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^{40} 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 intentsity 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 Aeons ($AE=10^9$ 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^{40}. By examining the rare gas studies arbitrarily selected from several laboratories on the thermal release of Ar^{40} from stone meteorites and lunar samples, I make a crude estimate of the temperature

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required to drive off a certain fraction of the Ar^{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^{40} loss I estimate that ≳87% of the Ar^{40} must have been lost to result in such a low K-Ar age. To remove ~87% of the Ar^{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 ~1000°C is generally necessary to remove 87% of the Ar^{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 ~250°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^{40} removal. For example, Frick et al. found that if a sample is heated linearly to a certain temperature, T_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^{40} release are observed until about T_m is reached, where the Ar^{40} release increases rapidly until the rate of Ar^{40} release is virtually identical with the rate observed during the initial heating. Gas release at temperatures below T_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 ≳ 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 $\geq$ 87% of its total Ar^{40} 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 transcient 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 transcient field accompanying the break-up of the parent body is more probable than a steady field.

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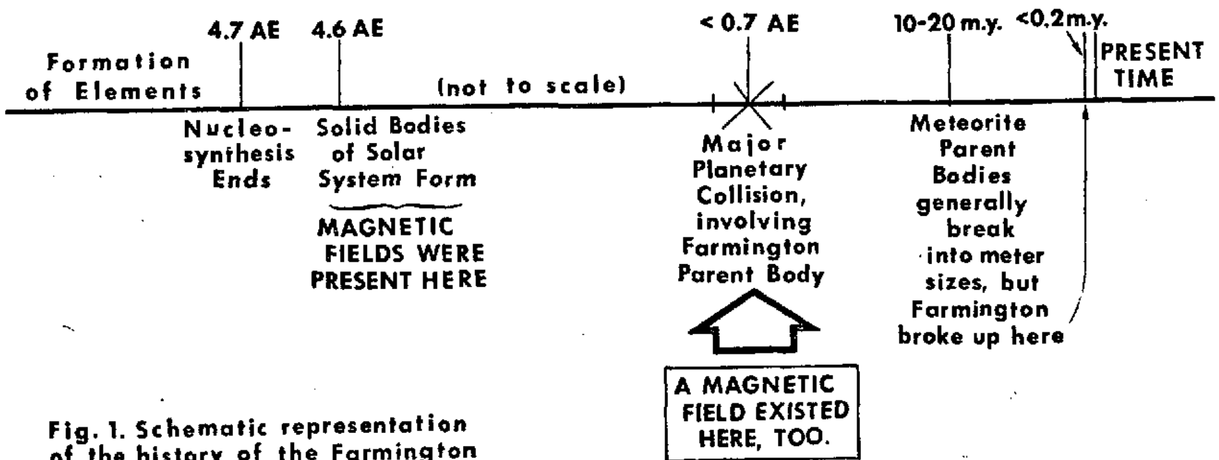

Fig. 1. Schematic representation of the history of the Farmington meteorite. Time axis grossly distorted.