MAGNETIC PROPERTIES AND TEMPERATURES OF FORMATION OF LUNAR BRECCIAS; G. W. Pearce*, D. W. Strangway+, and W. A. Gose*
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We have examined two processes that have contributed to the character of lunar soils and breccias. In one of these (1) the iron-bearing silicates will reduce to native iron under reducing conditions at high temperatures. By annealing for periods of a few days or less at temperatures below 900°C, the fine grained-single domain (SD) and superparamagnetic (SP) iron found in lunar soils and soil breccias (2) is produced. At higher temperatures the iron produced is coarser, being almost entirely of multi-domain (MD) size (> 1000Å). Subsolidus reduction can account for the excess metallic iron in the soils and breccias compared to that in the igneous rocks (2).

The second process examined is grain coarsening of the iron already present in a sample. We have observed this phenomenon in heating experiments on soils and soil breccias. The mechanism involved appears to be vapor transport of iron from smaller particles to larger particles, a process driven by reduction of surface energy. The experiments consisted of heating a sample to a particular temperature for about one hour in a good vacuum (10^{-5} mm Hg or better), cooling the sample, measuring its magnetic properties at room temperature and comparing them with the properties measured before heating. Two properties illustrate the coarsening particularly well: magnetization curve shape and coercivity (H_c). The magnetization curve varies from a very rounded shape when fine-grained iron is abundant (< 1000Å) to a ramp shaped curve when only MD iron is present (2). H_c for lunar soils and soil breccias is greatly reduced by induced magnetization of SP (< 150Å diameter) grains and as these are removed, H_c should increase (3). In figure 1, H_c at room temperature is plotted against annealing temperature for two soils, 12020 and 15601, and for a soil breccia, 15498. H_c for the soil samples increased drastically after heating to about 600°C whereas the breccia shows no appreciable increase and, in fact, is initially at the level the soils reach after the heating to 600°C. Since this breccia was formed from soil, it is probable that it was heated to 600°C or more during its formation. The magnetization curve for one of the soils (fig. 2) shows considerable flattening after annealing at 671°C and the curve is quite ramp like after heating to 800°C. 15498 shows little change in magnetization curve after heating to 610°C but,

like the soil, the curve after heating to 800°C is fairly ramp shaped. Thus much of the SD iron as well as the SP iron is eliminated by heating to 800°C and neither soils nor soil breccias could have been heated that high for long.

The results of these experiments and those of the subsolidus reduction experiments have been combined and summarized in fig. 4 to present a rough picture of temperatures of formation for the different grades of breccias as defined by Warner (4).

References

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(4) J. Warner, Geochim. Cosmochim. Acta, Suppl. 3, 623 (1972).

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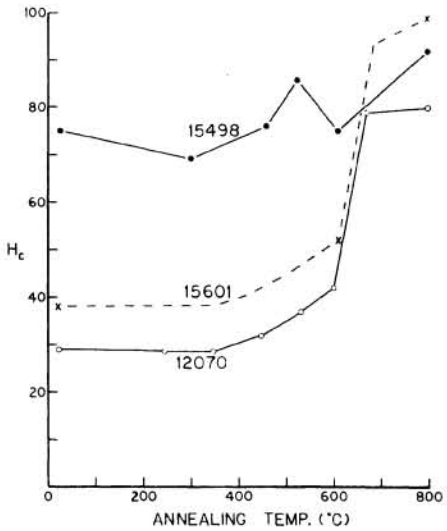
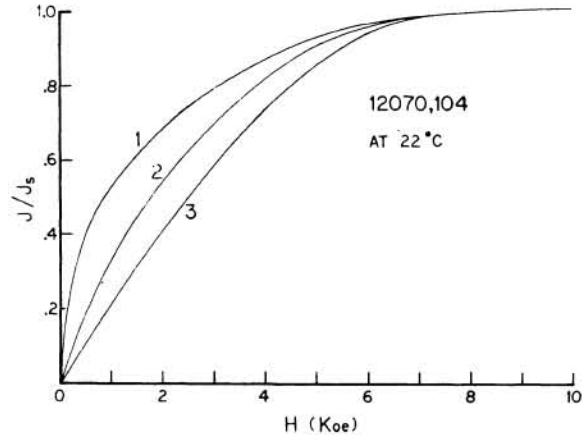
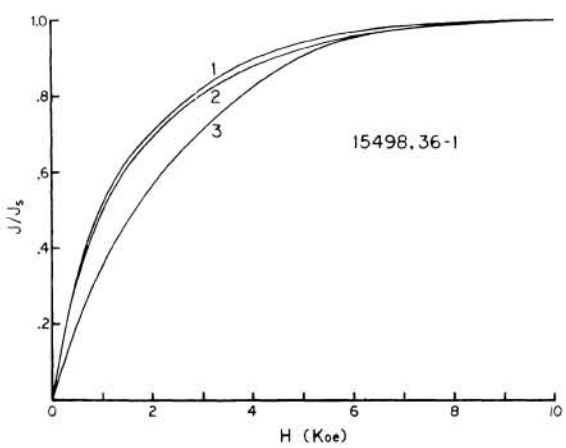


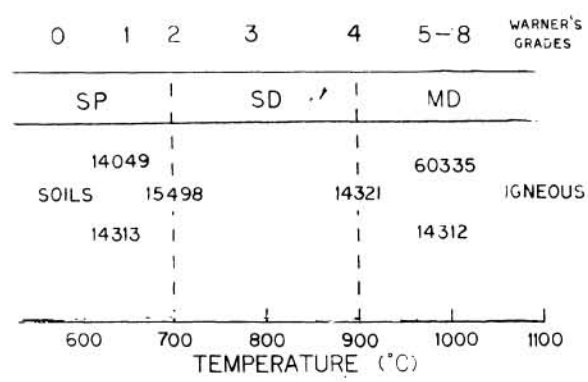
1 - Change of room temperature coercivity H_C with annealing temperature.



2 - Magnetization curves at room temperature for 12070. Curve 1 is initial measurement, curve 2 is after annealing at 671°C and curve 3 is after J_s-T curves.



3 - Magnetization curves at room temperature for 15498. Curve 2 is initial curve; curve 1, after heating to 610°C and curve 3 after J_s-T.



4 - Classification of some lunar samples with respect to temperature of formation, metamorphic grade and characteristic iron grain size.