PALEOPROTEROZOIC BONINITE-LIKE ROCKS IN AN INTRACRATONIC SETTING FROM NORTHERN BASTAR CRATON, CENTRAL INDIA by D.V. Subba Rao, V. Balaram, K. Naga Raju and D.N. Sridhar. Jour. Geol. Soc. India, v.72, 2008, pp.373-380.

Deepanker Asthana (dasthana@hotmail.com) and **Jitendra Kumar,** Department of Applied Geology, Indian School of Mines University, Dhanbad - 826 004, comments:

1. Subba Rao et al. (2008) have presented valuable information on Paleoproterozoic high-Mg dykes from the Northern Bastar craton, Central India. In my opinion, however, considerable uncertainty remains regarding the classification and interpretation of these dykes as “intracratonic boninite-like rocks”.
2. The term “intracratonic boninite-like rocks” was introduced by Smithies (2002) for the 2.97-2.95 Ga. high-level sills of Mallina Basin that show boninite-like geochemistry and U-shaped Rare Earth Element pattern (REE) from Mallina Basin, Pilbara craton, Australia. However, in subsequent papers the boninite-like rocks have been related to subduction of an oceanic crust, including compositionally homogenized sediment (Smithies et al. 2004a, b).
3. Several occurrences of “boninite-like”, “boninite-type” or “boninite-series” have been described from Archaean and Proterozoic terranes. Depending on their geological association and subtle differences in geochemistry the Archaean boninitic rocks have been divided into “Whundo-type second stage melts”, if associated with arc-related rocks and “Whitney-type second stage melts”, if associated with komatiites (Smithies et al. 2004a).
4. Zr (31 to 100 ppm), Y (15 to 20 ppm), La/Yb_N (3.74 to 28.4) and Gd/Yb_N (1.13 to 2.33) ratios in the “boninite-like and noritic dykes” of the northern Bastar craton are an order of magnitude higher compared to the Cenozoic boninites as well as the Archaean second stage melts (cf., Table 1, Smithies et al. 2004a) and significantly do not reveal the characteristic U-shaped REE patterns.
5. To date neither komatiites nor their variants, have been reported from the Bastar craton. Accordingly, on the basis of field association alone the possibility of these rocks being siliceous high-magnesium basalts (SHMB) and/or “Whitney-type second stage melts” can be ruled out. Therefore, the so called “boninitic and noritic dykes” of the northern Bastar craton neither have the field association, nor the geochemical characteristics of boninites and/or the Archaean “second stage melts”, including SHMBs (c.f., Smithies et al. 2004a).
6. Hornblende-rich gabbroic and dioritic rocks intruding subduction-related batholiths, are frequently associated with and dominate the basal section of continental-arcs, and have much in common with the North Bastar craton “boninitic and high-Mg noritic dykes” that intrude the basement granites (Subba Rao et al. 2008), in striking contrast to the pyroxene-rich gabbros that are commonly associated with intracratonic rifting environments (c.f., Sisson et al. 1996).
7. These intrusive are low-Ti primitive basaltic andesite to andesite (SiO_2: 52.77 wt% to 56.61 wt%), and were in equilibrium with mantle peridotite, as revealed by

Mg# = 65 [Mg#= molar Mg/ (Mg + Fe^t)], and up to 193 ppm Ni and 849 ppm Cr. They are calc-alkaline, as per the SiO_2 versus FeO^t/MgO plot of Miyashiro (1974) and accordingly are classified as high-Mg andesites (HMA's) (Keleman 1995) or high-Mg diorites. In the TiO_2 vs. MgO/(MgO+FeO*), Sr/Y vs.Y and $(La/Yb)_N$ vs. Yb_N plots of Kamei et al (2004) the North Bastar craton dykes plot solely in the sanukitic HMA field. The REE and primitive mantle normalized plots for the North Bastar craton high-Mg diorites reveal a coherent and consistent pattern that is nearly identical to the Cenozoic Setouchi andesite (sanukite) of SW Japan and strongly contrasts with Cenozoic boninites. Early crystallisation of ortho- and clinopyroxene, and the presence of An-rich plagioclase are key petrologic characteristics of HMA (Kemp, 2004). Despite the presence of plagioclase and minor alkali feldspar none of the samples reveal negative Eu anomaly, indicating the late appearance of plagioclase. Such delayed plagioclase crystallization that is confined to the groundmass typifies HMAs and high magmatic water activity (Crawford et al. 1989, Kemp, 2004). The presence of similar Setouchi-type HMAs in the Dongargarh Supergroup of Central India (Asthana et al. 2006; Asthana and Sharma, 2008) lends independent credence to the interpretation that the North Bastar craton high-Mg diorites described by Subba Rao et al. (2008) are plutonic equivalent of the Dongargarh Supergroup HMAs.

D.V. Subba Rao, V. Balaram, K. Naga Raju and **D.N. Sridhar** reply:

We thank Deepankar Asthana and Jitendra Kumar for their interest and useful comments on our work on the Chhattisgarh boninitic and noritic dykes under study. Our point-wise reply is as follows:

1. On the basis of petrological characteristics (invariable presence of Opx/Cpx and occasionally olivine) and diagnostic geochemical parameters such as high MgO, SiO_2 coupled with low TiO_2 when compared to normal dolerite/gabbro/amphibolite dykes, we have classified them as boninitic and noritic rock types following the classification proposed by Hall and Hughes (1989) and Smithies (2002).
2. Some of the coarse-grained melanocratic gabbroic dykes occurring at Pithora described by us show similarities to that of Archaean Melanogabbros of the Mallina Basin in terms of petrology and geochemistry and hence we have referred the Pithora, Lohara and Raitam high MgO dykes as boninite-like rocks of probable an intracratonic origin.
3. Since the high MgO dykes of Chhattisgarh region represent an intracratonic setting and there is no komatiitic association, we have not attempted further classification.
4. The REE patterns of the Chattisgarh boninitic and noritic dyke intrusions show striking similarities to that of the boninitic dykes of southern Bastar craton which were also formed in intracratonic settings as reported by Srivastava and Singh (2003) and Srivastava et al. (2008). While Cenozoic boninites are of an oceanic origin, the observed high MgO boninitic and noritic dykes of Chhattisgarh region are of intra-cratonic setting and hence may not exactly be similar to them. Similarly the absence of U-shaped REE patterns suggest that these are not of an oceanic affinity.
5. Even though there is no spatial and temporal relationship between komatiites and its variants with the mafic dykes under study ruling out the Whitney-type second stage melts, we have concluded that the high Mg magmas which produced these Chhattisgarh boninitic and noritic dykes were probably generated by the melting of an enriched sub-continental lithosphere during the Proterozoic.
6. Most of the high MgO dykes described by us are characterized by the invariable presence of two pyroxenes and olivines leading us to interpret them as boninitic-noritic types.
7. Although the possibility that these high MgO dykes may represent the plutonic equivalents of HMA's occurring at the base of the Dongargarh Supergroup (Asthana et al. 2006) exists as suggested by the critics, we believe that presence of high MgO dykes in the entire Chhattisgarh region in the NBC may not support such a view. Further the sedimentary basins adjacent to the NBC batholiths are all of an intracratonic origin suggesting that the high MgO dykes are also probably of intracratonic origin. Hence we have invoked the melting of an enriched continental lithosphere as a source for these high MgO dykes.

References

Asthana, D., Kimura, J-I., Shinjo, R., Katakuse, M. and Pophare, A.M. (2006) Geochemical and Sr-Pb-Nd-Hf isotopic study of Neoarchaean "Setouchi-type" high magnesium andesite suite from Central India. Geochim. Cosmochim. Acta, v70(18), Supplement 1, August-September, A24.

Asthana, D. and Sharma, S. (2008a) The Pitepani Volcanics, Central India: a tale of two volcanic suites, Jour. ISM, v.3(1), pp.11-18.

Crawford, A.J., Falloon, T.J. and Green, D.H. (1989) The classification, petrogenesis and tectonic setting of boninites. *In:* A.J. Crawford (Ed). Boninites and Related Rocks. Unwin Hyman Ltd., London, pp.1-59.

Hall, R.P. and Hughes, D.J. (1990) "Norite magmatism". *In:* R.P. Hall and D.J. Hughes (Eds.), Early Precambrian Basic Magmatism. UK, Blackie, pp.83-110.

Kamei, A., Owada, M., Nagao, T. and Shiraki, K. (2004) High-Mg diorites derived from sanukitic HMA magmas, Kyushu Island, southwest Japan arc: evidence from clinopyroxene and whole rock compositions. Lithos, v.75, pp.359-371.

Kelemen, P.B. (1995) Genesis of high Mg# andesites and the continental crust. Contrib. Mineral. Petrol., v.120, pp.1-19.

Kemp, A.I.S. (2004) Petrology of high-Mg, low-Ti igneous rocks of the Glenelg River Complex (SE Australia) and the nature of their interaction with crustal melts. Lithos, v.78, pp.119-156.

Miyashiro, A. (1974) Volcanic rock series in island arcs and active continental margins. Amer. Jour. Sci., v.274, pp.321-355.

Sisson, T.W., Grove, T.L. and Coleman, D.S. (1996) Hornblende gabbro sill complex at Onion Valley, California, and a mixing origin for Sierra Nevada batholith. Contrib. Mineral. Petrol., v.126, pp.81-108.

Smithies, R.H. (2002) Archaean boninite-like rocks in an intracratonic setting. Earth Planet Sci Lett., v.197, pp.19-34.

Smithies, R.H., Champion, D.C. and Sun, S-S. (2004a) The case for Archaean boninites. Contrib. Mineral. Petrol., v.147, pp.705-721.

Smithies, R.H., Champion, D.C. and Sun, S-S. (2004b) Evidence for early LREE-enriched mantle source regions: Diverse magmas from the c.3.0 Ga Mallina Basin, Pilbara craton, NW Australia. Jour. Petrol., v.45, pp.1515-1537.

Srivastava, R.K. and Singh, R.K. (2003). Geochemistry of high-Mg mafic dykes from the Bastar craton: evidence of late Archean boninite–like rocks in an intracratonic settings. Curr. Sci., v.85, pp. 808-812.

Srivastava, R.K. (2008) Global intracratonic Boninite-Norite magmatism during the Neoarchean –Paleoproterozoic: Evidence from the central Indian Bastar Craton. Internat. Geol. Review., v.50, pp.61-74.

Subba Rao, D.V., Balaram, K., Naga Raju, K. and Sridhar, D.N. (2008) Paleoproterozoic boninite-like rocks in an intracratonic setting from northern Bastar craton, Central India. Jour. Geol. Soc. India, v.72, pp.373-380.