THE APOLLO 17 CENTRAL CRATER CLUSTER AND A NEW LOOK AT POSSIBLE TYCHO COMPONENTS IN THE SOIL. B. L. JOLLIFF, R. L. KOROTEV, AND L. A. HASKIN, Dept. of Earth & Planetary Sci. and the McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130. (blj@levee.wustl.edu)

Summary. The Apollo 17 site is crossed by a ray from the crater Tycho and one expectation has been that there might be some identifiable remnants of Tycho primary ejecta at the site. We use a multiple approach, including geochemistry of rock fragments and soils from central-valley samples, new crater-ejecta modeling, and results from studies based on Clementine UVVIS data to reconsider this old and puzzling, but important problem. We find no evidence for a KREEPy Tycho component, rather the data suggest the possibility of added incompatible-element-poor granulitic and troctolitic lithologies.

Background and motivation. The central crater cluster on the floor of the Taurus Littrow Valley is thought to have formed from Tycho secondary impacts ~100 my ago [1, 2, 3]. Using a recent model for crater ejecta [4, 5], we estimate that, given a range of ejecta fragment sizes, there could be as much as 10% Tycho ejecta mixed with local regolith around the central crater cluster. The proportion of added material may be less, depending on the depth to which local soils were mixed and subsequently gardened. For a minimal case of a thin layer of added fine ejecta, gardening to 1 meter depth would reduce the proportion of Tycho material to one or a few percent.

Some unusual Apollo 17 materials have been suggested to be Tycho ejecta: the ropy glasses at station 4 [6] and "KREEP glass" from the deep drill core [7]. The ropy glasses, however, have compositions that are consistent with their being a mixture of Apollo-17-type highland and mare materials [6, 8]. The KREEP glasses may be exotic to the site, and if they represent Tycho ejecta, that implies widespread KREEP distribution on the nearside of the Moon, an important tenet that should also be tested with data from the Lunar Prospector gamma-ray experiment. However, the KREEP glasses are most abundant in the 210–260 cm interval [9]. Whereas the entire depth of core may represent deposition less than 200 my ago [10], particle tracks [11] and the fine-scale stratigraphy of the core [12] indicate that only the upper 80 cm [11] or 111 cm [12] were deposited significantly less than 200 my ago and could therefore be consistent with the implied 100 my year age of the Tycho secondary impacts based on rare-gas contents of exposed rocks [1].

It is possible that Tycho ejecta consisted mostly of typical, fragmented highland lithologies, such as anorthosite-norite-troctolite (or brecciated equivalents), as suggested by [13], or perhaps similar in makeup to the feldspathic lunar meteorites. In either case, such constituents might be difficult to distinguish from common Apollo 17 highland materials. Clementine UVVIS data for the Tycho central peak suggest a relatively mafic suite of gabbroic, noritic, and troctolitic lithologies [14].

One of the potentially best places to look for Tycho components is in those soils that contain the least highland material and are farthest from the massif slopes, i.e., those from station 5, in the ejecta of Camelot Crater, and LRV 12, in the ejecta of Sherlock Crater. There is only about 8–16% highland material in the <1-mm soil fractions from these stations [8]. Based on our analysis of Clementine images [15], the interiors and ejecta of the central cluster craters have among the highest FeO concentrations of any central-valley soils, approaching 19 wt.%, thus they did not excavate highland materials from below the basalt flows. It is in the ejecta of these craters that we would most expect to find remnants of the secondary projectiles mixed with basaltic debris, but uncontaminated by highland materials derived from smaller, more recent impacts into the highland massifs and Sculptured Hills. It should be possible to identify unusual highland lithologies by comparing to the extensive suite of rocks and rock fragments found in the North and South Massif soils [e.g., 15], and to their known proportions in highland soils. We have thus initiated a study of 1–4 mm rock fragments from two soils from each of those sampling locations (70312/3, 70322/3, 75062/3, 75082/3); we will refer to these as "central-cluster" soils. The following results are based on preliminary INAA of 112 rock fragments from these samples. We included a suite of basaltic fragments and regolith breccias so we could address mixing trends involving highland components.

Results. The rock fragments fall into 5 compositional groups: incompatible-trace-element(ITE)-poor highland lithologies, ITE-rich melt breccias, high-Ti mare basalt (Sc-rich), very-low-Ti (VLT) basalt (intermediate Sc, ITE-poor), and regolith breccias (Fig. 1). Based on similarities to large melt-breccia samples from highland stations, we have no reason at the present time to believe that any of the ITE-rich rocklets are exotic to the Apollo 17 site. Among the ITE-poor rock fragments, compositions are similar to rock fragments found in highland soils, but mainly in those from North Massif, all of which were collected just downrange of large secondary craters that presumably were from Tycho. The distribution of highland rock types, however, is unusual and may reflect a Tycho contribution.

First, ITE-poor granulitic rock fragments are abundant in the central-cluster soils. The proportion of ITE-poor highland rock fragments exceeds that of the ITE-rich ones by 5:1. Among rock fragments from Station 6 soil, representative of North Massif, this ratio is ~ 1:1, and in Station 2 soils, representative of South Massif, 1:5 [16]. In <1 mm soils from all Apollo 17 stations, none have such a high ratio of ITE-poor to ITE-rich components. Furthermore, slightly over half of these are relatively Sc-rich granulitic breccias (10–18 ppm Sc), which typically indicates a more ferroan major-element composition, consistent with anorthositic-gabbro precursors. Also, the siderophile-element contents of these rock fragments are on average lower than those of their typical Apollo 17 counterparts. We suggest that some or most of these ITE-poor rock fragments may come from the Tycho region.

Secondly, we find among the ITE-poor highland rock fragments some feldspathic fragmental and granulitic impactites that are compositionally similar to troctolite and troctolitic anorthosite. These have notably high Cr/Sc ratios (140–400) and siderophile-element concentrations that reflect a meteoritic component. Fragments such as these are not found in all Apollo 17 highland soils, in fact, they are found only in North Massif soils, and mainly at Station 6 [16] where 76535 (troctolite) and 76335 (troctolitic anorthosite) were also found. These lithologies constitute ~ 18 wt.% of the ITE-poor highland rock fragments in the central-cluster soils, more even than in Station 6 sample 76503 [16], where they are probably the most abundant of any Apollo 17 sample station [8].

The regolith breccias also hold important clues; they have substantial highland components, more than the local soils (Fig. 1), but similar to other central-valley soils. Their compositions form a narrow trend between mare basalts and highland lithologies (ITE-poor and ITE-rich). However, on the Sc-Sm plot, which separates the two highland groups, the regolith-breccia trend extrapolates to a compositional gap between the two groups. The fairly narrow trend of compositions among regolith breccias reflects, to a first approximation, binary mixing between a Sc-rich mare component and Sc-poor highland components, and indicates that the highland components were already fairly well mixed at the time the regolith breccias formed. The scatter in compositions, however, shows that the mixture ranged from about 50:50 to 80:20 (ITE-poor:ITE-rich). As a working hypothesis, we suggest that the regolith breccias incorporating the highest proportions of ITE-poor constituents relative to ITE-rich melt rocks formed during the impact of Tycho secondaries.

We will continue to investigate these samples for clues to a possible Tycho origin. We will compare compositions to those found during careful dissection and previous analyses of the deep drill core and test them using mixing analysis. We will examine Prospector data over the Tycho region for evidence of enrichment in mafic and KREEP components.

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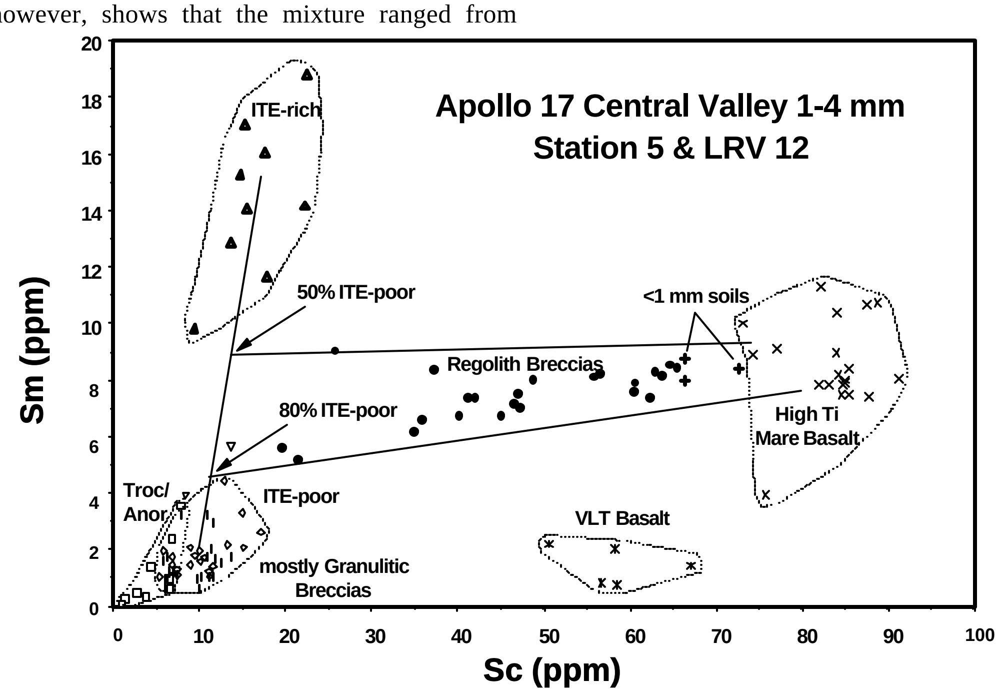

Figure 1. Sc vs. Sm in 1-4 mm rock fragments from Station 5 and LRV-12 soils.