Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PPS24-13 Room:106 Time:May 23 15:30-15:45

Evidence for Late Stage Heavy Bombardment from Centimeter-sized Impact Melt Clasts in Apollo 16 Regolith Breccias

Takafumi Niihara[1*], BEARD, Sky P.[2], SWINDLE, Timothy D.[2], KRING, David A.[1]

[1]CLSE LPI-USRA, NASA Lunar Science Institute, [2]University of Arizona, NASA Lunar Science Institute

Isotopic ages from lunar rocks cluster around 4.0-3.8 Ga [e.g., 1,2] and are interpreted to indicate terminal lunar cataclysm [3]. However, this age cluster can be also interpreted as the overprint of a single large impact event; the Imbrium basin forming event. To evaluate this issue, we are focusing on impact melt clasts in ancient regolith breccias that lithified ˜3.8 Ga recovered at the Apollo 16 traverse site. Norman et al. [4] first addressed and reported that at this issue and report at least 4 distinct impact events are required based on petrological textures and Ar-Ar ages of large-sized Apollo 16 impact melt rocks. Among 25 samples, they found ages from 3.75 to 3.96 Ga. To further test this issue, we examined 11impact melt clasts from 60016, 65095 and 61135 [6-8].

To clarify the origins of impact melt clasts, we focus on compositions of relict minerals and bulk compositions. Relict minerals could remain information about original target materials if the shock-metamorphic overprint is not severe. For 6 melt clasts from 60016, at least 4 different target regions are required; Clast 1 comes from a terrain with high bulk Al_2O_3 (26.4 wt. %) and bimodal compositions in mafic minerals (Mg-suite and ferroan anorthosite), Clasts 2, 3 and 4 come from a terrain with low Al_2O_3 (20.4-16.4 wt %) composition and relatively ferroan composition in mafic minerals (Mg-suite), Clast 5 comes from a terrain with high-bulk Al_2O_3 (23.9 wt. %) and high Mg# in mafic minerals (Mg-suite), and Clast 6 comes from a terrain with low bulk Al_2O_3 (18.6 wt. %) and high-Mg# in mafic minerals (Mg-suite). All clasts have high- K_2O (>0.3 wt. %) and - P_2O_5 (>0.3 wt. %), and require KREEPy material [6]. Three clasts from 65095 have similar relict mafic mineral (Mg# in olivine =˜79.5) and bulk (Al_2O_3=˜23.5 wt. %; K_2O=0.16 wt. %; P_2O_5=0.22 wt. %) compositions among the clasts implying they have a same origin, however, different origin from clasts form 60016 [7]. Five regions in 2 clasts from 61135 might be generated by mixing of two end member melts; high-K (K_2O=0.72 wt. %) and low-K (K_2O=0.27 wt.%) and require at least one distinct impact site [8].

We obtained Ar-Ar shock retention ages for 6 impact melt clasts from 60016 and a clast from 65095 [6]. We find evidence for at least five different impact events clustered within short span of 4.0-3.7 Ga for 6 clasts from 60016. However, a recent thermal disturbance of the K-Ar system means that the formation age of the one clast in 65095 analyzed so far cannot be determined precisely enough to compare. Analyses of siderophile elements in some of these clasts also point to multiple impact events [9].

From the combined results from relict minerals and bulk compositions, 11 melt clasts require at least 6 individual target regions with KREEPy material. Ar-Ar ages confirm that clasts from 60016 originated from at least 5 distinct impact events. Thus, multiple impact events occurred in or near the PKT region and impact melt clasts were not produced by a single (i.e., Imbrium) impact event.

References: [1] Papanastassiou D.A. and Wasserburg G.J. 1971. EPSL 11. 37-62. [2] Turner G et al., 1973. Proc. LPSC 4, 1889-1914. [3] Tera F et al., 1974. EPSL 22, 1-21. [4] Norman M.D. et al., 2006 GCA. 70, 6032-6049. [5] Korotev R.L. 1994. GCA 58, 3931-3969. [6] Niihara T. et al., 2012.GCA submitted. [7] Niihara T. and Kring D.A. 2012 MAPS 47, Suppl. #5074. [8] Niihara et al., 2013 LPSC 44 submitted. [9] Liu et al., 2013 LPSC 44 submitted.

Keywords: Apollo16, Impact melt, Late Stage Heavy Bombardment, KREEP