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Basalt-Andesite-Dacite-Rhyolite (BADR) Metavolcanic Sequence from the Central Part of Dharwar-Shimoga Greenstone Belt, Western Dharwar Craton

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Abstract: *The petrographic and major element geochemical characteristics clearly suggest that the metavolcanic rocks of Medur Formation in the central part of the Dharwar-Shimoga greenstone belt comprise basalt, andesite, dacite and rhyolite (BADR) sequence. These metavolcanic rocks are metamorphosed to greenschist-amphibolite facies. The basalts show mixed tholeiitic and komatiitic composition. The andesites are mainly tholeiitic, while dacite and rhyolites are calc alkaline nature. Good correlation exists between SiO2 and major oxides, which suggests that these metavolcanic series (BADR) compositions are genetically inter-related and were derived probably from differentiation of magma at different depths.*

Keywords: *Metavolcanics, Petrography, Geochemistry, Dharwar-Shimoga greenstone belt, Dharwar Craton*

Introduction

The Dharwar Craton of south India is composed largely of tonalitic-trondhjemitic-granodioritc (TTG) gneisses and several supracrustal belts, commonly referred to as greenstone belts. The craton has been divided in to the western block and the eastern block, the boundary between them is demarcated by a steeply dipping mylonite zone traced along the eastern boundary of the Chitradurga greenstone belt [1-2]. Mafic to felsic metavolcanic sequences are encountered in the greenstone belts of both the blocks [1, 3-8]. In general, in the greenstone belts of the western block of the Dharwar craton, the felsic metavolcanics occur as a stratigraphic member of classic basalt-andesite-dacite-rhyolite (BADR) sequence. While in the greenstone belts of the eastern block of the Dharwar Craton andesites are absent, and hence felsic metavolcanics do not occur as a member of BADR sequence. Considerable amount of studies have been carried out on the mafic metavolcanics of the greenstone belts of the Dharwar Craton [9-17]. Ugarkar et al. [18] have reported basaltic komatiites, tholeiitic basalts and tholeiite basaltic andesites from the northern part of the Dharwar-Shimoga belt.

Recently, Manikyamba et al. [19] and Ganguly et al [20] have reported occurrence of felsic volcanics and boninites from the metavolcanic suite of the central part of the Dharwar-Shimoga greenstone belt. Our study has indicated occurrence of classic basalt-andesite-dacite-rhyolite (BADR) metavolcanic sequence from this area, which has implications for petrogenesis of metavolcanics. The present paper deals with the preliminary study of field, petrography and major oxide geochemistry of BADR sequence in the central part of the Dharwar-Shimoga greenstone belt.

Geology

The Dharwar-Shimoga greenstone belt of the Western Dharwar Craton comprises wide range of volcano-sedimentary sequence mainly greywacke, shales, mafic to felsic volcanic rocks along with arenites, limestones, stromatolitic dolomite, carbon phyllites, banded iron formations and banded manganese formations [21-23]. These rocks are metamorphosed to greenschist-amphibolite facies. The lithounits of this belt are divided into four different formations namely Jandimatti, Joladhal, Medur and Ranibennur formations of Chitradurga Group [21].

The present study area belongs to the Medur Formation in the central part of the Dharwar-Shimoga greenstone belt (Fig. 1), which comprises huge volcano-sedimentary assemblage predominantly basic, intermediate and acid volcanic rocks with subordinate chemical and detrital sediment deposits. Basic-intermediate volcanic flows, pillowed andesites and andesitic pyroclasts have been reported from the southern and central part of the study area [24]. Greywackes with bands of ferruginous cherts/quartzites dominates the northern part. The basic-intermediate volcanism is intercalated with pyretiferous argillites, orthoquartzites and shales. Felsic volcanism is represented by thick elongated sheet like body of quartz porphyry (rhyolite) in the eastern margin and pinching out towards west within the study area. The rocks have been folded into a major east-west trending antiform plunging towards WNW at a moderate angle and is superimposed by the secondary folding with NNW-SSE axis and strike of

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foliation/schistosity is WNW-ESE with dip varying from 70-75^{o} due NE as well as SW.

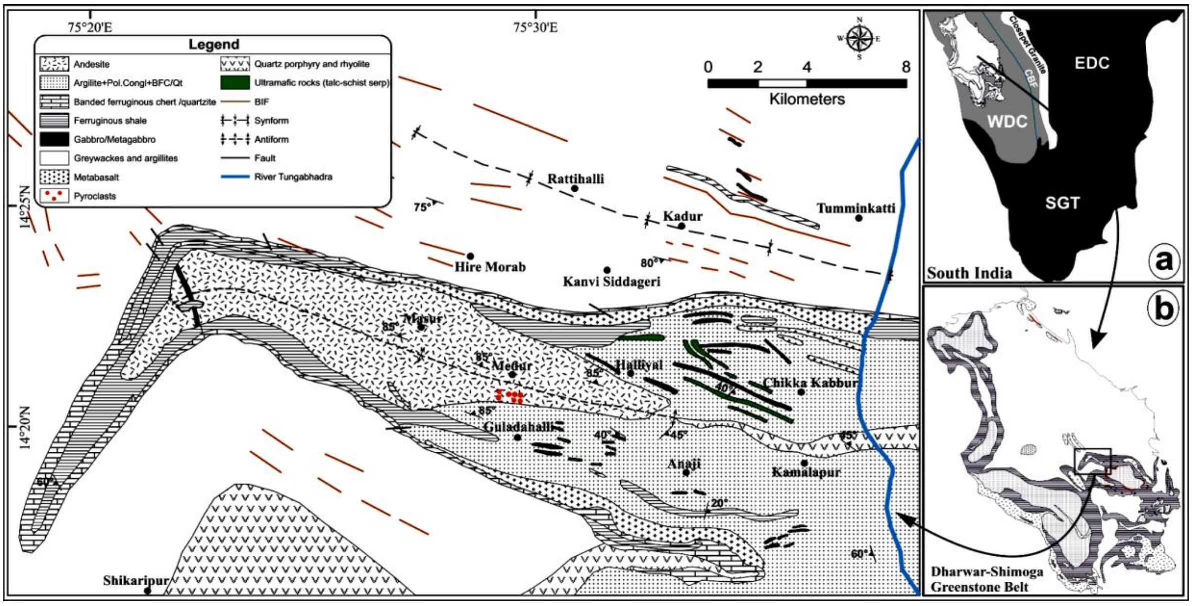

***Fig.1:** Geological map of central part of Dharwar-Shimoga greenstone belt*

Field occurrence of metavolcanic rocks

Metabasalts are well exposed in the north part of Hirekabbar village, striking in regional trend of Dharwar Craton (NNW-SSE). They are very fine grained, greenish to grey in color. It is hard and compact showing weak schistosity due to deformation.

Pillowed metaandesites are well exposed near Medur and Angaragatti villages. The pillow structure indicates submarine volcanism, and the pillows are generally ellipsoidal or spherical and occasionally irregular in shape. These are lighter to dark grey in color. The sizes of the pillows range from few centimeters to a meter. The chilled margins of the pillows, ~2 - 5 cm thick and which is dark compared to their core. Well-developed pyrite crystals are embedded within these rocks. The pillows are convex towards southern side with indicates their younging direction. Pillow rims are rich in vesicles and their abundance decreases towards the core of the pillow.

Pyroclastic metaandesites are light-grey, and are exposed 5km south of Medur village. The clasts are lighter compared to matrix. The clasts are ellipsoidal or elongated and range from 2-15cm in size. Pyrites are common in this rock. Metadacite and metarhyolite are well exposed in the eastern margin of the study area, near Hallur village, which is pinching westward tongue like projection. They are leucocratic, medium grained, moderately foliated and consist of rounded white blebs of quartz set in a groundmass.

Petrography

Metabasalt rocks of the study area are grayish to green in color. Under microscope these rocks exhibit porphyritic texture. The pyroxene, hornblende and plagioclase are common minerals forming phenocrysts within the groundmass. The groundmass includes fine grained plagioclase, pyroxene, amphibole, carbonate, quartz and magnetite. The hornblende is partially altered to chlorite (Fig. 2A). Similarly, metaandesites also exhibit porphyritic texture, where the phenocrysts of plagioclase and pyroxenes are surrounded by fine grained feldspar, hornblende, pyroxene and quartz (Fig. 2B). They also exhibit glomeroporphyritic texture, with pyroxenes forming glomerocrysts. The leucocratic dacites commonly exhibit porphyrytic texture with phenocrysts of plagioclase and quartz, along with flakes of chlorite in the matrix of quartz, feldspar, chlorite and mica (Fig. 2C). The metallic minerals like pyrite and magnetite are common within these rocks. The felsic metavolcanic rocks (dacite-rhyolite) are mainly quartz porphyry. They exhibit porphyritic texture, with phenocrysts of quartz blebs embedded in the quartzo-felspathic groundmass (Fig. 2D). These rocks also show spherulitic texture.

Geochemistry

Twenty-four fresh representative volcanic rock samples devoid of quartz and calcite veins were carefully collected from the surface, trenches, quarries and road cuttings from central part of the Dharwar-Shimoga belt. These samples were pulverized around -200$^{\#}$ size, manually to avoid contamination. To quantify major oxides in the rocks, the powdered samples were subjected to X-ray fluorescence (XRF: Philips MAGIX PRO Model 2440) on pressed pellets at the CSIR-National Geophysical Research Institute, Hyderabad and NCESS, Trivandrum.

The analyzed rocks show variable concentrations of major oxides (Table 1). The silica content ranges between 38.03 and 76.51 wt%, while the total alkali (Na_2O+ K_2O) ranges between 1.49 and 7.58 wt%. In the total alkali-silica (TAS) diagram of Le Bas et al [25], the studied rock samples plot in the fields of basalt, andesite, dacite and rhyolite (Fig.3). The average content of silica is in metabasalt 44.31 wt%, metaandesite 56.80 wt%, metadacite 64.60 and metarhyolite 74.41 wt%. The average total alkali content is in basalt 2.32 wt%, andesite 4.52 wt%, dacite 2.92 wt% and rhyolite 7.37 wt%. The average MgO contents of metabasalt (21.14 wt%), metaandesite (7.75 wt%), metadacite (7.87 wt%) and metarhyolite (1.81 wt%) are high. Good correlation exists between SiO_2 and major oxides (Fig. 4). The concentrations of major oxides like MgO, CaO, Fe_2O_3, MnO and TiO_2 show negative correlation, while (Na_2O+ K_2O) and K_2O show positive correlation with SiO_2 (Figs. 3 and 4). Rajamani et al [9] suggested that most of the mafic metavolcanic rocks belonging to the Archaean greenstone belts are tholeiitic or komatiitic in nature. The studied metabasalts exhibit komatiitic nature, metaandesite exhibits tholeiitic, metadacite and metarhyolite exhibit calc alkaline nature [Fig.5; 26]. However, out of ten basalt samples analyzed, five samples have ratios of CaO/Al_2O_3 more than 0.9, indicating mixed tholeiitic and komatiitic nature.

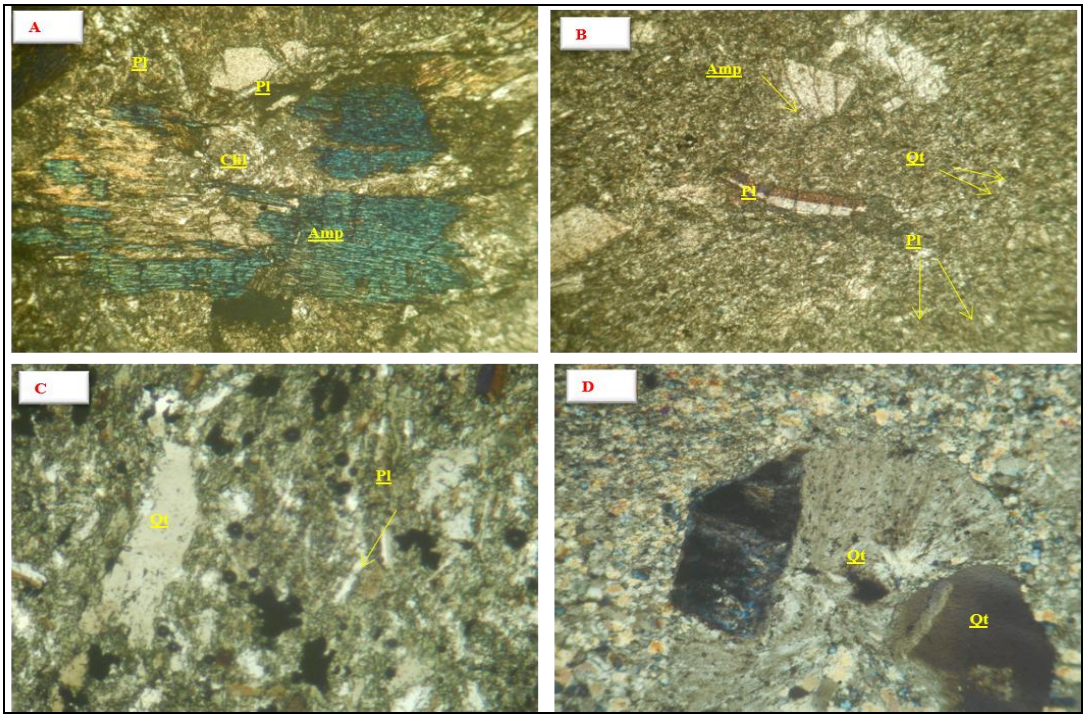

Fig.2: *Photomicrographs A, metabasalt; B, andesite; C, dacite; D, quartz porphyry (crossed nicols, 50X)*

Table.1*: Major Oxide composition of Metavolcanics of central part of Dharwar-Shimoga greenstone belt*

	Basalt			Andesite			Dacite			Rhyolite		
Sample	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
SiO_2	38.03	50.74	44.31	54.14	59.76	56.80	63.84	65.49	64.60	72.39	76.51	74.41
TiO_2	1.18	0.32	1.06	1	1.14	1.12	1.7	0.43	1.01	0.23	0.12	0.17
Al_2O_3	10.9	11.59	11.61	11.79	10.83	12.58	10.23	5.58	8.22	12.96	13.34	12.80
MnO	0.17	0.12	0.12	0.16	0.1	0.17	0.09	0.13	0.10	0.02	0.01	0.03
Fe_2O_3	10.12	7.05	8.39	6.2	6.77	7.58	6.17	5.68	7.70	1.99	1.23	1.60
CaO	7.79	9.89	8.96	11.09	6.23	8.58	4.62	11.72	6.03	0.82	0.2	0.89
MgO	26.93	16.28	21.14	9.95	10.04	7.75	6.7	7.29	7.87	2.88	0.66	1.81
Na_2O	1.46	1.61	1.90	3.83	3.73	4.15	3.71	1.27	1.98	1.47	0.33	0.91
K_2O	0.03	1.15	0.43	0.27	0.53	0.37	1.21	0.55	0.94	5.7	7.25	6.46
P_2O_5	0.11	0.09	0.20	0.19	0.21	0.28	0.28	0.1	0.17	0.02	0.01	0.01
Total	96.72	98.84	98.12	98.62	99.34	99.36	98.55	98.24	98.61	98.48	99.64	99.09
CaO/Al_2O_3	0.71	0.85	0.79	0.94	0.58	0.68	0.45	2.10	0.92	0.06	0.01	0.07
MgO/Al_2O_3	2.47	1.40	1.90	0.84	0.93	0.64	0.65	1.31	1.02	0.22	0.05	0.14
Fe_2O_3/MgO	0.38	0.43	0.42	0.62	0.67	1.11	0.92	0.78	0.96	0.69	1.86	1.06
CaO/TiO_2	6.60	30.91	11.77	11.09	5.46	7.82	2.72	27.26	10.64	3.57	1.67	4.50
Na_2O+K_2O	1.49	2.76	2.32	4.10	4.26	4.52	4.92	1.82	2.92	7.17	7.58	7.37

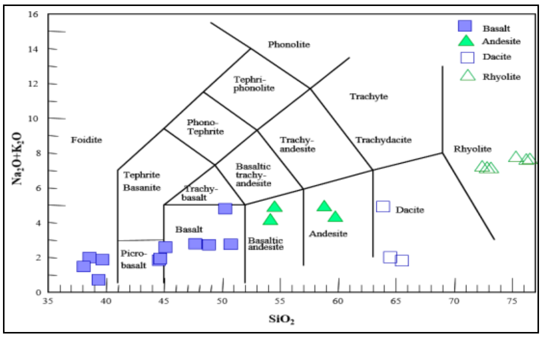

Fig.3: *Total alkali – silica plot for metavolcanics after Le Bas et al. (1986)*

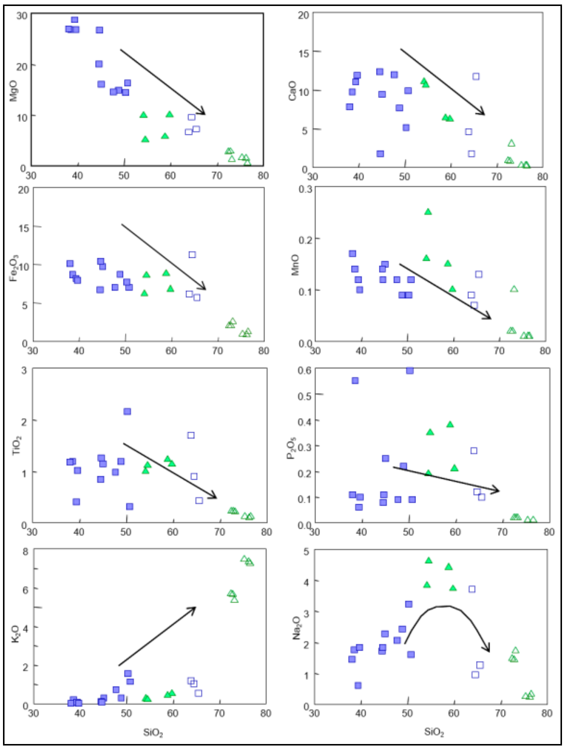

Fig.4: *Harker plots of Silica vs other major oxides of metavolcanics*

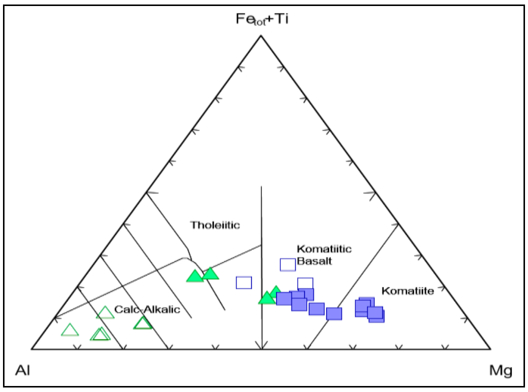

Fig.5: *AFM plot for metavolcanics after Jensen (1976)*

Conclusions

The presence of pillow structures in the metaandesites suggests that the volcanism took place under submarine environment. These metavolcanic rocks are metamorphosed to greenschist-amphibolite facies. The petrographic and major element geochemical characteristics clearly suggest that the metavolcanic rocks of Medur Formation in the central part of the Dharwar-Shimoga greenstone belt comprise basalt, andesite, dacite and rhyolite (BADR) metavolcanic sequence. The metabasalt is fine grained foliated and show mixed tholeiitic and komatiitic composition. The metaandesites include pillowed andesite, pyroclastic andesite, which are melanocratic and mainly indicate tholeiitic nature. The metadacite and metarhyolites are leucocratic and indicate calc alkaline nature. Good correlation exists between SiO_2 and major oxides, which suggests that these metavolcanic series (BADR) are genetically inter-related. These rocks of BADR compositions were derived probably from differentiation of magma at different depths. However, a detailed study based on the major, trace and rare earth element geochemistry is in progress.

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