A PETROLOGIC COMPARISON OF ISOTOPICALLY DISTINCT LUNAR LOW-TI BASALTIC METEORITIES NWA 032 AND LAP 02205. S. M. Elardo,[1] C. K. Shearer, Jr.[1], and P. V. Burger[1]. [1]Institute of Meteoritics, University of New Mexico, Albuquerque, NM 87131. selardo@unm.edu

Introduction: Several basaltic lunar meteorites have ages suggesting that they sample regions of the lunar crust outside of those explored by the Apollo and Luna missions. This also suggests that they are more closely related to each other than to Apollo and Luna mare basalts [1], thus providing a window into basaltic magmatism on the Moon that was not available from the returned sample collection.

Although not identical, the lunar low-Ti basaltic meteorites Northwest Africa (NWA) 032 and LaPaz (LAP) 02205 (and its parings) share many compositional and mineralogical characteristics [2, 3]. They are both unbrecciated mare basalts with bulk compositions, mineral major element compositions and ages that have been interpreted [3, 4] as being source cratered paired and perhaps representing samples of different regions of the same geologic unit on the Moon.

The hypothesis that NWA 032 and LAP 02205 are from the same geologic unit is supported by their similar crystallization ages (2947 ± 16 Ma [1] and 3020 ± 30 – 2990 ± 18 Ma [5, 6] respectively). It is also supported by their nearly identical trace element geochemistry. [1] showed that NWA 032 has a chondrite normalized REE pattern nearly identical in magnitude and shape to that of LAP 02205. Together, similar ages, mineral chemistry and trace elements suggest these magmas to have come from similar, if not the same source region in the lunar mantle.

However, this conclusion is most strongly refuted by the initial Sr and Nd isotopic compositions, which differ outside of analytical uncertainty. [6] determined an initial ε_{Nd} of +2.9 ± 0.9 for LAP 02205, whereas [5] reported an initial ε_{Nd} of +1.2 ± 0.2. These initial Nd isotopic compositions are in marked contrast to the initial ε_{Nd} of +9.71 ± 0.74 determined from the 2931 ± 92 Ma Sm-Nd isochron of NWA 032 [1]. The differences in Sm-Nd isotopic systematics indicate that NWA 032 is derived from a source region that is significantly more LREE-depleted (lower LREE/HREE) than the source region of LAP 02205. The goal of this study is to provide a thorough petrologic comparison of NWA 032 and LAP 02205 to determine if any other features of their geochemistry indicate derivation from similar (or dissimilar) source region and/or the petrogenetic processes which would have produced these two basalts.

Analytical methods: Phenocrystic phases in NWA 032 and LAP 02205 were analyzed for major and minor elements using a JEOL JXA 8200 electron micro probe at the University of New Mexico. Analyses were made using an accelerating voltage of 15 keV and a beam current of 30 nA. SIMS analyses of Ni and Co in olivine were made using a Cameca ims 4f operated at the University of New Mexico. A primary O^- ion beam was accelerated through a nominal potential of 10 kV. A 15 nA beam current was used with a spot size of ~15 µm. Sputtered secondary ions were energy filtered using a sample offset voltage of 105 V. Absolute concentrations were calculated using empirical relationships of trace element/$^{30}Si^+$ ratios (normalized to known SiO_2 content) to element concentrations as derived from calibration.

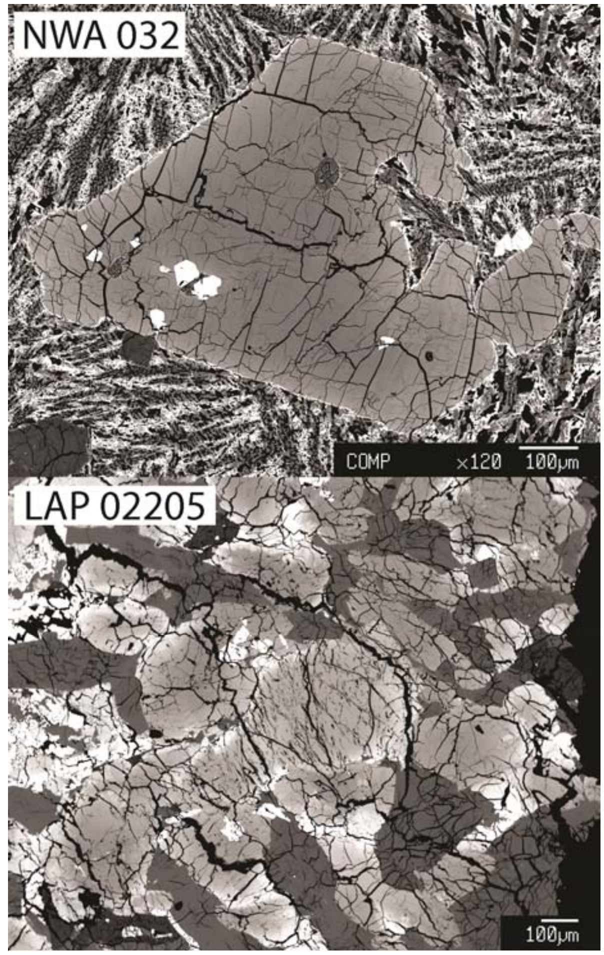

Figure 1: BSE images of NWA 032, showing phenocrystic olivine, chromite and pyroxene in a fine-grained groundmass, and LAP 02205, showing a subophitic texture of plagioclase, pyroxene and ilmenite with minor olivine and other trace phases.

Results and Discussion: The two basalts are texturally distinct. NWA 032 contains phenocrystic olivine, pyroxene and chromite set in a fine grained crystalline groundmass of plagioclase, pyroxene, troilite, ilmenite, and trace metal (Fig. 1). Chromite often appears partially or fully surrounded by olivine and may have been the liquidus phase. Shock melt veins of whole rock composition are observed [2]. LAP 02205 is a medium to coarse grained subophitic basalt. It is dominated by pyroxene, plagioclase and ilmenite phenocrysts with minor olivine as well as spinel, metal, sulfides and baddeleyite (Fig. 1). The crystalline mesostasis consists of Fa-rich olivine, silica, silica glass, phosphates, metal and shock melt veins [e.g. 7, 8]. However, even though the two rocks are texturally dissimilar, [4] suggested that they could represent different depths in a single flow, given their similar chemical and mineralogical characteristics.

Another distinguishing feature of NWA 032 is the oscillatory zoning of Ti and Al in pyroxene (Fig. 2). This zoning is not seen in pyroxene in LAP 02205. [9] interpreted this zoning to be indicative of a complex cooling history for NWA 032. Although NWA 032 and LAP 02205 could represent different portions of the same basalt flow, similar zoning would be expected in LAP 02205 if the two meteorites were part of the same geologic unit that experienced the cooling history recorded by pyroxene in NWA 032.

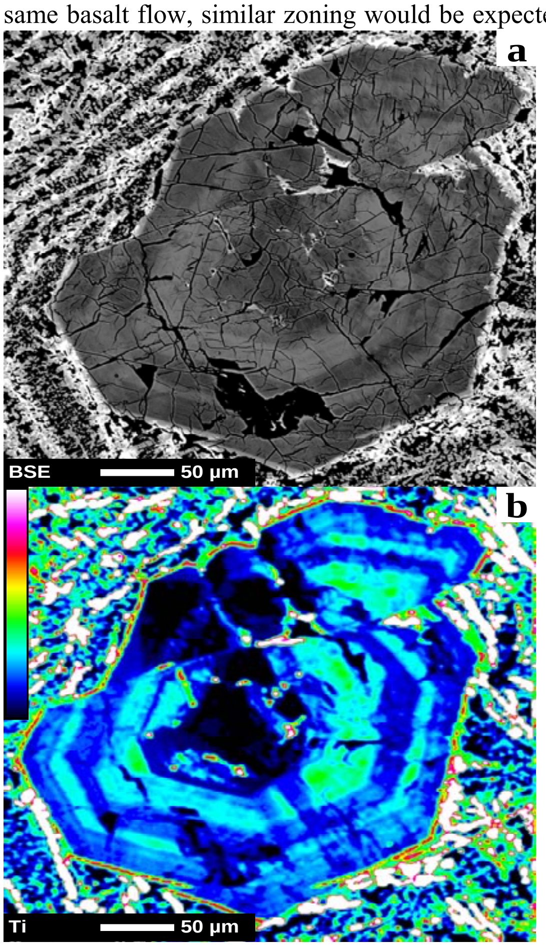

Figure 2: (a) BSE image of intermediate size pyroxene in NWA 032. (b) Ti x-ray map of the pyroxene illustrating oscillatory zoning. Al zoning is correlated to Ti. After [9].

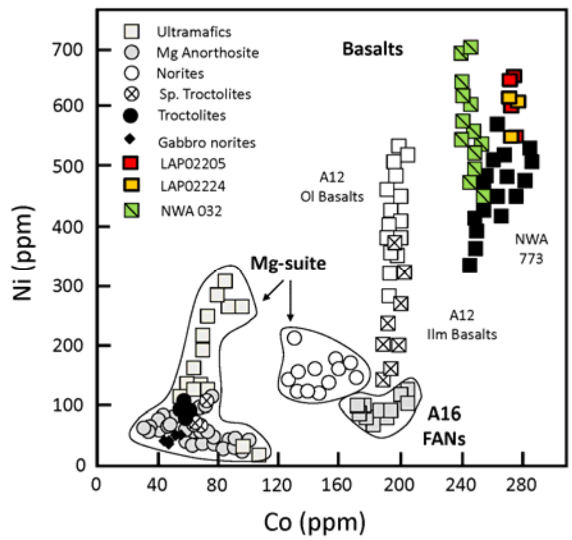

Figure 3: A plot of Ni and Co in lunar olivine. After [1].

Nickel and Co in olivine can be used as a discriminator to distinguish between different lunar basalts and source regions [e.g. 10]. Preliminary Ni and Co in olivine data from NWA 032 [1] and from LAP 02205 are shown in Fig. 3 alongside Apollo 12 olivine and ilmenite basalts, Mg-suite rocks and FANs. NWA 032 and LAP 02205 are compositionally and mineralogical most similar to Apollo 12 basalts amongst the mare basalts sampled by the Apollo and Luna missions.

However, Ni and Co in olivine from these meteorites make them, and presumably their source regions, distinct from the Apollo 12 mare basalt suite. Their Ni and Co systematics are distinctly different from Apollo 12 mare basalt olivine. Additionally, olivine in LAP 02205 contains higher Co at Ni concentrations similar to that in NWA 032 (Fig. 3). This provides further suggestion that the magmas that crystallized these two basalts and perhaps their source regions were different.

Future work will continue to examine a possible relationship between these basalts, perhaps through fractional crystallization, or place their distinct isotopic characteristics and source regions in the context of models of lunar differentiation.

References: [1] Borg et al. (2009) *GCA* 3963 – 3980. [2] Fagan et al. (2002) *MAPS* 371 – 394. [3] Zeigler et al. (2005) *MAPS* 1073 - 1101. [4] Day and Taylor (2007) *MAPS* 3-17. [5] Nyquist et al. (2005) *LPSC* #1374 [6] Rankenburg et al. (2006) *Science* 1369 – 1372. [7] Righter et al. (2005) *MAPS*, 1703 – 1722. [8] Day et al. (2006) *GCA*, 1581 – 1600. [9] Burger et al. (2009) *LPSC* #2043. [10] Shearer et al (2005) *MAPS* A139