

Hidden in the neutrons: physical evidence for lunar true polar wander

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Abstract. The cold, permanently shadowed, polar region of the Moon possesses a significant reservoir of subsurface hydrogen, likely in the form of water ice. The primary evidence for these polar volatiles comes from epithermal neutron deficits measured by the Lunar Prospector and Lunar Reconnaissance Orbiter¹⁻³. Surprisingly, the observed distribution of hydrogen does not correlate well with the expected distribution of ice deposits inferred from the Moon's present-day thermal environment; a significant portion of the volatiles is off-polar⁴⁻⁵. Here we show that these off-polar hydrogen deposits are antipodal, fossilized cold traps, recording a past lunar spin pole. From the location of these deposits and analysis of the Moon's moments of inertia, we find that this change in lunar spin pole (true polar wander) was likely caused by the unique thermal evolution of the Procellarum region⁶⁻¹⁰. Radiogenic heating within province resulted in extensive volcanism across the lunar nearside early in the Moon's history. This excess heating altered the Moon's moments of inertia, resulting in polar wander consistent with the location of the fossilized polar deposits identified here. This work not only explains the enigmatic spatial distribution of lunar polar hydrogen, but also connects polar volatiles to the geologic evolution of the bulk Moon and the bombardment history of the early solar system.

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