A Major KREEP-Basalt—Mare Basalt unconformity on the Moon. Paul D. Spudis, Lunar and Planetary Institute, Houston TX 77058 (spudis@lpi.usra.edu) and G. Jeffrey Taylor, HIGP/SOEST, Univ. Hawaii, Honolulu HI 96822 (gjtaylor@higp.hawaii.edu)

The lunar regolith records both the geological history and processes of the Moon and also that of particles from the Sun and galaxy. Such a record extends back to the age of the rock unit upon which the regolith is developed, but complex impact gardening and processing makes this record difficult to recover and interpret. Ancient rock units, such as lava flows, begin to have regolith developed upon them immediately after emplacement. If covered or buried by another unit, this ancient regolith can preserve conditions as they were on the Moon billions of years ago. Such a *paleoregolith*, sandwiched between two lava flows, should be common on the Moon, but may be largely inaccessible. However, in places where natural outcrops occur, such as the walls of large impact craters or the interiors of rilles and graben, such units may be exposed [1,2].

Station 2, Apollo 15 landing site. The Apollo 15 landing site in the Hadley-Apennine region contains rock units that span over a billion years of lunar history [3]. The maria here consist of at least two distinct lava flows and a pyroclastic deposit erupted around 3.3 Ga ago [3]. A non-mare volcanic KREEP basalt unit, the Apennine Bench Fm. [4] forms the 3.84 Ga basement upon which these lavas were erupted. The walls of Hadley Rille expose the mare section in this area; potentially, this section could include a 500 Ma unconformity. Where is it?

The Apennine Mt. range (Imbrium basin ejecta) was a major target for the Apollo 15 crew [5]. A traverse to the front was planned for the first EVA, to St. George crater on the Hadley Delta massif to sample highlands material. The planned station also happened to be on the edge of Hadley Rille, upslope from a small, very fresh 50 m diameter crater (Fig. 1). The crew decided to stop and sample a 1 m boulder on the slope of Hadley Delta. This glass-coated block was angular and apparently recently emplaced. The block and soil from beneath it was sampled and analyzed; information from cosmic-ray exposure ages indicate that it was emplaced < 100,000 years ago [6]. The Field Geology team associated this Station 2 block with the very fresh impact crater, located about 300 m north of the LRV (Fig. 1).

Samples 15205 and 15206 (Fig. 2) were collected from the Station 2 boulder. Both are classified as "regolith breccias" [7,8], but appear to be unusual. Apollo 15 KREEP basalt is the dominant component of these rocks, with lesser amounts of Apollo 15 quartz-normative mare basalt (QNB) and Apollo 15 green glass pyroclastics [8]. As regolith breccias, these rocks are *very* immature, with Is/FeO values of zero [9]; the breccias contain few agglutinates or other normal regolith products. The other local mare basalt, Apollo 15 olivine-normative, appears to be absent. Green glass spheres and fragmentary clods occur within the breccias. The block's surface displays a greenish-gray glass coating and brown glass veins penetrate the rock. This glass can be modeled as a mix of KREEP basalt, QNB, and green glass. Schonfeld [10] modeled the bulk composition of 15205 as 84% KREEP basalt, with the remainder being mostly QNB.

Fig. 3 shows the variation in La concentration and I_S/FeO (the maturity index) for Apollo 15 regolith breccias [9]. Four breccias are rich in La (hence in KREEP basalt) including 15205. One of the breccias, 15028, contains an olivine basalt clast and was collected at the LM. Olivine basalts have not been reported in the others, which were collected at stations 2 (15205), 7 (15467), and 9A (15528). They have a range in maturity, suggesting that some of the regolith on KREEP basalt was more mature than that represented by 15205. The two regolith breccias lowest in La are composed mostly of pyroclastic glass, 15426 and 15427, and vary in maturity index. Interestingly, both contain not just green glass, but other colors, including orange (see [9]; Table 4). This suggests that early stages of mare volcanism in this area was not only pyroclastic, but variable in composition. Also, the two pyroclastic breccias do not contain KREEP basalt, suggesting that some regolith developed on top of the pyroclastic deposit did not garden down into the underlying KREEP basalt; either there was not enough time (likely) or a thick pyroclastic deposit or both.

A Lunar Paleoregolith? The Apollo 15 Station 2 Boulder is *not* highlands material, as it contains QNB and green glass, but it cannot be post-mare, as no Apollo 15 olivine basalt, the surface unit [3,11], is present. The likely source for the block is the fresh, 50 m-diameter crater seen in the surface pan (Fig. 1). This crater occurs 20-30 m *below* the inferred elevation of the lip of Hadley Rille. The crater is surrounded by a field of fresh blocks and may have formed on a contact.

Apollo 15 KREEP basalt is derived from the Apennine Bench Fm., a regional unit present beneath the Apollo 15 site [4,12]. Mare basalts lie directly on top of Apennine Bench Fm. and may correlate with outcrops observed in the walls of Hadley Rille at Station 9 ([13], [14]; Fig. 4). The covered interval between the middle massive unit and lower layered unit, which occurs about 25-30 m below the rim of the rille, may be a paleoregolith developed on Apennine Bench KREEP basalt flows. The fresh crater near Station 2 formed on this unit, a regolith developed on KREEP basalt (Fig. 4).

The clast population and chemical composition of 15205 suggests a protolith consisting of mostly Apollo 15 KREEP basalt (3.85 Ga), but broken up and constituting an immature regolith. Textural studies of the Apollo 15 QNB indicate that they are derived from a lava flow at least 20 m thick [15], consistent with assigning a QNB composition to the middle massive unit observed in the rille wall. The presence of green glass (but absence of olivine normative basalt) within the breccias suggests that the green glass pre-dates the surface mare flows and may pre-date the stratigraphically lower QNB as well. All mare volcanics at the Apollo 15 site are indistinguishable in radiometric age at 3.3 Ga [8,11].

Thus, we may possess already a lunar paleoregolith among the Apollo samples [9]. Alternatively, the Station 2 boulder samples are not regolith but fragmental breccias [16], created during the impact that formed the fresh 50-m diameter crater north of Station 2. In either case, these samples contain a record of processes on the Moon over 3.8 Ga ago, including a preserved major unconformity from the lunar stratigraphic record. As such, these samples warrant additional detailed study, which we plan to undertake.

References [1] Taylor G.J. and Spudis P.D., eds. (1990) *Geoscience and the Lunar Base* NASA CP-3070, 73 pp. [2] LEXSWG (1992) A Planetary Science Strategy for the Moon. NASA JSC 25920, 26 pp. [3] Spudis P.D. and Ryder G. (1985) EOS 66, 721. [4] Spudis P.D. (1978) PLPSC 9, 3379; Hawke B.R. and Head J.W. (1978) PLPSC 9, 3285. [5] Swann G. A. et al. (1972) Apollo 15 PSR, NASA SP-289, 5-1 to 5-112. [6] Bhandari N. (1977) PLSC 8, 3607. [7] Dymek R.F. et al. (1974) PLSC 5, 235. [8] Ryder G. (1985) *Catalog of Apollo 15 rocks*. NASA JSC 20787, 1296 pp. [9] McKay D.S. et al. (1989) PLPSC 19, 19. [10] Schonfeld E. (1975) LS VI, 712 [11] Ryder G. (1989) PLPSC 19, 43. [12] Spudis P.D. and Hawke B.R. (1986) A15 Workshop, LPI TR 86-03, 105. [13] Howard K.A. et al. (1973) PLSC 3, 1. [14] Spudis P.D. et al. (1988) PLPSC 18, 243. [15] Grove T. and Walker D. (1977) PLSC 8, 1501. [16] Stöffler D. et al. (1980) Proc. Conf. Highlands Crust, LPI-Pergamon, 51.

Fig.1 Panorama of Station 2.

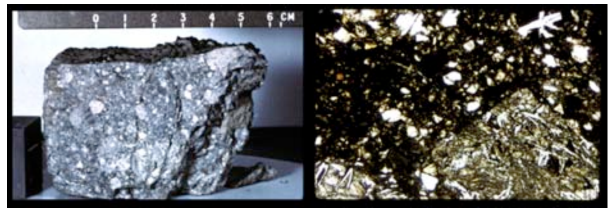

Fig. 2 Sample 15205 consists of only KREEP basalt and QNB mare basalt, with minor green glass

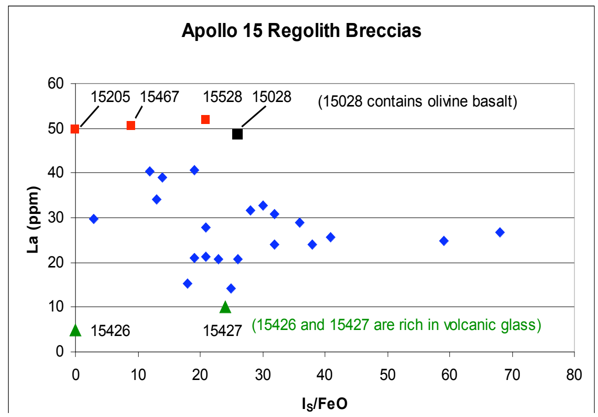

Fig. 3. Apollo 15 regolith breccias are typically mixtures of lithologies present at the site, but some are distinctly enriched in La (hence KREEP basalt), with pyroclastic glass and quartz-normative basalts. Other breccias are dominated by pyroclastic glasses.

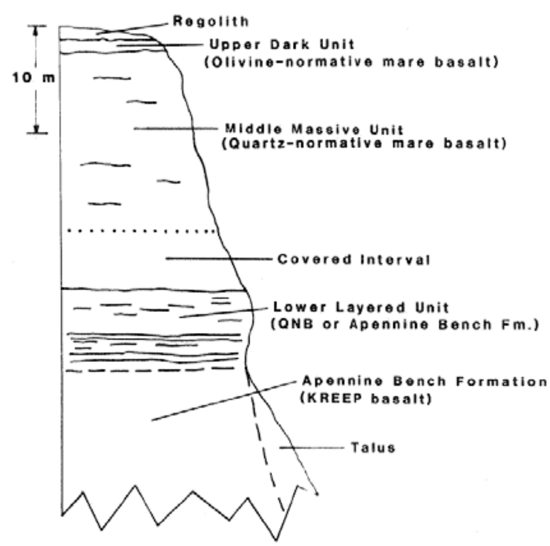

Fig. 4 Inferred cross section of A15 site exposed at Hadley Rille (from [14].)