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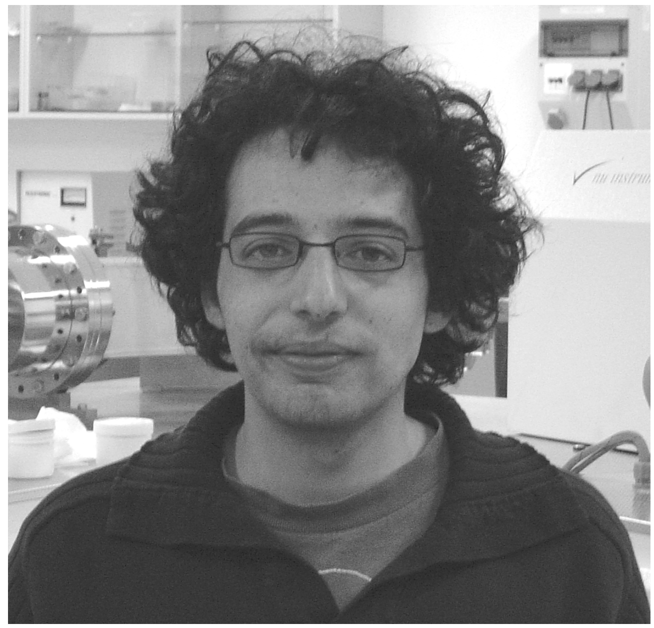
Award

2008 Pellas-Ryder Award for Mathieu Touboul

This year the Pellas-Ryder Award is given to Mathieu Touboul for his paper "Late formation and prolonged differentiation of the Moon inferred from W isotopes in lunar metals" (*Nature* 450:1206–1209). The Pellas-Ryder award, jointly sponsored by the Meteoritical Society and the Planetary Division of Geological Society of America, recognizes the best planetary science paper of the year written by an undergraduate or graduate student.



Mathieu Touboul.

Mathieu was born in February 1978 and grew up in Suresnes, Hauts de Seine (France). He moved to Paris to study earth sciences and early on developed a keen interest in time scales. In his first years at the Institut de Physique du Globe de Paris (IPGP) and University Paris VII, he wrote a short thesis on the absolute age of CAIs but then, during his master's degree with Bernard Bourdon, went on to study the time scales of more recent processes. Using U-series, Mathieu investigated the time scales of magma differentiation in lavas of the last magmatic eruption of Guadeloupe Soufriere, French Antilles (*Chemical Geology* 246:181–206). For his Ph.D., Mathieu started working on more ancient processes again: determining the time scales of the early solar system using short-lived nuclides. Mathieu started his Ph.D. at IPGP with Bernard Bourdon but both decided to move to Zurich, Switzerland, where Bernard Bourdon established a new Isotope Geochemistry group at the Swiss Federal Institute of Technology (ETH).

Mathieu's main research interest currently is in the formation and early evolution of the Moon. To determine when the Moon formed and when its magma ocean solidified, Mathieu used the ^{182}Hf-^{182}W system. Although this chronometer was quite successful in determining planetary accretion time scales, there has always been a problem of applying it to the Moon. Thermal neutrons, produced during the cosmic-ray exposure of the lunar surface, convert ^{181}Ta to ^{182}Ta, which then decays to ^{182}W. These effects are so large that any attempt at correcting them was unsuccessful. Mathieu used a different approach and looked at tiny metal grains that occur in most lunar samples. These metals are enriched in W but do not contain any Ta and hence cosmogenic ^{182}W. Although this approach was not new, Mathieu was the first to bring the analytical techniques to a level that allowed the precise W isotope measurement on pure metal separates.

All previous W isotope studies on lunar samples concluded that there are ^{182}W variations in the Moon, requiring formation and differentiation of the Moon within the first ~50 Ma after CAI formation. This time constraint was difficult to reconcile with results from Sm-Nd chronometry, all of which argued for a much later time of differentiation. Mathieu could show that all lunar metals he investigated have the same W isotope composition, although these metals come from a comprehensive set of various lunar samples. The obvious explanation of this surprising result is that the lunar magma ocean must have crystallized later than ~60 Ma after formation of the solar system. All of the ^{182}Hf had already decayed away after this time. The ^{182}Hf-^{182}W age for the lunar magma ocean of >60 Ma agrees very nicely with Sm-Nd ages for ferroan anorthosites, resulting in a consistent chronology for the early Moon.

In the course of his study, Mathieu made another intriguing observation. All the lunar samples have a W isotope composition that is identical to that of the Earth's mantle. Although this may not be anything peculiar at first glance, it becomes a crucial observation when compared to the W isotope variations among all the other objects from which we have samples. The homogeneous W isotope composition of terrestrial and lunar samples clearly stands out compared to the variability seen in meteorites. This requires special circumstances and Mathieu suggested that the answer may lie in an equilibration between the proto-lunar magma disk and proto-Earth, as has recently been proposed by Pahlevan and Stevenson to account for similarities in O isotopes (*Earth and Planetary Science Letters* 262:438–449).

Perhaps even more important is that the identical W isotope compositions of terrestrial and lunar samples can be used to determine an age for the giant Moon-forming impact, which must have occurred later than ~60 Ma and most likely around ~100 Ma after the formation of the solar system. This age is now consistent with U-Pb model ages for the Earth and also with I-Xe ages for the terrestrial atmosphere. Thanks to Mathieu's work, we now have strong evidence that the formation of the Moon and the major differentiation of the Earth all occurred ~4.45 billion years ago.

In closing, I wish to join with the officers and members of the Meteoritical Society and the Planetary Division of the Geological Society of America, and the nomination committee, in congratulating Mathieu Touboul. He is an outstanding student and worthy recipient of this year's Graham-Ryder award.

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