Extended abstract for Penrose conference. Plume IV: beyond the hypothesis
(poster presentation)

Cenozoic intraplate volcanism in Mongolia; if not a mantle plume then what?

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Diffuse, small-volume basaltic volcanism has occurred intermittently throughout central Mongolia for the past 30 My. Trying to determine causes of long-lived intraplate volcanism is difficult, particularly where there is uncertainty over the timing of related extension, uplift, and of course magmatism. The problem is most acute in central and east Asia, one of the largest and least known areas of intraplate igneous activity. In this region, Cenozoic basalt fields are scattered across an area approximately 2000 km from east to west, and 1500 km from north to south (Whitford-Stark, 1987). This region provides an excellent opportunity to study intraplate continental volcanism that is far removed from the effects of subduction-related processes or continental rifting. The crust within central Mongolia is estimated to be 45 km thick on the basis of P-T studies of crustal xenoliths (Stosch *et al.,* 1995). Although magma has erupted through 45 km thick crust, the basalt rocks appear to show very little crustal contamination (Barry *et al.,* 2003). The volcanism provides an important link between Cenozoic basaltic volcanism to the north around the Baikal rift zone and similar aged basaltic volcanism to the east in NE China which infills extensional grabens. Volcanism and rifting in the Baikal region has been explained by a range of processes including (1) partial melting of small asthenospheric diapirs (Ionov *et al.,* 1998) or a mantle plume (e.g., Logatchev, 1984; Windley and Allen, 1993), (2) a crustal weakness (Yarmolyuk *et al.,* 1991) or (3) the combined effects of the India-Asia collision with secondary input from a mantle plume (Khain, 1990). Whereas lavas erupted in NE China have been attributed to passive upwelling of ocean island basalt (OIB)- and/or mid-ocean ridge basalt (MORB)-type mantle, with subsequent modification of magmas by assimilation of continental lithospheric mantle or crust (e.g., Song *et al.,* 1990; Tatsumoto *et al.,* 1992). A close spatial relationship between older Paleogene Chinese basalts and sedimentary basins suggests that, initially at least, Cenozoic magmatism was associated with extension and thinning of the lithosphere along the eastern margin of the Eurasian plate (Northrup *et al.,* 1995), which in turn related to the rate of convergence between the Pacific plate and Eurasia, with the Indo-Eurasian collision only a 'far-field' influence (cf. Northrup *et al.,* 1995). Younger Neogene basalts, however are not confined to basins. Despite contrasting explanations, the chemical composition of lavas in Baikal, Mongolia, and NE China are remarkably similar, especially given differences in underlying crustal and lithospheric mantle compositions and ages of eruption (Barry & Kent, 1998). This is inferred to suggest that the mantle source region beneath this vast area has played a significant role in contributing to magma genesis. Therefore, when considering a model to explain volcanism within Mongolia, which shows neither rifting-dominated processes (e.g. like Baikal) nor extension-related processes such as the NE China basins, one general model should be able to explain all the volcanism.

Trace element, REE and isotopic modeling of Mongolian basalt compositions indicates that basaltic melts were most likely sourced within the lowermost lithospheric mantle. Large-ion lithophile elements and Nb concentrations suggest recently metasomatised lithosphere. This is futher supported by studies on mantle xenoliths erupted in the Mongolian and Russian basalts that show multi-enrichment and replacement textures (Ionov *et al.,* 1994). There is no evidence for high heat flow within the mantle beneath Mongolia (Khutorskoy & Yarmolyuk, 1989), but recent geophysical studies infer anomalously dense material to be present at the base of the lithospheric mantle (Petit *et al.,* 2002) which is coincident with a low velocity zone at ~200 km depth (Villaseñor *et al.,* 2001). However, there does not appear to be anomalous low velocity material within the asthenospheric mantle or extending deeper towards a mantle boundary. The geochemistry of the basalts gives no positive indication for the presence of an underlying mantle plume and can be explained by progressive enrichment of the lithospheric mantle by small degree partial melts from the asthenosphere; even helium isotopes plot within the range of values found for sub-continental upper mantle and are not elevated. Conversely, whilst localized extensional tectonics may have facilitated transport of magma to the surface, the small amount of extension cannot account for the generation of the basalts (McKenzie & Bickle, 1988) thus requiring a mantle process to first generate melt. The area lacks evidence for a high heat flux mantle plume e.g. any age progression of volcanic eruptions, any excess lithospheric temperatures within mantle xenoliths (Ionov *et al.,* 1998), and lack of geophysical evidence for a mantle upwelling. Therefore, rather than a mantle plume it is suggested that Mongolia and adjacent regions are underlain by a thermal anomaly, i.e. elevated thermal energy within the asthenosphere but not a chemically distinct, thermally bouyant anomaly sourced from a boundary layer within the mantle. The ultimate cause of such a phenomenon remains enigmatic but, if understood, may help explain other regions of diffuse, long-lived intraplate continental volcanism.

References

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