NEW CONSTRAINTS OF THE PETROGENESIS OF PIPLIA KALAN EUCRITE

A. Basu Sarbadhikari[1] (amitbs@prl.res.in), R. R. Mahajan[1], P. Das[1], S. Chakraborty[2], E. V. S. S. K. Babu[3], T. Vijaya Kumar[3], and M. S. Sisodia[1], [1]Physical Research Laboratory, Ahmedabad 380009, India, [2]University of California, San Diego, Dept of Chemistry, La Jolla, California 92093-0356, USA, [3]National Geophysical Research Institute, CSIR, Hyderabad 500007, India

Introduction: The Piplia Kalan achondrite fell at Rajasthan, India on June 20, 1996. Previous study have shown that the meteorite is an equilibrated, monomict, non-cumulate eucrite [1]. Piplia Kalan consists of two distinct grain-sized igneous clasts; "type-A" coarse (up to 3 mm) and "type-B" fine (<0.1-0.5 mm with an average size ~ 0.2 mm). Mineralogically both the clasts are similar in composition [2]. A somewhat mineralogically and texturally different third type of clast "type-C" occurs as pockets in type-A clast, and at the boundary between type-A and type-B clasts, containing silica, augite and plagioclase with minor oxides, troilite, and apatite.

Methods: Mounted sample were chemically characterized using Cameca SX-100 EPMA at PRL and NGRI. The oxygen isotopic measurements were made in 3–6 mg of powdered samples at the University of California, San Diego, by fluorination technique, using a CO_2 laser.

Results: Modal calculations indicate nearly equal proportion of high-Ca pyroxenes (augite: 18-19%) and low-Ca pyroxenes (orthopyroxene + pigeonite: 30-31%), and silica-phase (3-4%) in type-A and -B clasts. Mode of plagioclase is higher in type-A (47%) than in type-B (43%). In contrast, type-C clast consists of high modal volume of silica (~ 48%). The proportions of plagioclase and augitic pyroxene are ~33% and ~16%, respectively.

Whole-rock major element data indicates Piplia Kalan is in the range of non-cumulate eucrites. Mass-balance calculations involving modal and mineral chemical data indicate different clasts have similar Mg/Fe ratio (Mg# = molar MgO/(MgO+FeO) = 0.34-0.37). Type-A and -B clasts have basaltic composition and show similarity with non-cumulate eucrites. On contrary, type-C clast is siliceous, dacitic in composition in total alkali vs silica plot.

Average oxygen isotope data from two separate measurements shows that Piplia bulk has a $\delta^{17}O$ value of +1.68 ± 0.11 ‰ and a $\delta^{18}O$ value of +3.66 ± 0.06 ‰. The $\Delta^{17}O$ value (-0.20 ± 0.12) is close to the eucrite fractionation line ~ 0.239 ± 0.007, defined by [3]. However, there is significant variation in the oxygen isotopic compositions among type-A, type-B clasts and bulk of different measurements, e.g., $\Delta^{17}O$ ranges from -0.26 to +0.02. Earlier studies have reported anomalous oxygen isotope compositions from many other eucrites, e.g., [4, 5, 6].

Conclusions: Some of the key feaures in petrography and geochemistry indicate differences in the petrogenesis of different clasts of Piplia Kalan. Type-A cooled slowly at deep interior of the parent body and chilled as a shallow intrusive unit with better oxygen partial pressure than that of type-B, which formed as a relatively shallow magmatic flow. A difference of ~1 $\log_{10}(fO_2)$ is observed between type-A and –B, based on Fe-Ti oxide oxythermobarometric calculations of [7], using ilmenite data from type-A and -B separately along with a same fortuitous magnetite composition for both. The bulk chemistry of type-C clast is different than the other two types, but observations like similar spinel and ilmenite compositions and spatial association in our studied sections indicate that type-C was formed after type-A underwent hydrous-, silica-melt metasomatism.

Although mineralogically, petrologically and bulk chemically Piplia Kalan and other anomalous eucrites are indistinguishable from the majority of the eucrites, earlier studies have noticed that the chondritic mixture is not responsible for anomalous oxygen behavior of different eucrites and inferred their origin from different Vesta-like parent bodies [4, 6]. In this study we have noticed that the oxygen isotope together with mineral chemical, trace element data [2] and oxygen fugacity suggests non-uniform source composition of the various clasts of Piplia Kalan eucrite. Type-A clast crystallized earliest at more oxidized condition in the magma chamber in the deep crust than the type-B. Type-B formed from a relatively shallow magmatic flow in less fO_2 than the earlier events. Type-C is a product of fluid-induced metamorphism and metasomatism event at similar or better fO_2 condition than that of type-A. This study indicates heterogeneity of the source composition of different clasts of Piplia Kalan eucrite vis-à-vis the clan of eucrites than that inferred by previous studies.

References: [1] Shukla A.D. et al. 1997. *Meteoritics & Planetary Science* 32:611-615. [2] Basu Sarbadhikari A. et al. 2016. Abstract #1841. *47th Lunar and Planetary Science Conference*, [3] Greenwood R.C. et al. 2005. *Nature* 435:916-918. [4] Scott E.R.D. et al. 2009. Geochimica et Cosmochimica Acta 73:5835-5853. [5] Janots E. et al. 2012. *Meteoritics & Planetary Science* 47:1558-1574. [6] Barrett T.J. et al. 2017. *Meteoritics & Planetary Science* 52:656-668, [7] Ghiorso M.S. and Evans B.W. 2008. *American Journal of Science* 308:957-1039.