THE COMPLEX IRRADIATION HISTORY OF THE GHUBARA (L5) REGOLITH BRECCIA. T. E. Ferko[1], M.-S. Wang [1], D. J. Hillegonds[1], M. E. Lipschutz[1], R. Hutchison[2], L. Franke[3], P. Scherer[3], L. Schultz[3], P.H. Benoit[4], D.W.G. Sears[4], A.K. Singhvi[5], and N. Bhandari[5, 1]Department of Chemistry, Purdue University, West Lafayette, Indiana 47907, USA, [2]Department of Mineralogy, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K., [3]Max-Planck-Institut für Chemie, Postfach 3060, 55020 Mainz, Germany, [4]Department of Chemistry and Biochemistry, University of Arkansas, Fayetteville, Arkansas 72701, USA, [5]Physical Research Laboratory, Ahmedabad 380 009, India.

Introduction: The Ghubara (L5) black xenolithic chondrite from Oman includes at least 4 large individuals, 3 being acquired in 1954, 1956 and 1958 by the British Museum (National History). To study cosmic ray effects as a function of position in the largest, the 101.6 kg 1958 individual, we prepared 3 orthogonal 1-cm cores (length, 42.5 cm, 45.8 cm, and 41.2 cm). [When cored, this individual (hereafter BM 1958) constituted >50% of the find: very recently, another 300 kg individual was found.] We split each core lengthwise and sampled host (H) and xenolithic types X1 and X2 at various points along each, for determination of noble gases and long-lived cosmogenic ^{36}Cl ($t_{1/2}$, 301 ka), ^{26}Al (705 ka) and ^{10}Be (1.50 Ma). We also sampled BM 1958 for determination of volatile trace elements by RNAA, thermoluminescence (TL) and track measurements. We measured cosmogenic ^{14}C ($t_{1/2}$, 5.73 ka) in BM 1958, BM 1954 and BM 1956.

Results: While PTS of all three Ghubara individuals are similar, sulfides in BM 1956 and 1958 (but not BM 1954) are spongy, sometimes containing an eutectic intergrowth indicative of a residual temperature $\geq$ 988°C. Troilite in BM 1954 is coarsely recrystallized but not spongy, indicating lesser shock-loading (and heating) than 1956 and 1958.

All M, X1, and X2 samples from BM 1858, as well as from BM 1954 lie along a single mixing line on a 3-isotope Ne plot. The average cosmogenic ^{22}Ne/^{21}Ne ratio is 1.08 and the solar ^{20}Ne/^{22}Ne ratio in Ghubara is 12.9, typical for solar gas-containing chondritic ratios. Apparently, xenoliths were irradiated as dust on an earlier surface and later combined with irradiated host. Host and xenolith samples contain equivalent levels of Bi, Tl, and In and are rich in Rb and Cs: these are chemical characteristics seen previously only in H portions of regolith breccias.

Cosmogenic radionuclides suggest a burial depth of ~20 cm in an 85-cm meteoroid for 4.2 Ma, but cosmogenic ^{21}Ne and ^{38}Ar suggest much longer exposure, hence two irradiation stages.

Interpretation: Ghubara is a regolith breccia exhibiting a light-dark structure, each part of which contains solar gases. From induced TL sensitivity, its regolith was moderately mature, like Pantar I or St. Mesmin. While Ghubara BM 1954, 1956 and 1958 are mineralogically similar, BM 1954 shows less shock-loading and heating than BM 1956 or BM 1958. From ^{14}C, all three individuals have terrestrial ages of 2.5 ka, consistent with derivation from a single meteoroid.

Differences between individuals are most noticeable for noble gases. BM 1958 cores lost most of their solar ^{4}He compared with BM 1954 and all previous Ghubara data. Shock heating in BM 1958 is also evident in loss of low-temperature TL and nuclear tracks, and in noble gas similarities between light and dark regions. Low temperature TL loss, while high temperature TL is still present, suggests peak temperatures $\leq$ 330°C.

The noble gas and RNAA results indicate that Ghubara matrix and clasts represent two generations of asteroid regoliths where solar noble gases were implanted and ~70% of the cosmogenic noble gases were produced. Ghubara was buried for >4-5 Ma, then re-excavated and heated. Ghubara acquired a 4.2 Ma CRE age as an 85 cm meteoroid, with BM 1958 being shielded at depths of ~20 cm. During the short heating, temperatures were non-uniform. Part of the object (BM 1958 and BM 1956 - but not BM 1954) lost much or nearly all ^{4}He with nuclear tracks being erased from BM 1958. Such heating differences are unprecedented in non crater-forming events, as is evidence for two generations of regolithic exposure of a single meteoroid.