APOLLO 17, STATION 2, BOULDER 1: REVISITING CONSORTIUM INDOMITABILE. David A. Kring[1,6], Debra H. Needham[2,6], Richard J. Walker[3,6], Alexander A. Nemchin[4,6], and Harrison H. Schmitt[5], [1]Lunar and Planetary Institute, USRA, 3600 Bay Area Blvd., Houston TX 77058 USA (kring@lpi.usra.edu), [2]NASA Marshall Space Flight Center, Huntsville AL 35812 USA, [3]University of Maryland, College Park MD 20742 USA, [4]Swedish Museum of Natural History, Stockholm SE-104 05 Sweden, [5]University of Wisconsin-Madison, P.O. Box 90730, Albuquerque NM 87199 USA, [6]NASA Solar System Exploration Research Virtual Institute.

Introduction: Apollo 17 astronauts explored the Taurus-Littrow Valley, bounded by the North and South Massifs, on the southeast margin of the Serenitatis basin [*1-3*]. The massifs were interpreted to be uplifted, variably rotated blocks produced by the Serentitatis impact event and potentially covered with Serenitatis ejecta. Rock exposed high on the flank of the South Massif produced boulders that rolled since 75 to 100 Ma [3] to near the valley floor where they were sampled (**Fig. 1**). The Lunar Sample Analysis Planning Team (LSAPT) set up four consortia to study the boulders. Consortium Indomitabile [*4-6*] focused on Station 2, Boulder 1 (**Fig. 2**). Here we review those results in the context of data that we and others obtained in the intervening 45+ years.

Serenitatis Basin: At the time of the Consortium, the Serenitatis region was interpreted to be the product of two overlapping impact basins [*7*], which was recently supported by GRAIL gravity data [*8*]. An older, ~420 km diameter northern basin is superposed by the ~920 km diameter Serenitatis basin. Ejecta at the landing site was likely dominated by Serenitatis [*7,9*], although contributions from Nectaris, Crisium, and Imbrium basins were also considered probable [*3*].

Massifs and Basin Ejecta: Consortium Indomitabile concluded Station 2, Boulder 1 on the South Massif was emplaced as Serenitatis ejecta. Taking the distance of the massif to be 375 km from the basin center [*8*], using a transient crater radii of 216 to 314 km for reasonable target thermal states [*10*], consistent with a measured central Bougher anomaly radius of 278 ± 32 km [*8*], and assuming an ejecta angle of 45°, we calculate the debris had a flight time of 4.6 to 11 minutes and landed with a velocity of 0.3 to 0.8 km/s (1100 to 2800 km/hr). That process should have deformed (through cataclasis and shear) the ejected material. Indeed, the ~2 m-diameter boulder is foliated (**Fig. 2**). Five layered zones were identified [*11*], three of which were sampled. Samples 72215, 72255, and 72235 represent knobs in those zones on the boulder. They are breccias with diverse clast assemblages and layered matrices, including layered aphanitic impact melt. A fourth sample (72275) was collected as representative of the boulder's matrix and came from the same zone as 72235. It has a slightly different clast content and clast/matrix value, but is otherwise similar.

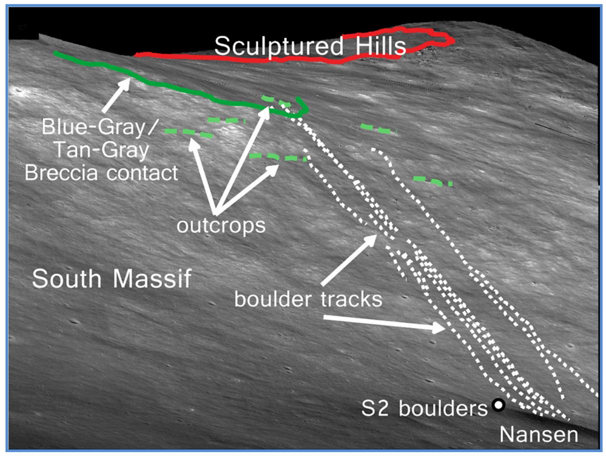

Figure 1. Source outcrop, boulder trails, and locations of Station 2 boulders. After [18].

Importantly, two textural classes of impact melts were identified in the Apollo 17 collection: aphanitic and poikilitic. Station 2, Boulder 1 samples are aphanitic. Poikilitic melts are found in nearby Station 2, Boulder 2 (72315, 72335, 72344, 72395) and both types of melts were collected at Stations 3 and 6. It is possible the two textural types of melt were produced by the same impact event. Wood [*9*] concluded the aphanitic melt of Station 2, Boulder 1 was produced by Serenitatis. Other investigators noted differences in chemistry and clast populations that were interpreted to indicate two or more impacts, with a Serenitatis origin reserved for the poikilitic melts and another impact assigned to the aphanitic melts [*12*].

Basin Ages(s) and Impactor(s): Differences in $^{40}Ar/^{39}Ar$ data were interpreted in the same fashion: a poikilitic melt age of 3893 ± 9 Ma was assigned to Serenitatis, while another impact, ~50 million years later, was inferred from aphanitic melt data [*13*]. More recent work has utilized the U-Pb system. Six analyses of five phosphate grains in the aphanitic breccia 72255 produced a mean $^{207}Pb/^{206}Pb$ age of 3922 ± 5 Ma and similar analyses of poikilitic melts from Station 6 produced an age of 3930 ± 5 Ma [*14*]. While the mean of the ages may reflect different impact events, the statistical overlap also allows for a single impact event. It is clear, however, that absolute and relative ages among the boulders is still an unresolved issue (e.g., [*3*]).

If the aphanitic and poikilitic melts were produced by different impact events, then it is possible they contain highly siderophile element (HSE) signatures of different impactors. Analyses of aphanitic and poikilitic melts (72395, 73215, 73255, 76215), albeit not from Station 2, Boulder 1, initially suggested they were carriers of different impactors [*15*]. The aphanitic melts seem to carry the signature of chondritic meteorites, while the poikilitic melts have a unique signature interpreted as possibly primitive chondritic material not currently delivered to Earth in meteoritic form. Additional analyses of Apollo 17 melt samples (72355, 72435, 72535, 73235, 76055, 76135) provided more clarity [*16*], although they also excluded samples from Station 2, Boulder 1. That study revealed the initial HSE distinction between the two types of melts was produced by granulite clasts within the aphanitic melts. Once that contribution was corrected, the HSE signatures of the aphanitic and poikilitic melts were the same and consistent with the same type of (and, thus, possibly the same) impactor. The data do not, unfortunately, resolve whether the aphanitic melts of Station 2, Boulder 1 were produced by Serenitatis or a younger impact event [*17,18*].

Clast Assemblage and Lunar Interior Water: The Consortium identified a diverse clast assemblage that included granulitic anorthosite-norite-troctolite (ANT) breccias, granulitic polygonal anorthosite, crushed anorthosite, devitrified glass, ultramafic particles, basaltic troctolite with pink $MgAl_2O_4$ spinel, other basaltic particles, granite clasts, norite, and a variety of isolated mineral grains. The granite clasts (e.g., 72215,178 and ,180), more recently described as felsites, are of particular interest, because they provide a new probe of magmatic intrusive conditions and lunar interior water abundances. Observed silica liquid immiscibility and measured [Ti] in quartz, suggest the felsites were intruded at depths ≥20 to 25 km in bodies of order 100 m wide [*19*]. Analyses of the felsites for evidence of lunar interior water are underway.

The issue of lunar interior water is also being explored by examining phosphate in KREEP basalt clasts. Based on Cl-isotope analyses of apatite (72275,491), one study concluded [H] is ~10^4 to 10^5 times lower than that of the Earth [*20*], while analyses of [OH] and D/H in other apatite (72275,469 and ,491) suggested compositions similar to that of the Earth's interior [*21*]. Those sample analyses complement theoretical calculations of volatiles emitted from Serenitatis mare flows [*22*] and pyroclastic vents (e.g., the source of Apollo 17 orange glass deposits) [*23*].

Conclusions: It may be timely to initiate a new consortium study of Station 2, Boulder 1 that produces new splits of the four boulder samples that can, in turn, be examined with new analytical techniques and interpreted in the context of more mature ideas about basin-forming impact events. At the moment, it is still unclear whether the samples were produced by one or more impact events, whether they represent the adjacent Serenitatis impact event or not, and whether the felsite clasts and phosphate indicate a relatively wet or dry lunar interior.

Figure 2. Station 2, Boulder 1. AS17-137-20901.

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