Geochemistry and petrogenesis of the Neoarchean Sandur metavolcanic rocks

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Abstract

The Sandur greenstone belt (SGB) is a distinctive greenstone belt as it is perched within the Closepet granitoid rocks (CG). The emplacement of the CG is attributed to intrusion in a crustal scale transcurrent shear zone towards the end of Archaean (Moyen et al., 2003). The Chitradurga shear zone that forms the eastern margin of the Chitradurga greenstone belt, located west of the Closepet granite, is considered as the boundary between WDC and EDC. As per the division of the Dharwar craton, the domination of volcano-sedimentary sequences in SGB with abundant BIF and considerable greywacke-argillite lithologies, attest their similarity to the greenstone belts of WDC. Closer to the SGB, the rocks of the CG are known to host excellent mafic microgranular enclaves (MME) which might indicate interaction between the granitic magma with the older greenstone belt lithologies during intrusion. It is interesting to note that there is a progressive increase in crustal thickness from north towards south in the Dharwar craton and the SGB is found associated with the CG in the shallow zones of the north (Moyen et al., 2003). The mafic volcanic rocks are predominantly basaltic in composition and are composed of amphibole, pyroxene, plagioclase and quartz with titanite and magnetite as accessory minerals. The rocks are classified as tholeiitic basalts that were metamorphosed to amphibolite grade. Preliminary geochemical studies on these rocks show significant differences in their trace element distribution. The chondrite-normalized REE patterns show moderate to high contents of REE and have unfractionated pattern. The basalts show a flat to slightly LREE enriched pattern. Some samples show slight negative Eu anomaly and some do not show any significant anomaly. Some associated rocks also have complementary enrichment-depletion of certain elements. All of these point to multiple petrogenetic processes involved in the generation of these magmatic precursor rocks.

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I. Background

- The Sandur Schist Belt(SSB)(2.7Ga;Nutman, 1996) lies within the Archean high temperature metamorphic terrain of the Eastern Dharwar Craton (EDC), separated by a steep ductile sheer zone i.e., Chitradurga Shear Zone(CSZ) from the Archean low temperature terrain of Western part(WDC)(Chadwick,1989).[Fig. 1]
- This belt was intruded by a narrow linear younger (2.5Ga) K-rich granitic body,the Closepet Granite(CG),thought to be an integral part of the Neoarchean polyphase granite terrain(Chadwick, 1996), known to host excellent mafic microgranular enclaves(MMEs) formed by mafic magma injection into crystallizing granitic host magma(Jayananda,2009).[Fig. 2]
- SSB comprises of eight different litho-tectonic units of volcano-sedimentary sequences such as ultramafic flows, massive and pillowed metabasalts-andesites-rhyolites-adakitic flows, quartzite, conglomerate, turbidites, shale, chert, BIF and BMF (Manikyamba,1997,2006,2008).
- The metavolcanic rocks of SSB have been subjected to lower greenschist to lower to middle amphibolite grade of metamorphism and have attained higher grade along the periphery of the schist belt (Roy & Biswas,1979). The reported range of pressure and temperature for these metabasalts are 4-5.2 Kbar and 550°-600°C(Prasad, 1996).
- Many earlier published works suggest the subduction of a plume-fed ridge might have given rise to the varied composition of this belt(Manikyamba,1997,2006)
- An accretionary orogenic setting has also been suggested for the development of this belt(Manikyamba & Kerrich,2008).
- An arc complex has been suggested for the development of the bimodal volcanism of this belt(Prasad,1997).

II. Approach

- In this work detailed field, petrographic and geochemical studies have been carried out on the metamorphosed volcanic rocks of the SSB as well as on the MMEs of CG in order to understand their petrogenesis and tectonomagmatic evolution.

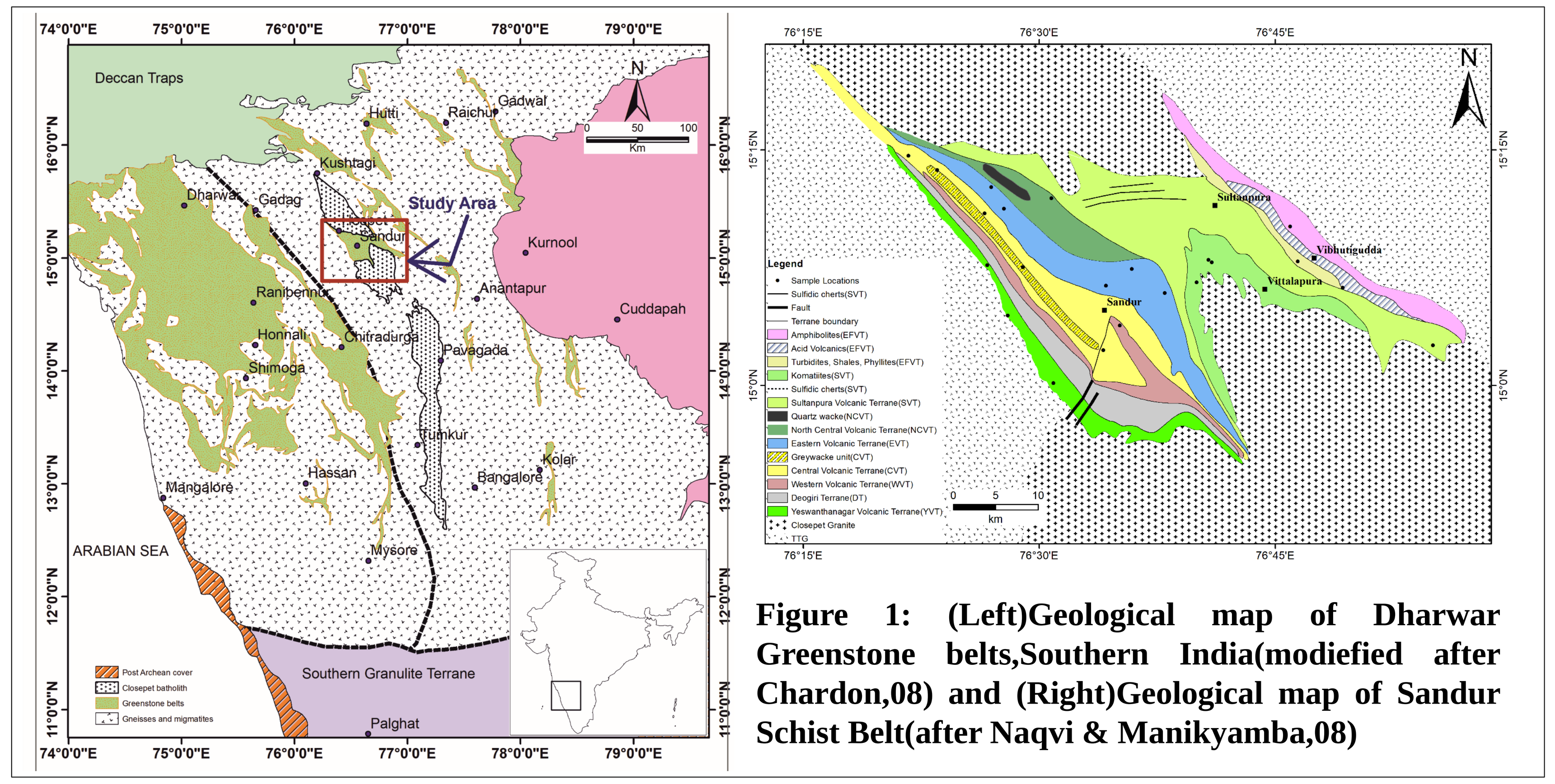

Figure 1: (Left)Geological map of Dharwar Greenstone belts,Southern India(modified after Chardon,08) and (Right)Geological map of Sandur Schist Belt(after Naqvi & Manikyamba,08)

III. Sampling and Petrography

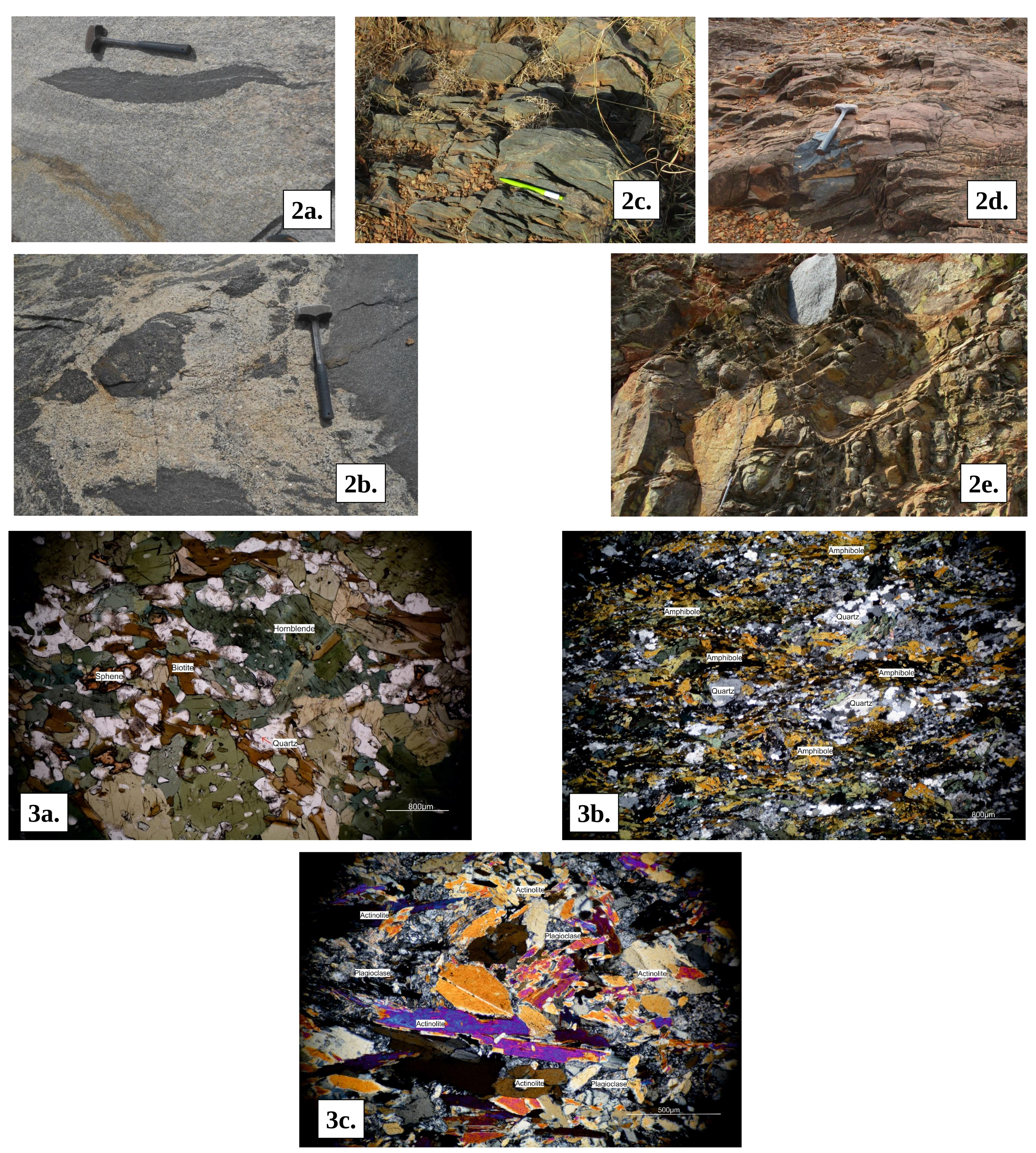

Figure 2 & 3: 2a and 2b are showing mafic microgranular enclaves of different sizes and shapes in the host granitoid of CG . 2c and 2d are the field photographs of schistose outcrops of the metavolcanics. 2e is a photograph of a pillow-structured metabasalt outcrop in the study area of SSB. 3a is a photomicrograph of the mineralogical compositions of the MMEs 3b and 3c are photomicrographs of two different types of metavolcanic rocks of SSB

IV. Results

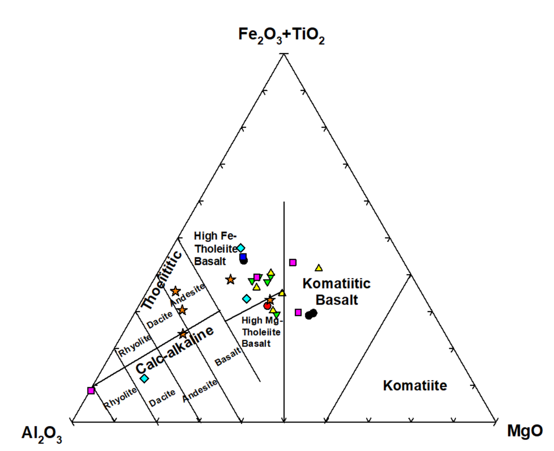

Figure 4: Jensen's Plot of the MMEs and the metavolcanic rocks of the SSB

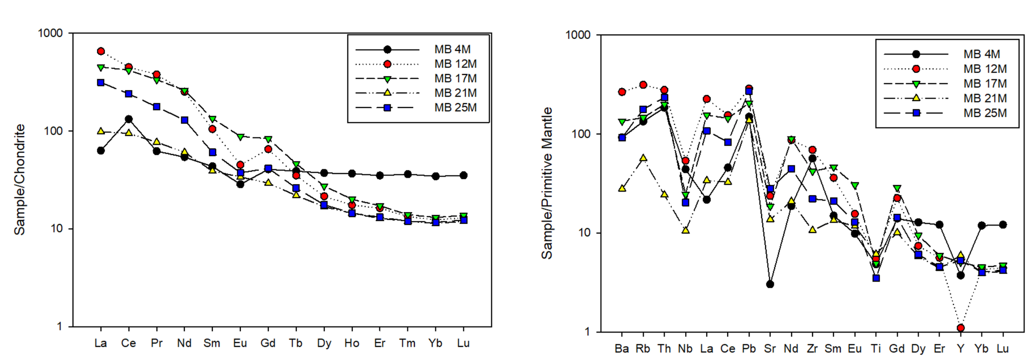

Figure 5:Primitive Mantle and Chondrite normalised diagrams of Mafic Microgranular Enclaves

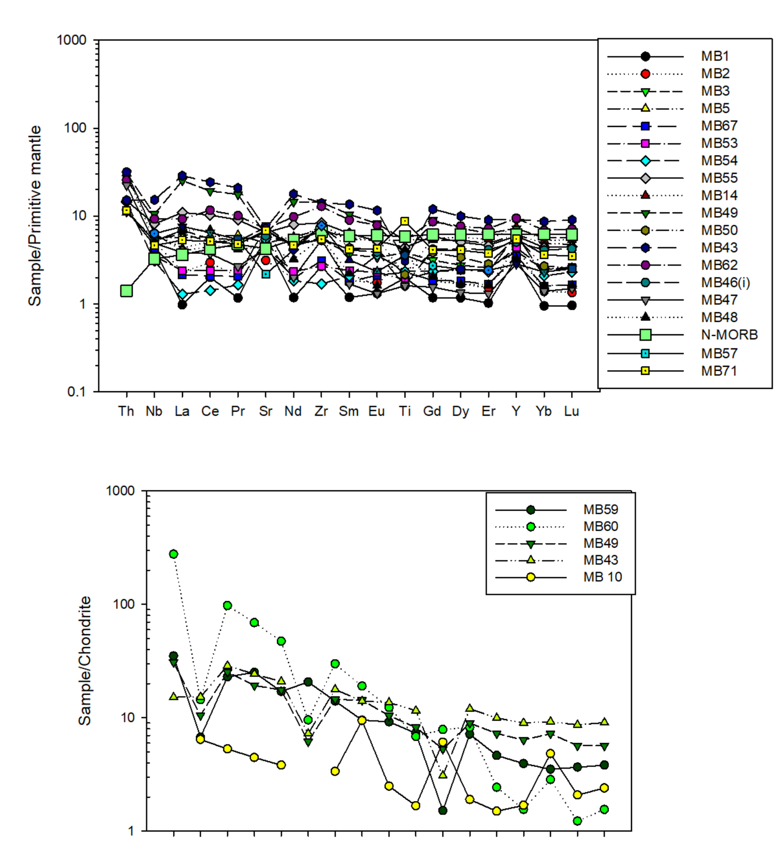

Figure 6: Primitive mantle normalised diagrams of the tholeiitic and komatiitic basalt samples of the SSB

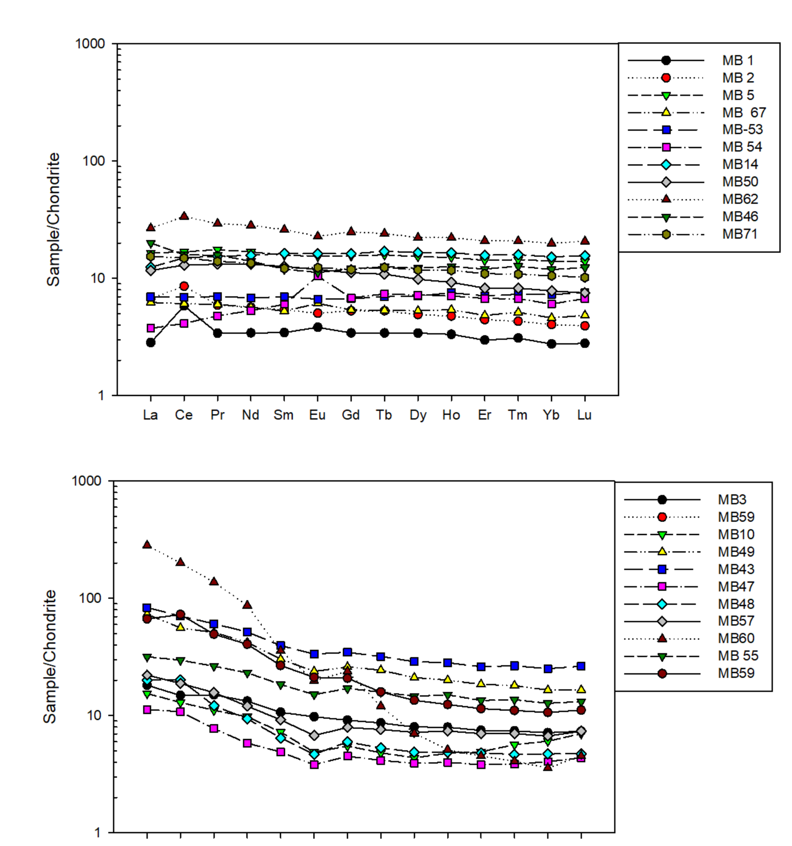

Figure 7: Both flat and LREE enriched Chondrite Normalised patterns of the metavolcanic samples of SSB

V. Summary and Prinliminary Conclusions

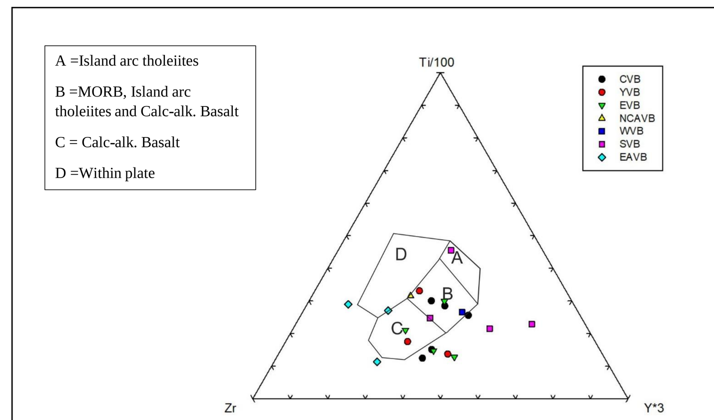

Figure 8: Ti-Zr-Y diagram for the tectonic setting of the metavolcanics of SSB(Pearce and Cann,1973)

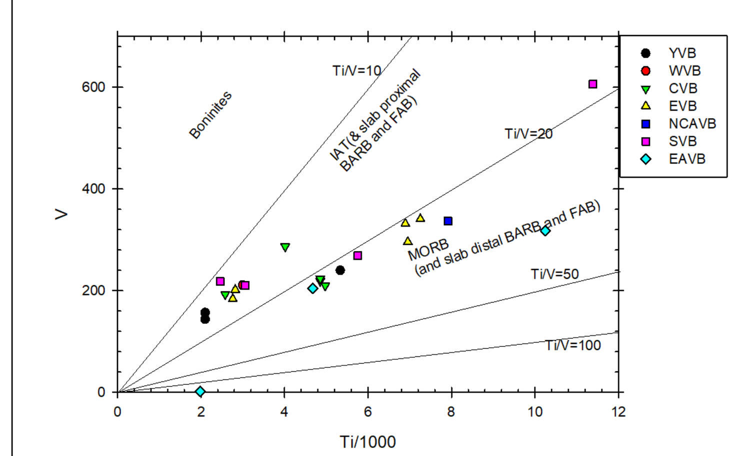

Figure 9: V vs Ti plot showing tectonic setting responsible for the greenstone terrain after Shervais,1982.

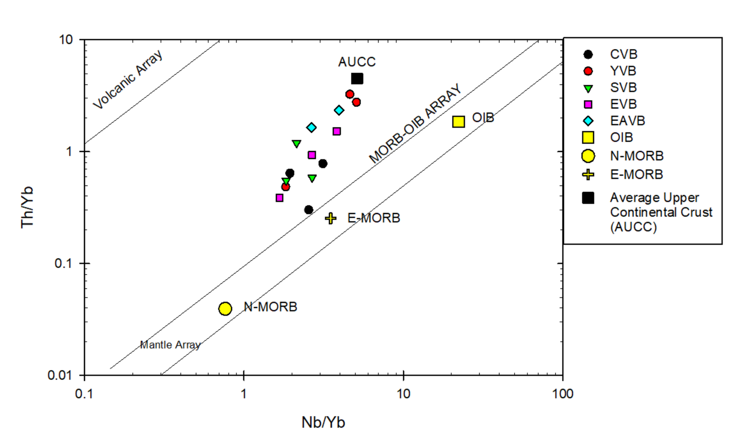

Figure 10: Th/Yb vs Nb/Yb plot showing interaction with the Archean continental crust after Pearce,2008.

- Geochemically the MMEs are both tholeiitic and calc-alkaline in nature(Fig.4) and are showing greater LREE enrichment pattern with –ve Eu anomaly. One sample that falls in the calc-alkaline field might imply contamination by diffusion during the interaction of mafic rocks with the intrusive granite during the emplacement of the later (Fig.5).
- These samples are showing HFSE depletion on the primitive mantle normalised diagram with Nb, Zr and Ti anomalies and La/Nb ratio > 1.4 indicating either the parental magmas of the MMEs had primary arc signature or were later contaminated by the younger granite.
- The metavolcanic samples of SSB are showing tholeiitic basalic, basaltic andesitic, komatiitic basaltic and calc-alkaline signature in the Jensen's plot (Fig.4).
- The komatiitic basalts and some of the tholeiitic basalts and basaltic andesites show flat chondrite normalised REE pattern (Fig.7) with some samples showing variable or no significant Eu anomaly. Other samples however, show LREE enriched patterns (Fig.7) with negative Eu anomalies.
- On the primitive mantle normalised diagram, most of the tholeiitic basalts and basaltic andesite and komatiitic basalts show N-MORB like unfractionated pattern with slight depletion in the incompatible element Nb relative to the LREE (Fig.6), as well as minor -ve Ti anomalies. These samples have La/Nb ratio <1.4 indicating MORB or OPB affinities (Rudnick,1995 & Condie,1999). Whereas, rest of the four tholeiitic basalt and basaltic andesite samples are enriched in incompatible elements but are depleted in Nb and to a lesser extent Ti on the primitive mantle normalised diagram(Fig.6), have La/Nb >1.4 and therefore suggesting arc affinities.
- Geochemical features such as Nb and Ti depletion on primitive mantle normalised diagrams are characteristic of subduction zone magmas as well as that have been contaminated by crustal material (Pearce and Peate,1995).
- Here both MORB and arc like signatures from the trace element geochemistry suggest a probable back arc basin setting for the .
- Moreover, on Ti-Zr-Y plot (Pearce & Cann,1973) the metavolcanic samples are falling in the fields of A,B and C (and away from D)(Fig.8) i.e., N-MORB, island arc and calc-alkaline basalt fields indicate that these rocks were not emplaced in an oceanic island or within a continental plate setting (Manya,2008).
- Plot of V vs Ti (Shervais,1982) shows that the metavolcanic samples of SSB are having both characteristics of IAT and MORB having a range of Ti/V ratios from 11.27 to 32.24 (BABB: Ti/V=10-50) again suggesting a probable back arc basin basalt signature for these rocks (Fig.9).
- The presence of both flat REE and LREE-enriched lithologies may also suggest a slab proximal transitional MORB/E-MORB setting. Alternatively, source magmas with transitional MORB or E-MORB signature could have interacted with pre-existing felsic crust which is also indicated by the trajectory of the sample points plotting along the line between E-MORB and Archean upper continental crust in the Th/Yb vs. Nb/Yb diagram (Fig. 10).

VI. Future Work

On the basis of trace element geochemistry, from different discrimination diagrams and trace element ratios a preliminary tectonic setting and petrogenetic history has been suggested although a detailed isotopic study (Sm-Nd) for the better understanding of the tectonomagmatic history of the volcanic associations is under progress. The relationship between the mafic lithologies of SSB and the MMEs of Closepet granite will also be studied in more details.

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