracturing and rifting of the protocontinental crust with local upwelling of upper mantle due to uprising mantle plume give rise to direct effusion of mantle material of komatiitic affinity.

In the light of above observation, the occurrence of komatiite within CGT at the northwestern part of Eastern Indian Shield is of paramount significance, as it suggests a possibility of the presence of Archaean component in CGT. So far the presence of Arachean rock in CGT had remained to be conjectural. Recent workers advocates that CGT is a cratonic block and not a mobile belt. Hence it would be interesting if geochronology could be performed on the rocks including the present rock type in a systematic way so that a crustal evolutionary modal could be attempted, as done in the Dharwar, Singhbhum, Bastar and other cratonic area of Indian Shield.

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