DURATION OF MAGNETIC FIELD(S) ACTING ON METEORITE PARENT BODY(S).

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Study of remanent magnetization in meteorites began 15 years ago when Lovering and Stacey [1959] and Stacey and Lovering [1959] initiated their studies. Although attempts have been made at estimating the intensities of paleofields which acted on meteorite parent bodies [Stacey et al., 1961; Weaving, 1962; Gus'kova, 1963; Banerjee and Hargraves, 1972; Brecher, 1972; Butler, 1972], none have been directed toward estimating the temporal distribution or duration of these fields. It is the purpose of this note to undertake a preliminary attempt at estimating the time that the magnetic field(s) existed and acted on meteorite parent bodies. Information necessary for this preliminary analysis is available in the literature, although a more careful check on the assumptions used will require further studies—both on the diffusion of Ar and on the magnetic properties of meteorites.

For the present, I will confine my comments to magnetic studies on ordinary stony meteorites (chondrites) since recent studies indicate that paleointensity determinations on carbonaceous chondrites may be more complex than originally thought [Watson et al., 1974; Herndon et al., 1974] and necessary data is not available on the iron meteorites. There are eight chondrites which have had estimations of the intensity of the ancient fields implanting the magnetization in them: Brewster [Weaving, 1962], Farmington and Mt. Browne [Stacey et al., 1961], and Mordvinoka, Ochansk, Pultusk, Rakovka, and Zhovtnevyi [Gus'kova, 1963]. Of these, five have undergone the necessary chronological studies, i.e., gas retention ages: Farmington, Mt. Browne, Ochansk, Pultusk, and Zhovtnevyi [Zahringer, 1966]. K-Ar ages reported were 0.7, 4.1, 3.7, 3.9, and 4.0 A a (AE=10 years), respectively for those meteorites.

The essential argument is: If a sample exhibits a low K-Ar age, I assume that the sample was heated to a temperature high enough to drive off the requisite amount of Ar. By examining the rare gas studies arbitrarily selected from several laboratories on the thermal release of Ar from stony meteorites and lunar samples, I make a crude estimate of the temperature...
required to drive off a certain fraction of the Ar\textsuperscript{40}. After estimation of the temperature reached, I examine the effect of this temperature on the magnetization of the sample.

Of the five chondrites above which are dated, only Farmington is much lower than the expected age of -4.6 AE with a K-Ar age of -0.7 AE. Thus assuming a one-stage Ar\textsuperscript{40} loss I estimate that \textasciitilde87\% of the Ar\textsuperscript{40} must have been lost to result in such a low K-Ar age. To remove \textasciitilde87\% of the Ar\textsuperscript{40} from lunar samples by stepwise heating, temperatures of 1040 to 1100°C were required in three independent studies [Alexander et al., 1972; Huneke et al., 1972; Kaiser, 1972] and similar studies on four stone meteorites required temperature of 750 to 1200°C [Reynolds and Turner, 1964; Manuel et al., 1972; Miller et al., 1973]. The value of 750°C stands alone; all others were 1000°C or more. I thus estimate from this data that a temperature of \textasciitilde1000°C is generally necessary to remove 87\% of the Ar\textsuperscript{40} from diverse samples in laboratory studies. This is obviously a long extrapolation, i.e., from laboratory heating to parent body heating. But Wood [1967] presented good petrologic evidence that Farmington had been severely heated. Note, that the estimated temperature (-1000°C) is \textasciitilde250°C higher than the Curie point of iron. While more experimentation is obviously desirable, new gas release studies via linear heating [Frick et al., 1973] seem to support this as a reasonable means for estimating the temperature necessary for Ar\textsuperscript{40} removal. For example, Frick et al. found that if a sample is heated linearly to a certain temperature, T\textsubscript{m}, allowed to cool and once again linearly heated to even higher temperatures, the gas release exhibits the following characteristic: Upon the second heating, only small amounts of addition Ar\textsuperscript{40} release are observed until about T\textsubscript{m} is reached, where the Ar\textsuperscript{40} release increases rapidly until the rate of Ar\textsuperscript{40} release is virtually identical with the rate observed during the initial heating. Gas release at temperatures below T\textsubscript{m} during the second heating is less than expected if the mechanism were purely classical diffusion loss.

Stacey, et al. [1961] demonstrated that the magnetization in Farmington was carried primarily by nickel-iron (as it was in all chondrites studied). Since the remanent magnetization in nickel-iron disappears at temperatures \textgtr 770°C, no remanent magnetization is expected in Farmington since the
time of outgassing (-0.7AE), unless it re-cooled in the presence of a magnetic field. Therefore I tentatively suggest that the Farmington chondrite parent body was outgassed -0.7 AE ago (or more recently) losing ≥ 87% of its total Ar and most likely reached at a temperature of >770°C, thus erasing whatever magnetic remanence was previously recorded. However, a magnetic field seems to have been present on the Farmington parent body as recently as -0.07 AE ago in view of the remanence found in the Farmington chondrite by Stacey, et al. Fig. 1 shows a schematic history of the Farmington meteorite.

That a magnetic field was associated with the Farmington meteorite as recently as -0.7 AE ago should not be taken as evidence that a steady magnetic field existed in the early history of the solar system and extended to at least 0.7 AE ago. As Stacey [1967] aptly stated, "While alternative explanations of the primary magnetizations of chondrites cannot be finally excluded, the most satisfying ones at the present time require a parent body with a magnetic field. However, there is no experimental basis for asserting that it was a steady (terrestrial-type) field, generated by a well-developed core, and not a transient field accompanying the break-up of the body." Perhaps, in view of the difficulties involved in maintaining an ~4 AE long core on meteorite parent bodies, [Fish et al., 1960; Wood, 1967; Fricker et al., 1970; Herndon and Rowe, 1973], a transient field accompanying the break-up of the parent body is more probable than a steady field.

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REFERENCES

REFERENCES (Continued)


Fig. 1. Schematic representation of the history of the Farmington meteorite. Time axis grossly distorted.