EFFECTS OF METEORITIC IMPACT ON MAGNETIC PROPERTIES OF LUNAR SURFACE MATERIALS

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The ferromagnetic constituents of Apollo lunar materials are metallic Fe-Ni alloys (with Co less than 2 weight per cent) in almost all cases. As shown in Fig. 1, the saturation magnetization (I_S) of lunar breccias and fines is larger than that of igneous rocks by about one order of magnitude. This fact could lead to a simple suggestion that the ferromagnetic metals in breccias and fines have mostly come from meteorites which impacted the lunar surface. The thermomagnetic curves of lunar materials have shown that the metals are either a single component of almost pure iron (with Co less than one per cent) or a superposition of two components, i.e. the almost pure iron and kamacite of 3 ~ 13 weight per cent of average Ni content. Histograms of the observed ratios (kamacite / total ferromagnetic metal in weight = m_k/m) are illustrated in Fig. 2, where the compositions of ferromagnetic metals can be classified into two distinct groups. With regard to the distinct grouping of m_k/m ratio, no essential difference can be observed between igneous rocks and breccias or fines.

Fig. 1 APOLLO 11-17 LUNAR SAMPLES HISTOGRAM OF SATURATION MAGNETIZATION

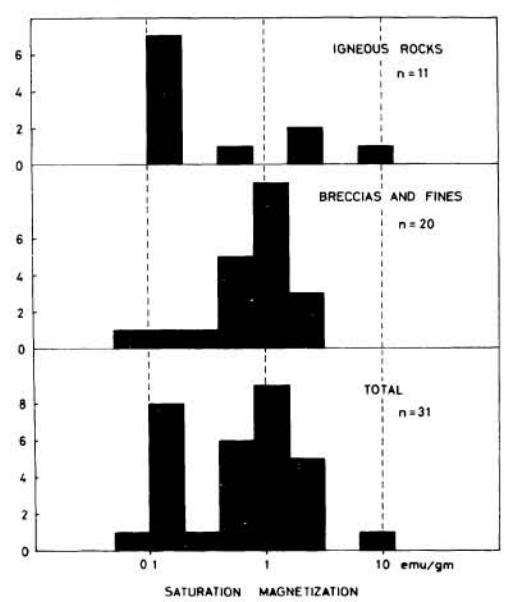
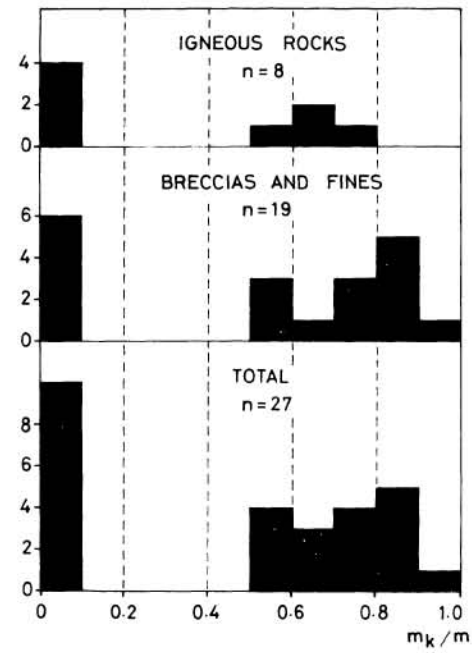


Fig. 2 APOLLO 11-17 LUNAR SAMPLES HISTOGRAM OF KAMACITE CONTENT IN METALLIC IRON (m_k/m)



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On the other hand, the observed thermomagnetic curves of kamacite components in lunar materials are considerably different from those of synthesized Fe-Ni alloys of a single composition ; particularly, the temperature range of the $\gamma - \alpha$ transition in the former is significantly broader than that in the latter. This fact may indicate that the lunar materials contain kamacite grains of a broad variety of Ni content. Since the standard thermomagnetic curves of a binary system of Fe-Ni alloys are known, the spectrum of Ni content can be evaluated by numerically solving an integral equation representing the observed thermomagnetic curves which consist of those of Fe-Ni alloys of different Ni contents. Fig. 3 shows the average spectra of Ni contents in kamacites for a group of lunar igneous rocks and another group of breccias and fines together with similar spectra of three kinds of meteorites for comparison. In this figure again, no essential difference can be observed between the spectrum of igneous rocks and that of breccias and fines. Namely, their spectra have the largest peak at 7% in Ni content and are extended up to about 20% of Ni. The Ni content spectra of lunar materials look very similar to that of carbonaceous chondrite (C4), except for the component of very low Ni content, but is significantly different from those of chondrites (H4 and L), which have a sharp upper cut at 6% Ni.

Summarizing these statistical results, the simple idea that the metallic Fe-Ni alloys of meteoritic origins have migrated only into lunar fines and breccias could hardly be accepted . The igneous rocks which contain a considerable amount of kamacite (15556 and 68415) (1) may be products of the remelting of pre-existing lunar surface materials. A possibility of this type of lunar igneous rock has already been pointed out (2,3 and 4). As shown in Fig. 2, six samples of lunar breccias and fines contain only almost pure iron and very little kamacite. As pointed out by El Goresy et al.(5), the abundant component of almost pure iron in sample 14053, which contains an anomalously large amount of metallic iron (1.01 weight%) as a lunar igneous rocks (6), is due to a product of the fayalite breakdown. Then, the abundant pure iron in breccias and fines also may be due to a similar mechanism, as suggested by Pearce et al. (7). It is not clear yet, however, why the spectrum of Ni content in the kamacite component in lunar materials is similar to that of the carbonaceous chondrite.

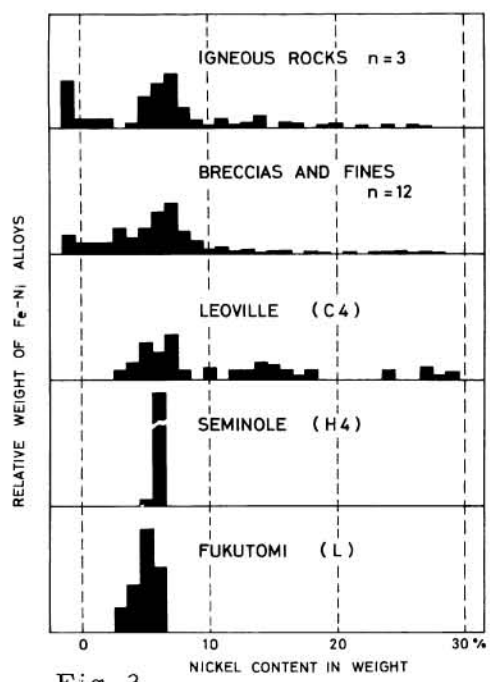

Fig. 3

Another remarkable effect of meteoritic impact on lunar rock magnetism is the magnetic

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hardening. Among 34 magnetically examined samples from Apollo 11 through 17 returned lunar materials, three samples (10048, 10085 and 60255) have an extremely stable component of natural remanent magnetization (NRM). These three samples are shock-metamorphozed breccias or coarse grains in soils, and consequently their coercive force (H_c) and remanence coercive force (H_{RC}) are very high compared with those of other lunar samples, namely, $H_c = 50$, 125 and 47 Oe. and $H_{RC} = 520$, 670 and 680 Oe. for samples 10048, 10085 and 60255 respectively. Because of the high value of H_{RC}, the relaxation time of magnetization of single domain particles is much larger than the moon's age (4.5×10^9 years) even at the lunar midday temperature. Thus, the stable component of NRM of these sample is considerably larger and extremely stabler than that of other lunar samples.

References

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