

A SOLAR ORIGIN FOR THE LARGE LUNAR MAGNETIC FIELD AT  $4.0 \times 10^9$  YRS AGO? S.K. Banerjee and J.P. Mellema, Dept. of Geology and Geophysics, Univ. of Minnesota, Minneapolis, Minn. 55455

We present here lunar paleointensity measurements after Shaw (1) on three subsamples from a meter-sized recrystallized breccia 72215 of age  $4.0 \times 10^9$  years (2). The average paleointensity is  $0.4 \pm 0.17$  oe. In terms of the two main competing models for the origin of the lunar magnetic field, the iron-core dynamo (3) and the uniformly magnetized lunar silicate core (4,5), the former is more compatible with our data. However, in view of the similarity in magnitude and age of this field and that deduced (6,7,8) from carbonaceous chondrites, we draw attention to another possibility: that such large fields were external to the moon and emanated from a pre-main sequence T-Tauri stage sun.

Shaw's (1) method consists basically of comparing the alternating field (AF) demagnetization curves of the NRM and a laboratory TRM given in a known field. It has two desirable characteristics: (a) reliance on simulating the natural remanent magnetization (NRM) directly with a thermoremanent magnetization (TRM) and (b) a built-in monitoring device for thermally-induced sample degradation (oxidation, sintering and annealing) which is a common hazard with all lunar samples.

Taken together, the data from AF demagnetization of NRM and textural and petrological evidences (9) point to a TRM origin of the NRM of 72215. Fig. 1a shows the comparative AF demagnetization data of ARM (1000 oe AF, 0.5 oe steady field) for 72215,56 before and after imparting of TRM necessary for paleointensity determination. The excellent agreement between the two curves point to the persistence of sample integrity after the single heating to  $790^\circ\text{C}$  in  $10^{-6}$  Torr. Fig. 1b is a replot after Shaw which identifies the unchanged coercivity fractions nearest to the  $45^\circ$  slope line. Fig. 2 is a plot of TRM versus NRM for indicated AF demagnetization levels ( $\approx$  remanence coercivities). An obvious break at 100 oe guided us in the choice of the coercivity threshold below which the data were rejected for the paleointensity determination. The inset in Fig. 2 shows a least squares fit through the best data giving a paleointensity of  $0.55 \pm 0.10$  oe. The other subsamples, 72215,46 and 72215,93 gave best fit values of  $0.41 \pm 0.17$  and  $0.28 \pm 0.07$ , respectively. The overall mean is about 0.4 oe.

Leaving aside other paleointensity determinations involving approximate methods such as simulating the TRM of the lunar samples with an ARM or IRM, there are now only five published determinations involving complete heatings to the highest blocking temperatures. Of these, our three values (mean = 0.4 oe at  $4.0 \times 10^9$  years) reported here and Collinson et al.'s (10) single value of 1.2 oe at  $3.9 \times 10^9$  years pertain to about the same early time in lunar history. Such high values (0.4 - 1.2 oe) mean an early lunar field some  $10^4$  times greater than the present interplanetary or solar flare fields.

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The fifth determination by Gose et al. (11) yielded a value of 0.02 oe at  $3.3 \times 10^9$  years, a significantly weaker field at a younger time. The large values at  $4.0 \times 10^9$  years require us to put some constraints on the two main competing models for an internal lunar field. Thus, the permanently magnetized silicate core hypothesis would now require an early solar field of 75 oe, uniform over  $10^3$  km, if we use the latest value (12) of lunar iron content. This is clearly less likely than an internal source in the form a Sonnett and Runcorn (13) core dynamo. However, the apparent coincidence of our values of 0.4 - 1.2 oe at  $4.0 \times 10^9$  years and that of 0.2 - 1.1 oe at  $4.0 - 4.4 \times 10^9$  years from carbonaceous chondrites suggests that the early lunar field may well have been solar and external and was operative only during the lunar assembly and the intense collisioning process. Later, the field decreased to low values of the order of  $\leq 0.02$  oe, as found by Gose et al. The source(s) for the latter could be different, such as locally magnetized crust, surficial dynamos operating at or just under the surface, etc.

## REFERENCES

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Fig. 1a.

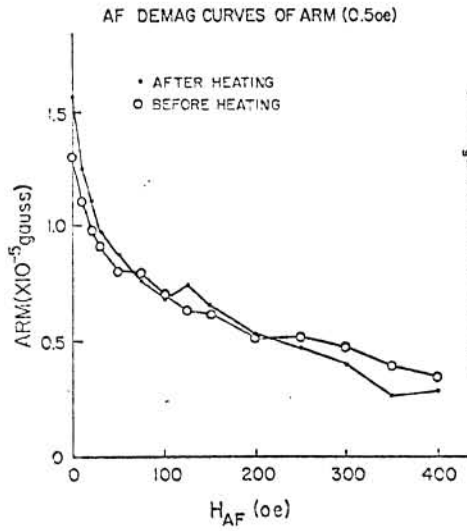


Fig. 1b.

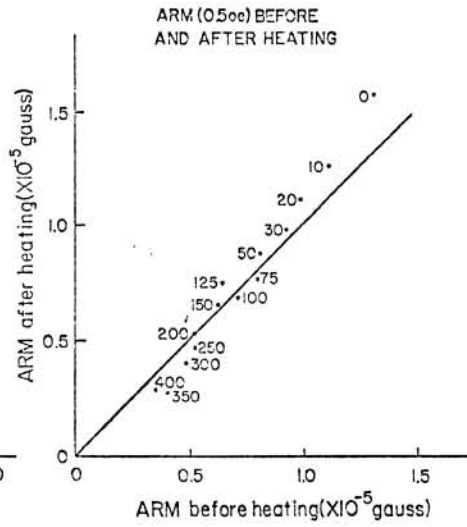


Fig. 2

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