PETROGRAPHY, GEOCHEMISTRY, AND PAIRING RELATIONSHIPS OF BASALTIC LUNAR METEORITE STONES NWA 773, NWA 2700, NWA 2727, NWA 2977, AND NWA 3160. R. A. Zeigler, R. L. Korotev, and B. L. Jolliff, Washington University in St. Louis, Campus Box 1169, Saint Louis, MO, 63130. zeigler@levee.wustl.edu.

Introduction: The basaltic lunar meteorite Northwest Africa (NWA) 773 is a 633 gram basaltic meteorite purchased in the North African desert during the year 2000 [1,2]. In 2005, five more stones were purchased in North Africa that appear to be paired with NWA 773: NWA 2700 (32 g), NWA 2727 (191 g), NWA 2977 (233 g), NWA 3160 (34 g), and an unnamed stone (33 g). Collectively these six stones constitute an immature regolith breccia with two prominent clast lithologies: cumulus olivine gabbro and porphyritic olivine basalt. Not all lithologies are present in each stone; the regolith breccia lithology is present in every stone but NWA 2977, the gabbro in every stone but NWA 3160, and the basalt is present in NWA 2727, 3160, and the unnamed stone. Here we summarize the petrography and geochemistry of each of the major lithologies found in the NWA 773 stones and give evidence that they are paired.

Methods: The bulk chemical composition was determined by INAA on numerous subsamples (typically 20-40 mg) of each lithology in the NWA 773 stones, and by EMPA (electron microprobe analysis) of fused beads made from the INAA samples. Mineral compositions were determined by EMPA.

Petrography: The textures and mineral compositions of each lithology do not vary appreciably from stone to stone (Fig. 1). The regolith breccia lithology contains abundant lithic clasts including clasts of the porphyritic olivine basalt, gabbroic clasts, lithic basalt clasts, symplectites, and a few plagioclase-rich impact melt clasts. Most mineral clasts in the regolith breccia are pyroxenes ($En_{1-70}Wo_{4-40}$) and olivines (Fo_{3-82}), with lesser amounts of plagioclase ($An_{82-97}Or_{0.1-2.8}$), and minor amounts of silica, glass, chromite, and ilmenite. The basalt lithology has phenocrysts of olivine (0.1-0.9 mm) and chromite (<0.1) set in a mesostasis consisting of glass, skeletal pyroxene ($En_{35-39}Wo_{11-23}$), and spinifex olivine (Fo_{29}). The olivine phenocrysts are zoned, from magnesian cores (Fo_{55-70}) to more ferroan rims ($Fo_{\sim 40}$). The olivine gabbro cumulate has a mode of ~50% olivine (Fo_{67-72}), 30-40% pyroxene ($En_{49-71}Wo_{4-37}$), and 10-20% plagioclase ($An_{76-93}Or_{0.3-6.8}$). The cumulate also contains minor amounts of chromite, ilmenite, FeNi metal, merrillite, apatite, barian K-feldspar, and zircon.

Geochemistry: Although subsamples vary considerably in composition, the average composition of a given lithologies (breccia, cumulate, basalt) does not vary much among the different NWA 773 stones (Fig. 2). The variability that is observed is due to small differences in the relative abundances of the major mineral phases. The basalt lithology is a VLT basalt (0.85 wt% TiO_2) that has absolute concentrations of elements associated with ferromagnesian minerals (21.6 wt% FeO, 39 ppm Sc, 3700 ppm Cr) and most ITEs (4.7 ppm Sm, 1.4 ppm Th) typical of other VLT or low-Ti basalts. The cumulate lithology also has a VLT composition (0.36 wt% TiO_2) and has concentrations of ferromagnesian elements (19.5 wt% FeO, 24 ppm Sc, 86.4 ppm Co, 203 ppm Ni) and most ITEs (3.6 ppm Sm, 1.1 ppm Th) typical of lunar VLT or low-Ti basalts. The regolith breccia lithology has a composition close to that of the basalt lithology, but with a slightly lower FeO (19.7 wt%) and higher Na_2O (0.19 wt% vs. 0.15 wt%) concentrations. All three lithologies within the NWA 773 stones have exceptionally low concentrations of plagiophile elements (e.g., Eu, Na), a high light-REE to mid- or heavy-REE ratio (Fig. 3a), and a high Th/REE ratio (Fig. 3b).

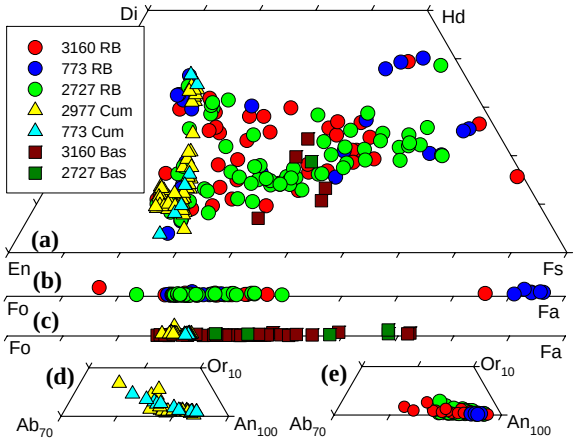

Figure 1: Pyroxene (a), olivine (b,c), and plagioclase (d,e) mineral compositions in the regolith breccia (RB), cumulate (Cum), and basalt (Bas) lithologies in various NWA 773 stones.

Pairing relationships: On the basis of similarities in texture, mineral assemblage, mineral chemistry, and bulk major- and trace-element composition among the different lithologies, and the mutual dissimilarity of the bulk compositions to any other mare basalts, the six stones are almost certainly paired. The cosmic ray exposure histories of NWA 773 and NWA 3160 are consistent with their being paired. Recent work has shown that the cosmic ray exposure histories of NWA 3160 and NWA 773 are similar [3] and that the Ar-Ar age of the cumulate and basalt lithologies are identical (within error) in different NWA 773 stones [4], further strengthening the argument. All three of the lithologies within the NWA 773 stones share several unusual geochemical characteristics (low Eu and Na_2O concentra-

tions, light REE enrichment, high Th/REE ratios) that together are rare to absent in other lunar basalts. This unique geochemical signature suggests there is a petrogenetic relationship between the different lithologies in the NWA 773 stones, a topic explored more fully by Jolliff et al. [5].

References: [1] Jolliff B.L. et al. (2003) *GCA 67*, 4857-79. [2] Fagan T.J. (2002) *MAPS 37*, 371-94. [3] Jolliff B.L. et al. (2007) *LPS 38*, (NWA 773 et al). [4] Fernandes V.A. (2007) *LPS 38*, (NWA 773 et al). **Acknowledgements:** This work was supported by NASA grant NNG04GG10G. We thank Tony Irving and Ted Bunch for providing samples of NWA 2700, 2727, 2977, 3160, and the unnamed stone, as well as the Natural History Museum, London for providing pieces of NWA 773.

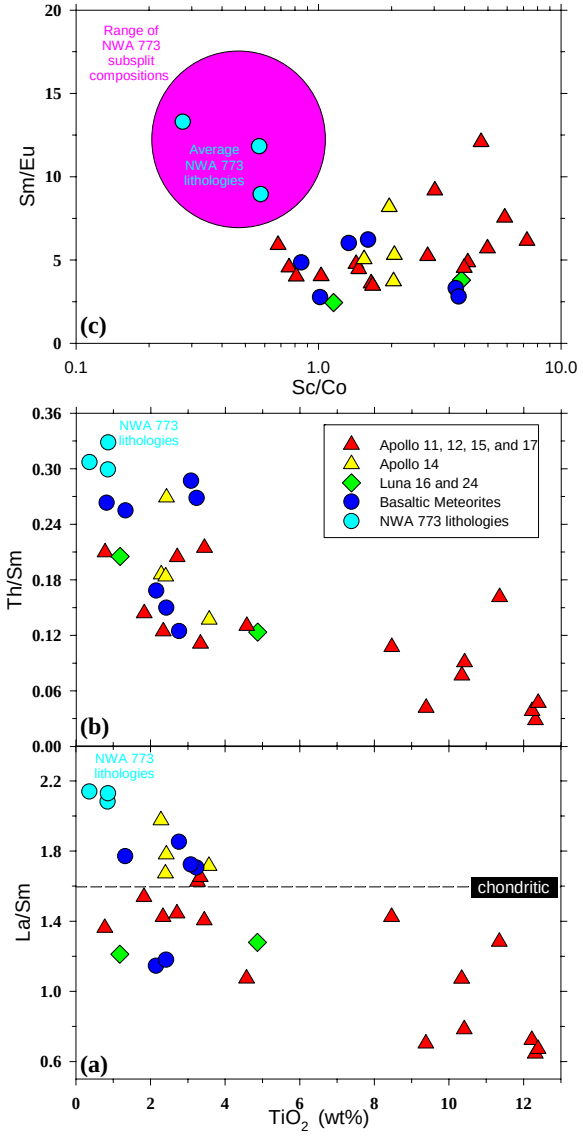

Figure 3: The average composition of the three NWA 773 lithologies compared to the average composition of the Apollo and Luna basalt suites (e.g., Apollo 17 high-Ti) and the other basaltic lunar meteorites. The NWA 773 lithologies have the highest light REE enrichment (a) and Th/REE ratio (b) of any lunar basalt. The NWA 773 lithologies have the lowest Sc/Co ratio (note the log scale), due to a high proportion of olivine relative to pyroxene, and a high Sm/Eu ratio, due to exceptionally low Eu concentrations. Collectively, these geochemical characteristics make the lithologies in the NWA 773 clan unique among lunar basalts.

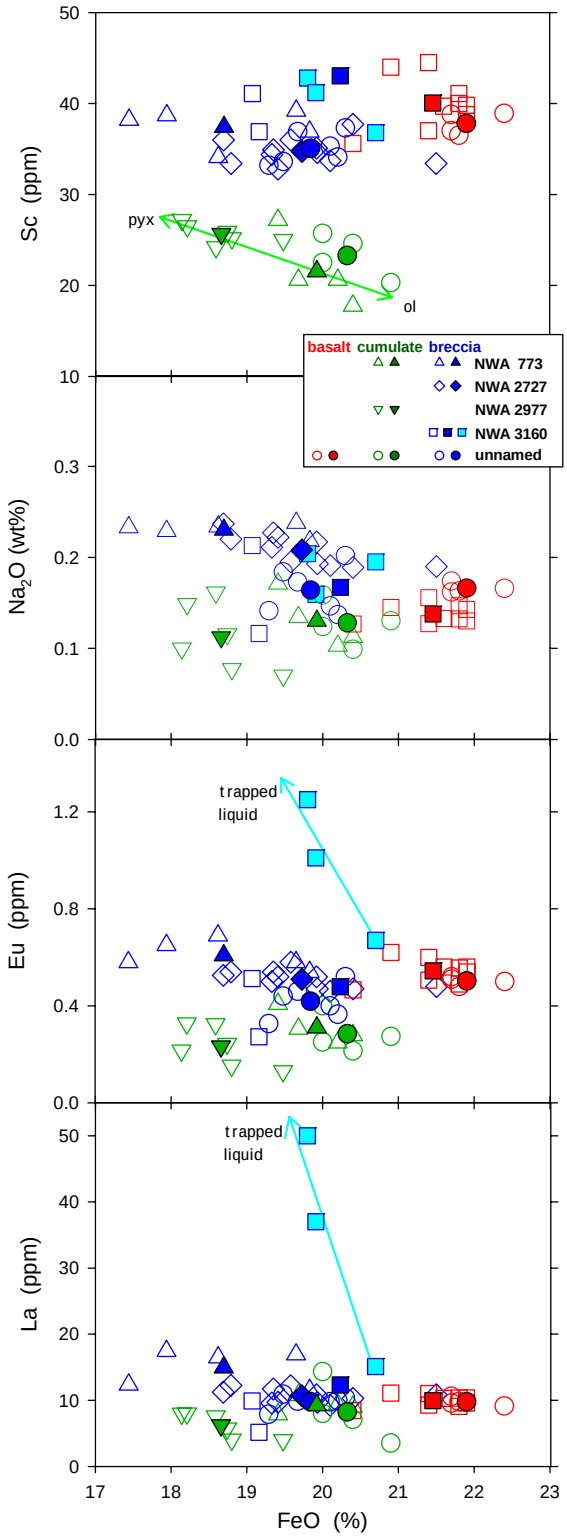

Figure 2: Composition of the individual INAA subsamples (open symbols) and the average (filled symbols) of each lithology for each of the NWA 773 stones. Also plotted are three NWA 3160 breccia subsamples (cyan squares) enriched in ITE, likely due to the presence of a trapped liquid [4].