TESTS OF THE GIANT IMPACT HYPOTHESIS. J. H. Jones, Mail Code SN2, NASA Johnson Space Center, Houston TX 77058, USA (john.h.jones1@jsc.nasa.gov).

Introduction: The Giant Impact hypothesis [1] has gained popularity as a means of producing a volatile-depleted Moon, that still has a chemical affinity to the Earth [e.g., 2]. As Taylor's Axiom decrees, the best models of lunar origin are testable, but this is difficult with the Giant Impact model [1]. The energy associated with the impact is sufficient to totally melt and partially vaporize the Earth [3]. And this means that there should be no geological vestige of earlier times. Accordingly, it is important to devise tests that may be used to evaluate the Giant Impact hypothesis. Three such tests are discussed here. None of these is supportive of the Giant Impact model, but neither do they disprove it.

Is the Moon's Volatile Depletion Due to the Giant Impact? No. Or at least lunar alkali element abundances must be due to some other process. First, if the Moon were mainly composed of devolatilized Earth materials, we would expect that the Rb/Cs ratio of the Moon would be higher than that of the Earth, because Cs is more volatile than Rb. In actuality, the Rb/Cs ratio of the Moon is lower than the Earth's [4].

Second, it is expected that volatile loss would have fractionated the isotopes of K during a Giant Impact. However, Humayun and Clayton [5] have shown that the isotopic composition of lunar K is identical to all other solar system materials. Thus, for the Giant Impact model to be viable, the Moon's alkalis must have been added after the impact as a late veneer [e.g., 6].

Is There Any Evidence that the Earth Ever Had a Magma Ocean? No. Another anticipated result of the Giant Impact is a terrestrial magma ocean [3]. This melting event was likely not an opportunity to homogenize but, rather, an opportunity to differentiate. And because there are mantle spinel lherzolites whose compositions closely approximate that of the bulk silicate Earth, this seems to imply that there was never a global magma ocean [7]. The model of [8] indicates that turbulent convection, in the early stages of a magma ocean crystallization, would have prevented crystal-liquid fractionation. But at issue is this: Is there a difference between 10% partial melting (i.e., basalt genesis) and 90% crystallization? In the former case, basalts are known to escape their source regions and may in the latter case as well. This could produce a general fractionation that might be difficult to erase.

One means of circumventing this argument is if subsequent convection homogenized a heterogeneous mantle. The best argument against this is the observation of Meisel et al. [9] that the Os isotopic composition of fertile spinel lherzolites approaches chondritic. Because Os is compatible and Re incompatible during basalt genesis, this close approach to chondritic Os would not ordinarily be expected if spinel lherzolites formed by the mixing of random, differentiated lithologies. Thus, it seems likely that there are mantle samples that have never been processed by a magma ocean.

Are Tungsten Isotopes in the Earth and Moon the Same? No. Lee and coworkers [10, 11] have presented W isotopic data for both the Earth and Moon. In particular, a search was made for W^{182} anomalies, the decay product of short-lived Hf^{182} ($t_{1/2}$ = 9 m.y.). The W isotopic composition of the Earth is chondritic, implying that either fractionation of W and Hf during core formation occured after most of the Hf^{182} had decayed, ≥27 m.y. after the formation of chondrites (AC), or that late accretion erased the radiogenic W^{182} signature. This timing may be consistent with the ~4.54 b.y. Pb-Pb age of the Earth [12] (~20 m.y. AC).

In contrast, lunar rocks sometimes have positive W^{182} anomalies [11], and it is unlikely that these anomalies are due to greater W depletion during lunar core formation [13]. One possible solution is that core formation in the Moon occurred earlier than on Earth. Another possibility is that extensive differentiation of the lunar magma ocean produced regions with highly fractionated Hf/W ratios, so that the effects of trace Hf^{182} were magnified. Regardless, an important early chronometer gives different results for the Earth and Moon.

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