Ultramafic Lamprophyre from the Wajrakarur Kimberlite Field of Southern India and it's Petrogenetic Significance

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Introduction

Wajrakarur kimberlite field (WKF) of southern India contains more than 45 intrusions of diamond host rocks. They have been identified as kimberlites, orangeites/ olivine lamproites and ultramafic lamprophyres during previous studies. All the so far reported kimberlites and related rocks show ~1100 Ma age except Timmasamudram kimberlite which gave ~90 Ma age (e.g. Chalapathi Rao et al., 2013; Chalapathi Rao et al., 2016).

Present detailed study from one of the pipe of Lattavaram cluster of WKF utilizes mineralogical genetic, radiogenic isotopic composition and whole rock geochemical approach on one of the previously known kimberlite pipe to shows its affinity towards ultramafic lamprophyre (UML) and to further discuss the genetic and geodynamic significance. The rock contains abundant elongated crystals of clinopyroxene in groundmass, olivine phenocrysts that are mostly serpentinised, microphenocrysts of phlogopite restricted to groundmass, and amphiboles, spinels and carbonates. However the additional presence of Ti-rich garnets (Schorlomite) in groundmass mineralogically confirms it to be aillikite (e.g. Tappe et al., 2005). It is considered that the present aillikite also belongs to the Mesoproterozoic (i.e. 1100 Ma) age spectrum of kimberlite and related rocks of WKF.

Constituent mineral compositions

Microphenocrysts of phlogopite are widespread in the present pipe that coexists with clinopyroxenes and schorlomites in groundmass. In phlogopites Ti content are high and ranging from 3.9 to 6.4 wt.% TiO_2 whereas Al_2O_3 shows constant range varying between 9-11 wt.%. High BaO content is up to 4.4 wt.% and correlates positively with Al_2O_3. The fluorine content is also high having concentrations up to 3.05 wt.%. These phlogopites differ from kimberlite and orangeites in terms of Al and Ti enrcihment and coexists with other aluminous phases in groundmass.

Clinopyroxne occurs only in groundmass and present in two paragenesis, one as elongate crystals of less than 40 µ at the base of serpentine and another as subhedral resorbed crystals associated with amphiboles. They mostly shows diopside composition rich in CaO (18.8 to 23.48 wt.%) and MgO (15.17 to 16.98 wt.%) and poor in FeO (3.87 to 7.9 wt.%). Diopsides here shows Al and Ti enriched trend typical of ultramafic lamprophyres. Atomic Al/Ti ratios is ~2 similar to aillikite clinopyroxenes from type area of Aillik Bay, Greenland (Tappe et al., 2008). Groundmass clinopyroxenes from recently reported Timmasamudram kimberlite of WKF (e.g. Dongre et al., 2017) are also plotted for comparison that are mostly showing composition similar to worldwide orangeite and lamproite and indicates a different composition.

Amphiboles are free from inclusion and any zoning and occur as subhedral grains at the margins of olivine crystals and also as discrete grains in groundmass. All the amphiboles are ranging in composition from potassium richterite to titanian potassium richterite having TiO_2 content 2 to 4 wt.%. They show higher and approximately constant Na/K ratio with varying Ti and composition away from the MARID field and similar to Torngat and Aillik Bay UMLs (e.g. Tappe et al., 2006) and are unlike of amphiboles from lamproites and orangeites. The Al_2O_3 content varies up to 1.2 wt.% and crystals typically co-exists in groundmass with other aluminous phases such as clinopyroxene, phlogopite and schorlomite.

Cr_2O_3 content in groundmass spinels reaches up to 46 wt.% and Al_2O_3 is mostly below 5 wt.%. Spinels rich in Cr, Al mostly follow the titanomagnetite trend ie. trend 2 (Mitchell, 1986) whereas rim composition rich in Mg (up to 16.7 wt.% MgO) and poor in Cr, Al follows magnesian ulvöspinel compositional trend.

Geochemistry and conclusion

The rock shows ultramafic nature with SiO_2 depletion (41-43 wt.%) and MgO enrichment (~19 wt.%). All samples have high incompatible element abundances when normalized to primitive mantle values (Sun and McDonough, 1995) and show very low HREE contents i.e. 1 x PM for Lu as well as fractionated LREE/HREE contents (La/Yb_n is ranging from 40-98). They show major depletions at K, Sr, Hf and Ti which are the characteristic of aillikites worldwide. Depletions at K in aillikites are relatively smaller when compared to kimberlites.

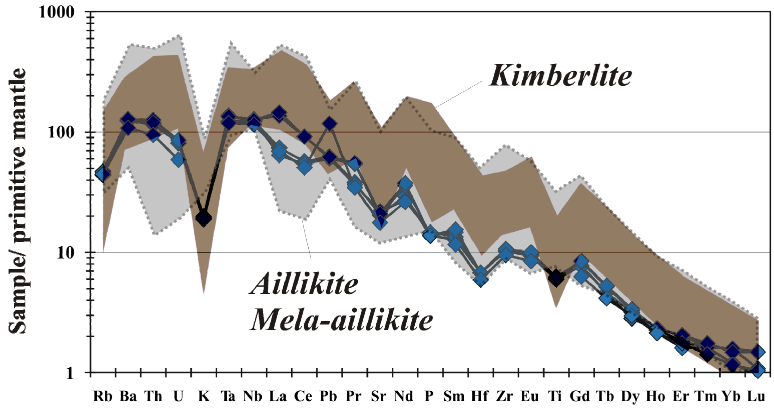

Figure 1: Primitive mantle normalized multielement diagram for samples under study. Field for aillikite and mela-aillikite composition is based on data from Tappe et al. (2006, 2008) and Donnelly et al. (2011), and for kimberlited is from Becker and Le Roex (2006) given for comparison.

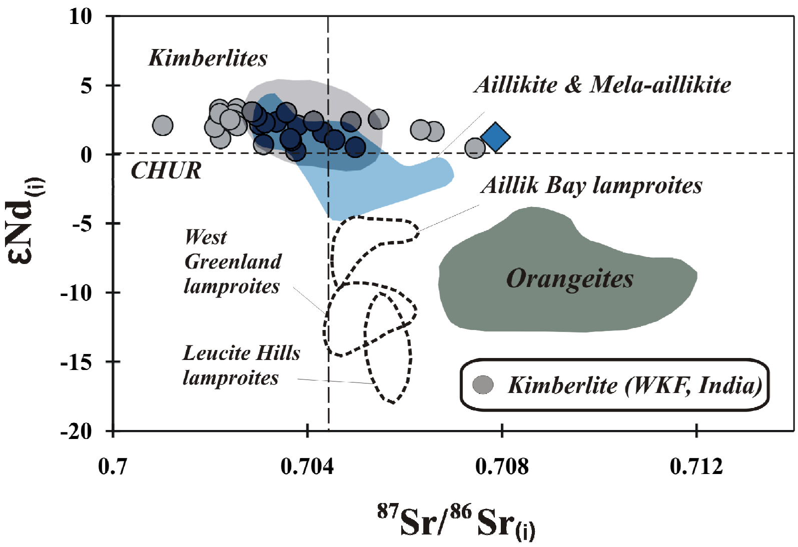

Figure 2: Initial εNd vs $^{87}Sr/^{86}Sr$ for aillikite under study. Compositional fields for aillikite and mela-aillikite are from Tappe et al. (2008) and references therein and from Donnelly et al. (2011). Unpublished data for Wajrakarur kimberlites, Southern India is given for comparison.

The aillikite dyke here shows isotopically depleted nature ($^{87}Sr/^{86}Sr_i$= 0.70786 and εNd_i= +1.25) similar to kimberlites of WKF ($^{87}Sr/^{86}Sr_i$= 0.70102-0.70744, εNd_i=+0.23 to +3.28). However initial $^{87}Sr/^{86}Sr$ values are on higher side and resembles upper limit of WKF kimberlties and close to recently reported aillikites from Kaapvaal craton, South Africa ($^{87}Sr/^{86}Sr_i$= 0.70670) (Donnelly et al., 2011).

Mineralogical, geochemical data and similar isotopic compositions of aillikite reported here and synchronous kimberlites from WKF indicates its origin from same tectono-magmatic event and from similar mantle source region with a different metasomatic assemblage and also indicates magma generation in the presence of CO_2 like those in the case of kimberlites.

References

Becker M, Le Roex AP (2006) Geochemistry of South African on and off craton Group I and II kimberlites: petrogenesis and source region evaluation. J Pet 47: 673-703

Chalapathi Rao NV, Dongre A, Wu FY, Lehmann B (2016) A Late Cretaceous (ca. 90 Ma) kimberlite event in southern India: Implication for sub-continental lithospheric mantle evolution and diamond exploration. Gond Res 35: 378-389

Chalapathi Rao NV, Wu FY, Mitchell RH, Li QL, Lehmann B (2013) Mesoproterozoic U–Pb ages, trace element and Sr–Nd isotopic composition of perovskite from kimberlites of the Eastern Dharwar craton, southern India: Distinct mantle sources and a widespread 1.1 Ga tectonomagmatic event. Chem Geol 353: 48-64

Dongre A, Chalapathi Rao NV, Viljoen KS, Lehmann B (2017) Petrology, genesis and geodynamic implication of the Mesoproterozoic–Late Cretaceous Timmasamudram kimberlite cluster, Wajrakarur field, Eastern Dharwar Craton, southern India. Geosci Front 8 (3): 541-553

Donnelly CL, Griffin WL, O'Reilly SY, Pearson NJ, Shee SR (2011) The kimberlites and related rocks of the Kuruman kimberlite Province, Kaapvaal craton, South Africa. Contrib Min Petrol 161: 351-371

Mitchell RH (1986) Kimberlites: Mineralogy, geochemistry and petrology. New York: Plenum

Tappe S, Foley SF, Jenner GA, Kjarsgaard BA (2005) Integrating ultramafic lamprophyres into the IUGS classification of igneous rocks: Rationale and implications. J Petrol 46: 1890-1900

Tappe S, Foley SF, Jenner GA, Heaman LM, Kjarsgaard BA, Romer RL, Stracke A, Joyce N, Hoefs J (2006) Genesis of ultramafic lamprophyres and carbonatites at Aillik Bay, Labrador: a consequence of incipient lithospheric thinning beneath the North Atlantic craton. J Petrol 47: 1261-1315

Tappe S, Foley SF, Kjarsgaard BA, Romer RL, Heaman LM, Starcke A, Jenner GA (2008) Between carbonatite and lamproite- Diamondiferrous Torngat ultramafic lamprophyres formed by carbonate fluxed melting of cratonic MARID type metasomes. Geochim Cosmochim Acta 72: 3258-3286