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Geochemical characterization and petrogenesis of the Proterozoic mafic magmatism in Gwalior Basin, Central Indian Shield – constraints on crustal evolution

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The Indian shield comprises of Proterozoic sedimentary basin called Purana Basin which occupies about 20% of the Shield. The study area in context, the E-W trending Gwalior Basin, is one such intracratonic basin deposited over the north-western fringes of the Archean Bundelkhand Craton. Gwalior group of rocks is made up of lower Par Formation and upper Morar Formation. The mafic magmatic rocks of tholeiitic composition outcrop as an intrusive body in the form of sills and gabbroic massif, in unmetamorphosed low grade Gwalior sediments. Huge sills of massive, mesocratic to melanocratic in appearance extending in height of more than 120m are exposed in quarries. Grain sizes variation with height is visible in the sills showing extremely fine near the contact with development of chilled margin. The mafic bodies are coarse to medium grained and exhibit well-preserved igneous texture. Plagioclase and pyroxenes constitutes as dominant minerals with subordinate quartz, alkali feldspar and opaque minerals. Secondary alteration minerals such as amphibole, chlorite, biotite and suassurites are also observed. Ophitic to sub-ophitic, porphyritic and intergrowth textures are common.

Major and trace element abundances of these mafic rocks show SiO_2 (47.68-51.27wt %), Zr (80.3-200.23 ppm), Ni (26-137.87 ppm) and Mg# ranges from 46.92-73.08 with an average of 62.23. They are classified as subalkaline basalt, quartz-normative tholeiite and show enriched LREE-LILE and depleted HFSE characteristic with negative Nb, P and positive Pb anomalies. Chondrite normalized REE patterns shows LREE enrichment [$(La/Sm)_N$=2.21] and slightly depleted HREE [$(La/Yb)_N$= 5.05, $(Gd/Yb)_N$=1.74] with very small Eu anomaly (Eu/Eu*=0.92). Major and trace elemental proportion suggest that the magma have experienced varying degree of differentiation caused by partial melting (~6-18%) and fractionation crystallization. The fractionating phases include both rock forming and accessory phases such as olivine, clinopyroxene, plagioclase, titanomagnetite, apatite etc. Positive correlation between Y, Nd, Gd, and La with Zr indicate their near pristine characteristics and their compositions preclude any significant alteration or element mobility. All these geochemical characteristics indicate that this magmatic suite formed in continental rift tectonic setting of a common garnet bearing enriched mantle source.

Three point TIMS whole rock-mineral Sm-Nd isochron correspond to an age of 2104±23Ma with an initial $^{143}Nd/^{144}Nd$= 0.509938±0.000023 and εNd^t= -0.89938 (t=2000). Present day average $^{143}Nd/^{144}Nd$ (~0.5118) and negative εNd value indicates these samples were derived from enriched mantle sources such as EM-II (0.5121). Nd model ages vary from 1.7 to 2.6 Ga indicating the protracted nature of the evolution of the Gwalior basin that was probably triggered by mantle plume derived mafic magmatism in an extensional intra-continental rift tectonic setting. Widespread mafic magmatic activity and development of sedimentary basin on various Archean craton worldwide during this time indicate that there was a large scale crustal extension or breakup of supercratonic landmasses undergoing at that time which was most probably triggered by an upwelling plume activity [1]. Thus, the mafic magmatic rocks of Gwalior Basin formed by crustal extension and thinning of lithosphere triggered by upwelling

plume associated with supercontinent break up marked by extensive mafic magmatism in Indian Shield during the Paleo-Proterozoic time.

References:

[1] French et al. (2008) Precambrian Res 160: 308-322