SEARCHING FOR CRISIUM BASIN EJECTA: CHEMISTRY AND AGES OF LUNA 20 IMPACT MELTS Swindle T.[1], Spudis P.D.[2], Taylor G.J.[3], Korotev R.[4], Nichols R.H.[4], and Olinger C.T.[4] 1. Univ. of Ariz., Tucson, AZ 85721 2. U.S. Geological Survey, Flagstaff, AZ 86001 3. Univ. New Mexico, Albuquerque, NM 87131 4. Washington Univ., St. Louis, MO 63130

We have studied fragments of impact melt rocks separated from Luna 20 samples. One of our goals was to identify samples of the impact melt sheet of the Crisium basin, which has not yet been characterized. Studies of Apollo 15 and 17 samples (e.g., [1-3]) have shown that the Imbrium and Serenitatis melt sheets differ in composition (though both are LKFM) and age. Apollo 16 samples contain impact melts richer in Al_2O_3 ("VHA basalt"), suggesting that the melt sheet of the Nectaris basin differs in composition from the melt sheets of both the Imbrium and Serenitatis basins [4]. We also wished to constrain the age of the Crisium basin by dating fragments of its basin melt. The only age data previously available for Luna 20 samples indicate that an impact occurred at 3.86 Ga ([5]; recalculated using decay constants of [6]), a date contemporaneous with the formation of the Serenitatis basin [2, 3]. This Luna 20 melt rock is interpreted as Crisium ejecta by some [7], but it could be from another basin or a crater.

From the Luna 20 coarse fines, we hand-picked six fragments (A-F, Table 1) that macroscopically appear to be fine-grained crystalline rocks. These samples were irradiated for INAA and ^{40}Ar-^{39}Ar analyses. Enough remained of fragments A and B to prepare thin sections; both samples are highland impact melts. Formation ages of these six samples are shown in Table 1; some selected chemical data are presented in Figure 1.

Our results, combined with published data for other Luna 20 samples [8, 9], indicate the presence of at least three distinct melt groups and a large cluster of loosely associated rocks. The three labelled groups of Fig. 1 are composed of impact melts that have homogeneous major and trace-element compositions; the age of at least one sample in each group has been determined. We interpret these three groups as representing three separate impact events. Group 3 overlaps the field for the Apollo 17 poikilitic impact melts, interpreted to be of Serenitatis basin origin [2, 3]. Sample 22007,1 was dated at 3.86 Ga [5], an age indistinguishable from that of the Serenitatis basin. Group 2 forms a tight compositional cluster and is dated at 3.72 Ga. Group 1 consists of only two members, but sample B is a fine-grained melt rock with bulk chemistry approximating "anorthositic norite" [10], and it has a well-determined age of 3.92 Ga (Table 1). Among our other samples, C and D have indistinguishable ages of about 3.7 Ga, and A and E have young ages close to 0.4 Ga. However, because the rocks are compositionally distinct, each represents a separate impact.

The Crisium basin predates the Imbrium basin (3.85 Ga) and possibly the Serenitatis (3.87 Ga) basin [7]; the age of our Group 2 melt sample F (3.72 Ga) precludes a Crisium basin origin. Group 2 likely represents the melt sheet of a post-basin crater somewhere in the vicinity of the Luna 20 site. Group 3 has a chemical composition and an age indistinguishable from those of the impact melts of the Serenitatis basin [2, 3]. Although Group 3 contains the sample suggested by Wilhelms [7] to be from the Crisium basin, we tentatively identify our Group 3 with the Serenitatis impact (despite the considerable distance (750 km) of the Luna 20 site from the rim crest of Serenitatis). Although sparsely populated, Group 1 contains an impact melt (sample B) with a precise age (3.92 Ga) and a composition similar to that of another Luna 20 sample. Group 1 is definitely older than both the Imbrium and Serenitatis impacts and is contemporaneous with the Nectaris impact. This group is distinctive chemically in that its composition does not resemble either the LKFM composition associated with the Imbrium and Serenitatis basins [1-3] or the VHA basalt composition associated with the Nectaris basin [4]. Group 1 corresponds chemically to "anorthositic norite," a polymict composition long recognized as a major component of the lunar highlands [10].

We tentatively associate Group 1 impact melt with the Crisium basin. The Luna 20 site is either inside the topographic basin [7] or on its rim crest [11]; thus, impact melt from Crisium should constitute at least some of the Luna 20 samples. If Group 1 is Crisium melt, its aluminous composition could result from the formation of the Crisium basin in a thicker, more anorthositic crust, farther away from the central near side of the Moon than Imbrium or Nectaris [7]. The association of Group 1 with the Crisium basin also suggests that Crisium, although younger than Nectaris [7], formed fairly soon afterwards, both impacts having occurred around 3.92 Ga.

LUNA 20 IMPACT MELT ROCKS: Swindle T. *et al.*

Two Luna 20 samples, A and E, have exceptionally young ages, 0.46 Ga and 0.35 Ga, respectively, and represent crater (rather than basin) impacts. The samples are compositionally distinct and probably represent two separate impacts. Sample A is a relatively coarse grained impact melt and formed during an impact into an anorthosite-rich terrain. We have no petrographic information about sample E, but macroscopically it also appears to be an impact melt. Both samples have cosmic-ray exposure ages equal (within errors) to their formational ages, indicating that (1) they represent the upper meter of their respective melt sheets, (2) they formed as meter-sized molten ejecta, or (3) they were ejected from their melt sheets by a subsequent impact soon after their formation.

References [1] Ryder G. and Spudis P. (1987) *PLPSC* **17**, *JGR* 92, E432. [2] Winzer S.R *et al.* (1977) *EPSL* **33**, 389. [3] Spudis P.D. and Ryder G. (1981) *PLPSC* **12A**, 133. [4] Spudis P.D. (1984) *PLPSC* **15**, *JGR* **89**, C95. [5] Podosek F.A. *et al.* (1973) *GCA* **37**, 887. [6] Steiger R.H. and Jäger E. (1977) *EPSL* **36**, 359. [7] Wilhelms D.E. (1987) *USGS Prof. Paper* **1348**, 303 pp. [8] Laul J.C. and Schmitt R.A. (1973) *GCA* **37**, 927. [9] Smith M.R. *et al.* (1983) *LPS* **XIV**, 716. [10] Taylor S.R. (1982) *Planetary Science*, LPI Press, 481 pp. [11] Spudis P.D. *et al.* (1989) *LPS* **XX**, 1042.

Table 1. ^{40}Ar-^{39}Ar Ages of Luna 20 Impact Melts

Sample	T (Ga)
A	0.46 ± 0.01
B	3.92 ± 0.03
C	3.71 ± 0.04
D	3.67 ± 0.05
E	0.35 ± 0.10
F	3.72 ± 0.03
22007,1*	3.86 ± 0.03
22006,1*	3.86 ± 0.03

* from Podosek et al. [5]

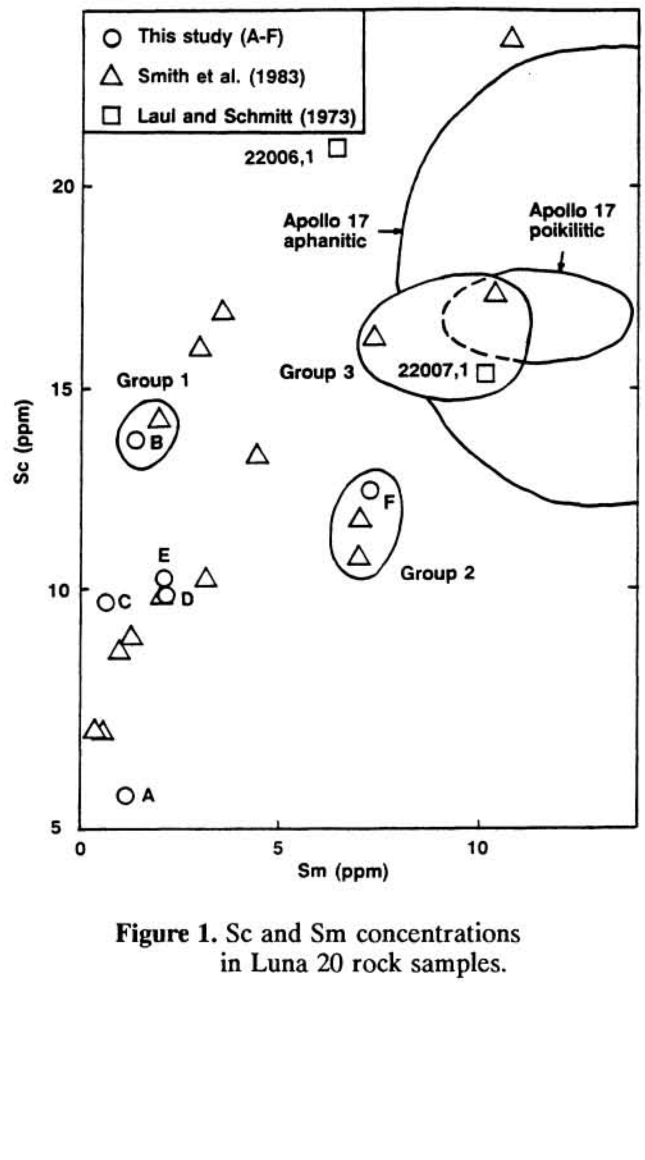

Figure 1. Sc and Sm concentrations in Luna 20 rock samples.