COMPOSITIONAL CONSTRAINTS ON THE LAUNCH PAIRING OF LAP 02205 AND PCA 02007 WITH OTHER LUNAR METEORITES. R. L. Korotev, R. A. Zeigler, and B. L. Jolliff, Washington University, Department of Earth and Planetary Sciences, Saint Louis MO 63130 <korotev@wustl.edu>

We report compositional data for two new lunar meteorites collected during the 2002–03 ANSMET (Antarctic Search for Meteorites) field season, LAP 02205 and PCA 02007 [1].

Analysis: By INAA (instrumental neutron activation) we have analyzed a total of 10 subsamples from 2 allocated splits of LAP 02205 (362 mg total mass; 4 are mineral separates not discussed here) and 14 subsamples from 4 allocated splits of PCA 02007 (494 mg total). By electron microprobe we have analyzed 4 fused beads prepared from 2 allocated splits of LAP 02205 (44 mg total), 8 fused beads from 4 allocated splits of PCA 02007 (83 mg total), and 1 fused bead from NWA (Northwest Africa) 032 [2].

LAP 02205: LaPaz Icefield 02-205 is a crystalline mare basalt (1226 g) [1], the 5th such lunar meteorite to be found. Like the other four, LAP is a low-Ti basalt (Fig. 1). Compositionally, LAP is very similar to NWA 032 but different from the other three basaltic lunar meteorites and Apollo and Luna mare basalts. Major similarities that together distinguish LAP and NWA from other basaltic lunar meteorites are (1) low *Mg´* (bulk mole % Mg/[Mg+Fe]), intermediate Co/Sc, and high Th/Sm [2; Figs. 2–4]. Compositionally LAP differs from NWA in having (1) lower concentrations of Mg, Cr, and Co, (2) higher SiO_2, (3) lower K and Ba (~2×), and (4) slightly higher concentrations of highly incompatible elements (10–30%; Figs. 2–4). The compositional differences for some elements (Mg, Co) are consistent with olivine fractionation, with a lower average abundance of normative of olivine in LAP (~0%, compared with 5.5% for our sample of NWA and 11% for the SI sample of NWA 032 of [2]). In detail, however, we cannot quantitatively relate the compositions by fractional crystallization (e.g., Ti, K, Ba) [3]. Nevertheless, the compositional similarities between LAP 02205 and NWA 032 are sufficiently great that, pending crystallization age and cosmic-ray exposure data, we conclude the two stones are probably geographically related and thus were likely ejected from the Moon by a common impact.

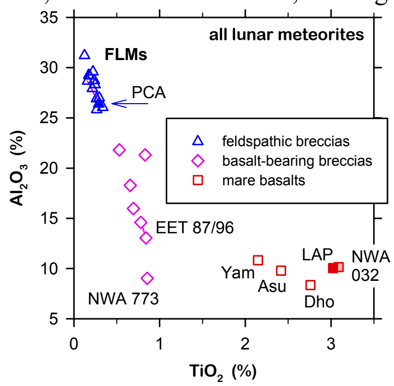

Figure 1. All lunar meteorites that are crystalline mare basalts are low-Ti basalts. The basalt component of all or most brecciated lunar meteorites is VLT basalt (<1% TiO_2). See [4 & 7] for sources of data.

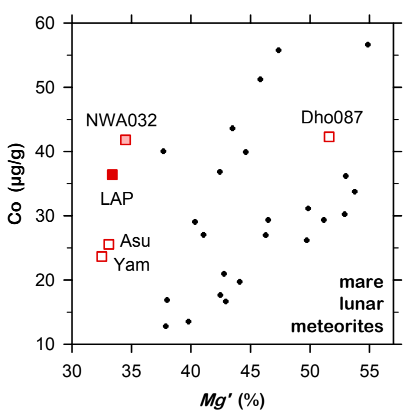

Figure 2. LAP 02205, NWA 032, Asuka 881757, and Yamato 793169 have low Mg/Fe ratios compared to other mare basalts. Each black symbol represents the mean for an Apollo or Luna basalt type, e.g. Apollo 12 olivine or Luna 16 high-Al.

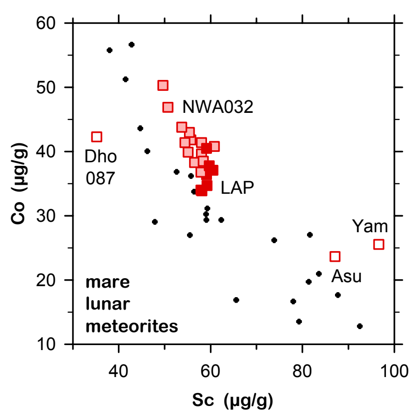

Figure 3. NWA 032 and LAP are distinct from other basaltic lunar meteorites. All INAA subsamples of LAP and NWA are plotted. The greater average Co/Sc ratio of NWA compared to LAP is consistent with a greater olivine/pyroxene ratio in NWA (Fig. 7).

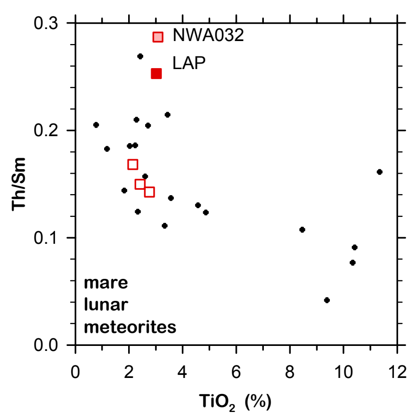

Figure 4. NWA032 [2] and LAP have high Th/Sm ratios compared to other mare basalts. The high-Th/Sm Apollo point is for Apollo 14 high-K basalt, but the data are imprecise (mean ± s.d.= 0.26 ± 0.07 compared with < ± 0.02 for NWA and LAP).

PCA 02007. Although described as a "lunar basaltic breccia" [1], Pecora Escarpment 02007 (22 g) is, in fact, a feldspathic regolith breccia. PCA is similar to the numerous other FLMs (feldspathic lunar meteorites) in being a breccia with low concentrations of incompatible elements (e.g., 0.4 µg/g Th). It differs in being compositionally more mafic (Figs. 5–6). Cr (Fig. 7) and Sc concentrations, in particular, are high, suggesting that the maficness is due to a component of mare volcanics [4]. For the following reasons, however, we suspect that the high concentrations of Sc, etc., in PCA may instead be mainly due to nonmare material. If PCA is a mixture of mare and nonmare material and the nonmare component has the composition of average feldspathic lunar meteorites (28% Al_2O_3 [4]), then 13±2 % mare material of very-low-Ti basalt composition is required to account for the high concentrations of Fe, Mn, Mg, Sc, and Cr and low concentration of Ti in PCA. Only a small proportion of material of possible mare origin is evident in thin section, however [5]. Also, the CaO/Al_2O_3 ratio of PCA is 0.58, identical to feldspathic lunar meteorites of greater Al_2O_3 concentration, whereas CaO/Al_2O_3 ratios of mare basalts are typically >1 (Fig. 6).

Like several other meteorites derived from mature lunar regolith, PCA 02207 has a highly vesicular fusion crust [1,5] as a result of the evolution of solar-wind implanted gases during atmospheric entry. There are also two compositional indicators that PCA 02007 derives from a mature regolith. First, concentrations of siderophile elements are high, e.g., 354 ppm Ni, compared with 454 ppm for mature Apollo 16 soil and 175 for Yamato 791197 [6,4]. Second, our 14 small (~35-mg) INAA subsamples are all very similar in composition, indicating that the regolith from which PCA formed was fine grained and well mixed. For example, the average of the relative standard deviations in concentrations of Na, Fe, Sc, and Eu (high-precision elements that occur mainly in major mineral phases) is only 2.2%. This value is comparable to that obtained from mature Apollo 16 soil (1.6%, eight 50-mg subsamples of sample 60601 [unpubl. data, this lab]). At the other extreme is EET 87521/96008, a fragmental breccia for which the mean RSD for these four elements is 18% among 24 subsamples (~35-mg) [8].

Compositionally, PCA most closely resembles Yamato 791197 among lunar meteorites. Both meteorites have similar absolute concentrations of TiO_2, Al_2O_3, FeO, and Sc and similar relative concentrations of rare earth elements, including low La/Yb ratios (Fig. 7). We have previously concluded that the "maficness" of Yamato 791197 results from a mare component [8,4], but PCA argues for re-examining that conclusion. The most significance compositional differences between the two meteorites are that PCA is enriched in incompatible elements (1.25–1.4×), Ir and Au (2.6×), MgO (1.09×), and Cr (1.23×). Correcting both meteorites to CI-free concentrations still yields enrichments for MgO (1.05) and Cr (1.17), a depletion for FeO (0.92×), and a consequently greater *Mg´* for PCA (67) than Yamato 791197 (64). The Cr/Sc ratio of PCA significantly exceeds that of Yamato 791197 (1.27×). We are unaware of any single lithologic component which when mixed with Yamato 791197 can simultaneously account for the greater Mg/Fe, Cr/Sc, and incompatible elements of PCA. Nevertheless, the compositional differences between the two meteorites are not so great that that we might reasonably conclude that PCA 02207 and Yamato 791197 cannot represent regoliths separated by, e.g., a kilometer of distance on the lunar surface. The compositional similarities, in fact, provide support for the hypothesis that the two meteorites are launch paired. If PCA 02207 and Yamato 791197 are launch paired, then the higher *Mg´* LAP compared to Yamato also provides a modicum of compositional support for the hypothesis that Yamato 791197 is launch paired with ALHA 81005 [9], a FLM with a particularly high *Mg´* (73 [4]).

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References: [1] Satterwhite & Righter, eds. (2003) *Antarctic Meteorite Newsletter* **26** (2). [2] Fagan et al. (2002) *M&PS* **37**, 371–394. [3] Jolliff et al., LAP, this volume. [4] Korotev et al. (2003) *GCA* **67**, 4895–4923. [5] Zeigler et al., PCA, this volume. [6] Korotev (1997) *M&PS* **32**, 447–478. [7] Korotev et al. (2003) *Antarctic Meteorite Research* **16**, 152–175. [8] Korotev et al. (1996) *M&PS* **31**, 909–924. [9] Warren (1994) *Icarus* **111**, 338–363.

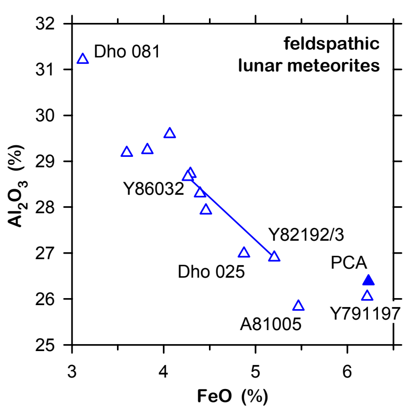

Figure 5. PCA and Yamato 791197 are at the Fe-rich, Al-poor end of the range of feldspathic lunar meteorites. Y86 and Y82 are different stones of a single meteorite, with Y82 probably containing some mare basalt [6].

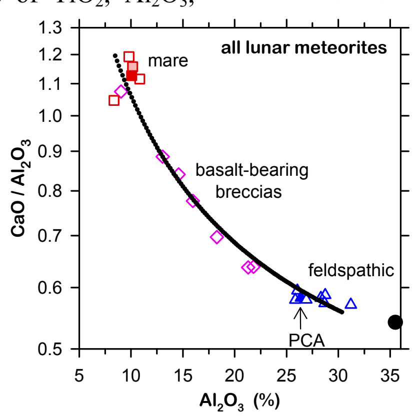

Figure 6. A mixing line between mean FLM [5] and mean mare basalt with <4% TiO_2. The black circle represents ferroan anorthosite. Feldspathic hot-desert meteorites are not plotted because some are contaminated with terrestrial Ca [5].

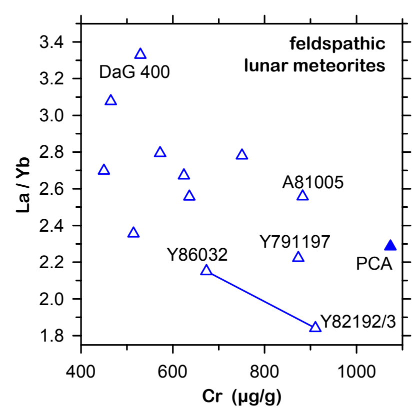

Figure 7. PCA is richer in Cr than any other FLM. PCA and Y791197 have very similar REE "patterns," each characterized by low La/Yb ratios [6].