QUE93069, A MORE MATURE REGOLITH BRECCIA FOR THE APOLLO 25TH ANNIVERSARY. M.M. Lindstrom[1], D.W. Mittlefehldt[2], R.V. Morris[1], R.R. Martinez[2] and S. J. Wentworth[2] 1) SN NASA-JSC, Houston TX 770582) C23 Lockheed, Houston TX 77058.

QUE93069 [1] is the 10th distinct lunar meteorite and the Apollo 11 25th anniversary lunar sample. It is a highlands regolith breccia that is more mature than the other highlands lunar meteorites. Based on partial analyses, its composition is similar to, but distinct from, that of MAC88104/5. Similarities in lithophile elements suggest similar protoliths, while differences in siderophile elements and I_S/FeO require distinct regolith histories.

Samples and Analyses. We were allocated a 300 mg bulk sample of QUE93069 (,17) and a 100 um thick section (,34) for extraction of clasts. Our sample description is based on a library thin section (,5). We split our bulk specimen for analyses. The clasts were too small to separate from the glassy matrix so we broke up the sample and hand-picked a clast-rich sample, a coarse clast-poor sample, and fine material. These samples were further split for INAA, RNAA and FB-EMPA. The fused bead portion of the fine sample was analyzed by FMR to determine maturity. We have done preliminary INAA on the three samples, but final data and other analyses are not yet complete.

Petrography. QUE93069 is a glassy matrix breccia containing numerous clasts which are seriate in size. The matrix consists of light to dark brown glass and very fine grained mineral fragments. Numerous glass spheres and fragments are evidence that the meteorite is a regolith breccia. Most of the glass spheres are colorless, but a few are orange. The breccia also has scattered tiny particles of metallic iron. The metal distribution is not uniform; some clasts are enriched and others depleted compared to the matrix. The two largest clasts are fine-grained granulitic breccias and the next largest clasts are fine-grained impact melts. None of the clasts preserve obvious igneous texture.

Surface Maturity. Ferromagnetic resonance measurements were taken on the fine portion of the bulk sample. I_S/FeO was calculated using the INAA FeO data. The value of I_S/FeO is 34 units, which is within the submature range for lunar soils (30-60; [2]). This is much higher than any of the other lunar meteorites. Our new value for MAC88105 is < 0.8 units and reported value for ALHA81005 is 5 units [3], both of which are immature.

Geochemistry. Partial INAA data for our three subsamples of QUE93069 are reported in the table and compared to mean compositions of the other highland lunar meteorites. Our partial major element analyses for fine and coarse bulk samples are essentially identical to Mason's [1] analysis of fusion crust. The meteorite is clearly a very feldspar-rich highland breccia. For essentially all elements measured the compositions of fine and coarse subsamples are very similar to each other and distinct from that of the clast-rich subsample. The distinctions between these bulk and clast-rich samples are minor, however, except for the siderophile elements. Ni, Co, Ir, and Au concentrations are about a factor of two higher in the clast-rich sample.

Comparison with other highland meteorites shows that concentrations of major elements and lithophile compatible elements in bulk samples are very similar to those of MAC88104/5 and Y86032, the two most feldspathic lunar meteorites. Concentrations of incompatible and siderophile elements distinguish these three lunar breccias. Incompatible concentrations in QUE93069 are about 25% higher than in MAC88104/5, which are in turn a factor of two higher than in Y86032. Internal variations in each sample are much smaller than variations between samples [4]. Concentrations of siderophile elements are a factor of two higher in QUE93069 than in either MAC88104/5 or Y86032.

Table 1. Major and trace element concentrations determined in lunar meteorites by INAA.

Sample	Q93069 ,17 fine	Q93069 coarse	Q93069 clast-rich	M88104/5 mean	A81005 mean	Y791197 mean	Y82192/3 mean	Y86032 mean
Ref				4	5	5	6	7
FeO (%)	4.36	4.35	5.10	4.31	5.51	6.39	5.68	4.22
CaO	16.4	16.3	16.0	16.7	15.0	15.4	14.7	16.2
Na2O	0.354	0.350	0.356	0.336	0.30	0.33	0.40	0.43
Sc (ppm)	7.62	7.59	7.52	8.67	9.10	13.3	12.5	8.27
Cr	599	603	630	630	890	900	997	666
Co	23.7	22.9	43.2	14.6	21.0	18.7	17.8	14.4
Ni	326	302	740	148	198	174	134	131
La	3.22	3.33	3.11	2.53	1.98	2.11	1.21	1.33
Sm	1.52	1.54	1.47	1.17	0.95	1.05	0.63	0.63
Eu	0.83	0.82	0.80	0.81	0.69	0.78	0.83	0.93
Yb	1.23	1.26	1.17	0.99	0.84	0.99	0.71	0.60
Hf	1.13	1.32	1.11	0.88	0.73	0.84	0.58	0.47
Ir (ppb)	14.9	13.0	26.0	7.1	6.8	6.6	4.3	5.3
Au	5.2	5.5	13.5	2.4	2.2	5.1	1.5	2.4

Discussion. QUE93069 is the most mature lunar regolith sample that has been recovered as a meteorite. Evidence of surface maturity is seen in its high I_S/FeO value, abundant glasses in thin section, and high siderophile element concentrations. Nonetheless, it has very similar bulk composition to other much less mature lunar meteorites from (presumably) other sites on the Moon. Since none of these lunar meteorites contain much of the mafic Mg suite or KREEP rocks found at major basins or basalts from the mare, they represent highlands areas remote these prominent nearside features. This suggests that the highlands protolith in is remarkably consistent in composition. Since all of these breccias now consist of far more granulitic breccias and impact melts than igneous fragments, their metamorphic and impact histories were similar. The major differences are in their regolith histories as seen in their surface maturities and siderophile elements. Closer examination of siderophile element concentrations shows that the ratios of siderophile elements are not constant. Ratios of Ni/Ir and Au/Ir are CI chondritic for bulk samples. In each case, clasts enriched in siderophiles have been identified. Such clasts in MAC88105 have sub-chondritic ratios, while our clast-rich sample of QUE93069 has super-chondritic ratios. Super-chondritic Ni/Ir and Au/Ir ratios have been observed in Apollo 16 soils and attributed to komatiite precursors [8] or to iron meteorite projectiles for the KREEPy Apollo 16 impact melts [9]. We favor a meteoritic model for highlands siderophile element variations, but find the number of distinct iron meteorite impacts required to account for the sample variations to be unreasonably large. The overall chondritic siderophile element ratios of the breccias suggest that there may have been minor fractionation of siderophiles during impact as seen for some terrestrial impact craters [10].

References. [1] Satterwhite C. et al. (1994) Ant. Met. News. 17 (2). [2] Morris R.V. (1983) GRL 10, 807. [3] Morris R.V. (1978) PLPSC9, 2287. [4] Lindstrom M.M. et al. (1991) GCA 55, 3089. [5] Warren P.H. & Kallemeyn G.W. (1987) NIPR 46, 3. [6] Lindstrom M.M. et al. (1991) NIPR 4, 12. [7] Koeberl C. et al. (1986) NIPR 2, 15. [8] Ringwood A.E. et al. (1987) EPSL 81, 105. [9] Korotev R.L. (1987) PLPSC17, E491. [10] Mittlefehldt et al. (1992) Met. 27, 361.