

TYPE, CHEMISTRY, AR-ISOTOPES AND MAGMA GENERATION OF NEW APOLLO 17 BASALTIC REGOLITH FRAGMENTS V. A. Fernandes^{1,2}, R. Burgess², L. Cooper³, P. Czaja¹, A. Khan⁴, C. Liebske³, C. Neal⁵, J. Sliwinski³, and M.-H. Zhu^{1,6}, ¹Museum für Naturkunde, Berlin, Germany, ²SEES, Univ. Manchester, UK, veraafernandes@yahoo.com, ³Inst. Geochemistry and Petrology, ETH-Zürich, Switzerland, ⁴Inst. Geophysics, ETH-Zürich, Switzerland, ⁵Dept. Civil & Env. Eng. & Earth Sci., Univ. Notre Dame, Indiana, U.S.A., ⁶Space Science Inst., Macau Univ. of Science and Technology, Macau, China.

Introduction: Many of the larger basins of the Moon are filled with different lava flows. The Serenitatis basin presents 29 spectrally different compositions on its surface [1], but the chemical diversity of the lava flows below is not known. Thus, a complete understanding of chemical and isotopic mantle evolution beneath this basin cannot yet be constrained. Apollo 17 basalts are divided into high- & very-low-Ti compositions with the high-Ti representing the majority. The range in ages for volcanic samples is 3.75-3.65 Ga [2] and from cratering statistics volcanism occurred between ~3.9 and 3.6 Ga [1]. Acquiring chemical composition, mineralogical and chronologic data from different lava types is needed. Here we present textural, chemical composition and isotopic ages of 6 Apollo 17 2-4 mm regolith fragments collected from impact ejecta of Shorty, Steno and Camelot craters. Ejecta from these small craters come from depths greater than any of the Apollo 17 drill-cores. Hence, these fragments potentially sampled material from underlying lava flows and intercalated regolith that probably included local and regional material (from other flows within Mare Serenitatis). The results obtained using different analytical techniques are compared with remote sensing and literature data to evaluate mantle source(s) evolution under the Serenitatis Basin.

Type and chemical composition:

74244,12 pyroxene-porphyrific high-Ti basalt, pyroxene (En₃₁₋₄₆Wo₂₇₋₄₆Fs₁₆₋₄₂), plagioclase (An₈₁₋₈₅) & ilmenite with armalcolite cores; 75063,13 olivine-porphyrific high-Ti basalt, sub-variolitic texture, contains olivine (Fo₆₉₋₇₃), plagioclase (An₈₅₋₈₈) & ilmenite of various sizes; 71063,7 high-Ti dolerite (phases >1mm), olivine (Fo₅₆₋₇₁), pyroxene (En₃₆₋₆₉Wo₆₋₂₆Fs₂₅₋₄₁), plagioclase (An₉₃₋₉₆) & ilmenite; 75063,5 high-Ti olivine dolerite with 2 size domains. Phases in the coarser domain are 0.5-1 mm Ø, composed of plagioclase (An₈₉₋₉₂), olivine (Fo₃₃₋₅₂), pyroxene (En₃₂₋₄₅Wo₉₋₃₅Fs₃₃₋₅₃) & ilmenite; 71064,12 vitrophyric high-Ti basaltic melt with 50-200 µm olivine crystals (Fo₇₂₋₇₆) & ~10 µm chromite; 74243,41 vitrophyric high-Ti basalt with olivine (Fo₆₄₋₇₃) & armalcolite phenocrysts. Potentially an impact melt composed of mare material. All samples show the same depletion in the LREE and a relative enrichment in the HREE as in literature data [3]. Fragments 71064,12 and 74243,41 show a negative Eu-anomaly and a pattern similar to Apollo 17 types A and U [3]. Fragment 71063,7 shows a steeper LREE depletion and a very

slight negative Eu-anomaly. Fragments 74244,12, 75063,5 and 75063,13 have similar REE pattern and a slight to positive Eu-anomaly.

⁴⁰Ar-³⁹Ar and CRE age: All data were corrected for blank, discrimination, decay of short-lived nucleogenic nuclides (³⁷Ar & ³⁹Ar), and where necessary cosmogenic and/or trapped Ar corrections were applied. Ages were obtained from Ar-release spectra, inverse or normal isochron. ⁴⁰Ar-³⁹Ar ages range from 3.96 to 3.68 Ga, extending the range previously determined for Apollo 17 basalts. CRE-ages define a range of 112-441 Ma.

Magma generation and source depth: initial modelling [4] using estimated bulk compositions gives primary pressure of 1.3-2.6 GPa and temperature of 1260-1400°C consistent with other Apollo 17 basalts [3]. Based on these P-T estimates, the thermodynamic model described in [5] was employed to convert to depth in the lunar mantle. Source depths were found to range from 240 to 480 km. There is no direct correlation between age and depth.

Preliminary sample bulk composition vs. remote sensing data: The mare units considered are the larger flows of [6]. FeO and TiO₂ values determined from Clementine data and K from CE-2 & LP. First results suggest the orbital data to have a higher K content than samples. This will be further assessed.

Summary: New basaltic regolith fragments show a chemical composition range similar to those reported earlier. Potentially some of the fragments represent lavas not identified before. Fragments 74244,12, 75063,5 and 75063,13 show a slight positive Eu-anomaly potentially indicative of a change in source region or note representative of whole rock. The ⁴⁰Ar-³⁹Ar age range suggests a longer volcanic period. The non-correlation between age and magma generation depth suggest that heating of the lunar mantle is heterogeneous [e.g. 7]

References: [1] Hiesinger et al. (2011) Geol. Soc. of America Sp. Pap. 477, 1-51. [2] Paces et al. (1991) GCA 55, 2025-2053. [3] Mare Basalt DB <http://www3.nd.edu/~cneal/Lunar-L/>. [4] Lee et al. (2009) EPSL 279, 20-33. [5] Khan et al. (2014) JGR 119, doi:10.1002/2014JE004661. [6] Hiesinger et al (2000) JGR 105, 29239-29275. [7] Laneuville et al. 118, 1435-1452.

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