

## South Pole Aitken Basin Magnetic Anomalies: Evidence for the True Polar Wander of Moon and a Lunar Dynamo Reversal. J. Arkani-Hamed<sup>1</sup> and D. Boutin<sup>2</sup>,

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**Introduction:** Magnetic anomalies inside South Pole Aitken basin have been interpreted in terms of shock remanent magnetization at the antipodal zones of Imbrium and Serenitatis impacts <sup>[1]</sup>, or the magnetization of thin layers of ejecta from a highly magnetic impactor that created the basin <sup>[2]</sup>. Both interpretations require a very short magnetization time. We model the magnetic anomalies of the basin and show that the magnetic source bodies were magnetized in a very long time, during which the Moon performed  $\sim 100^\circ$  true polar wander and a distinct core dynamo reversal occurred.

**Magnetic Anomalies of South Pole Aitken Basin (SPAB):** We use the vertical component of the Lunar Prospector magnetometer data, which are least contaminated (Figure 1a). The magnetic anomalies, identified by circles, show two distinctly different polarities. Anomalies 1 to 5 have positive lobes on the north of the negative lobes, whereas anomalies 7 to 14 have negative lobes on the north of the positive lobes. Anomaly 6, the north Crisium anomaly, is outside Figure 1, hence not shown though modeled. The source bodies were magnetized after the formation of the basin, occurred at  $\sim 4.1$  Ga. The overlap of two anomalies 5 and 14 with distinctly different polarities implies that the source body of the small anomaly formed well after the magnetization of the source body of the large anomaly. It is, therefore, feasible that the source bodies of the first category anomalies are magnetized after the formation of SPAB, but earlier than the magnetization time of the source bodies of the second category, and that there was a dynamo reversal between these two times. We model

a magnetic anomaly using a uniformly magnetized vertical prism with an elliptical horizontal cross section, while taking the altitude variations into account<sup>[3]</sup>. The north paleomagnetic pole associated with the magnetization vector of a source body is determined assuming that the magnetizing field is dipolar.

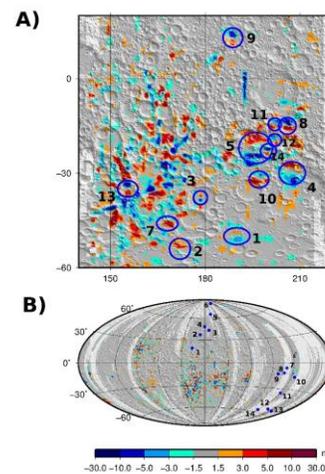


Fig. 1. (A) magnetic anomalies of the South Pole Aitken Basin. (B) Paleomagnetic poles.

**True Polar Wander of Moon:** Figure 1b shows two distinct groups of paleomagnetic north poles. The huge surface mass deficiency produced by the impact that created SPAB caused true polar wander of the Moon. In the absence of large surface mass anomalies (the large mascon maria were not yet formed), the mass deficiency was the main driving force of the true polar wander at the time, which moved the basin southward in the coordinate system fixed to the core, hence the magnetic north pole which is fixed to the core

shifted northward relative to the basin as time passed. The magnetic source bodies were forming and being magnetized by the core dynamo as the true polar wander was taking place. Accordingly, the north paleomagnetic poles were moving northward as the source bodies were getting younger. Anomaly 1 is the oldest and anomaly 6, the north Crisium anomaly, is the youngest among the first category anomalies. The almost linear motion of paleomagnetic pole indicates that the polar wander was driven majorly by a single source, the SPAB.

Figure 1b shows core dynamo reversal after the formation of Crisium basin. Shock pressures of 10-20 GPa produced by the Imbrium impact travelled through the core in less than a few minutes. The interaction of the shock waves with the core dynamo, together with the sudden change in the angular momentum of the lunar mantle by the impact, probably caused the dynamo reversal.

The subsequent formation of large basins that resulted in huge surface mass concentrations (mascons) initiated the second true polar wander that rotated the Moon southward along  $\sim 310^\circ$  meridian.

To unravel the effects of the two polar wanders, we first rotate the Moon together with the paleomagnetic poles of the first category magnetic anomalies northward along  $310^\circ$  meridian by  $41^\circ$  (the latitude difference between the most consistent paleomagnetic poles, anomalies 10 to 14). Figure 2B shows the rotated Moon, which unravels the effects of the second polar wander and shows the SPAB position before the formation of the mascon basins. The lining up of the paleomagnetic poles 1 to 6 along almost the north-south direction seen in Figure 2B supports the expectation that the surface mass deficiency cause by the Aitken impact was the major driving force for the polar wander that moved SPAB to south. The resulting Moon (Figure 2B) is then rotated northward by  $64^\circ$  (the lati-

tude difference between the paleomagnetic poles of magnetic anomaly 1 and 6) along the  $159^\circ$  meridian, the best fitted meridian to the corresponding paleomagnetic pole positions. This rotation unravels the effect of the first polar wander and results in the original location of SPAB immediately after its formation (Figure 2A).

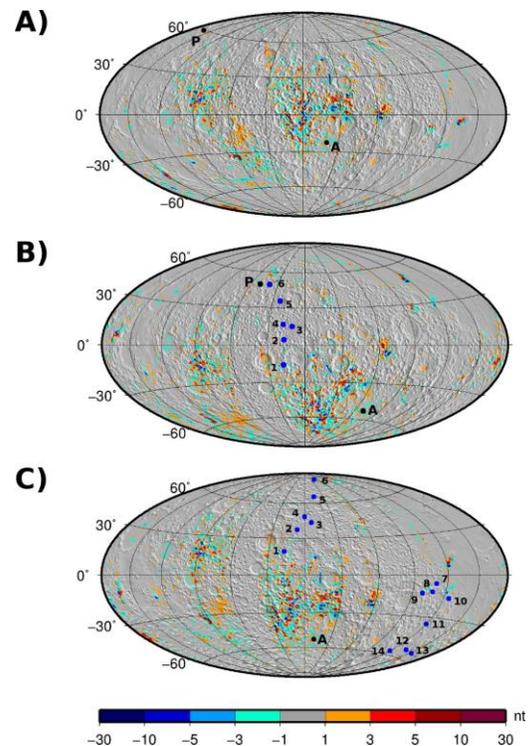


Figure 2. The geographic location of the South Pole Aitken basin. (A) immediately after the formation of the basin, (B) before the formation of mascon basins, and (C) at present. The point A is the location of the center of the basin, and P shows the present geographic north pole in the past. We note that there should be no magnetic anomaly on Panel A, we keep them for easy comparison of the orientation of the three panels

**References:** [1] Hood, L.L., and N.A. Artemieva, (2008) *Icarus*, 193, 485–502. [2] Wieczorek, M.A. et al. (2012) *Science*, 335, 1212-1215. [3] Arkani-Hamed, J. and Boutin, D (2015) *Icarus* 237 (2014) 262–277.