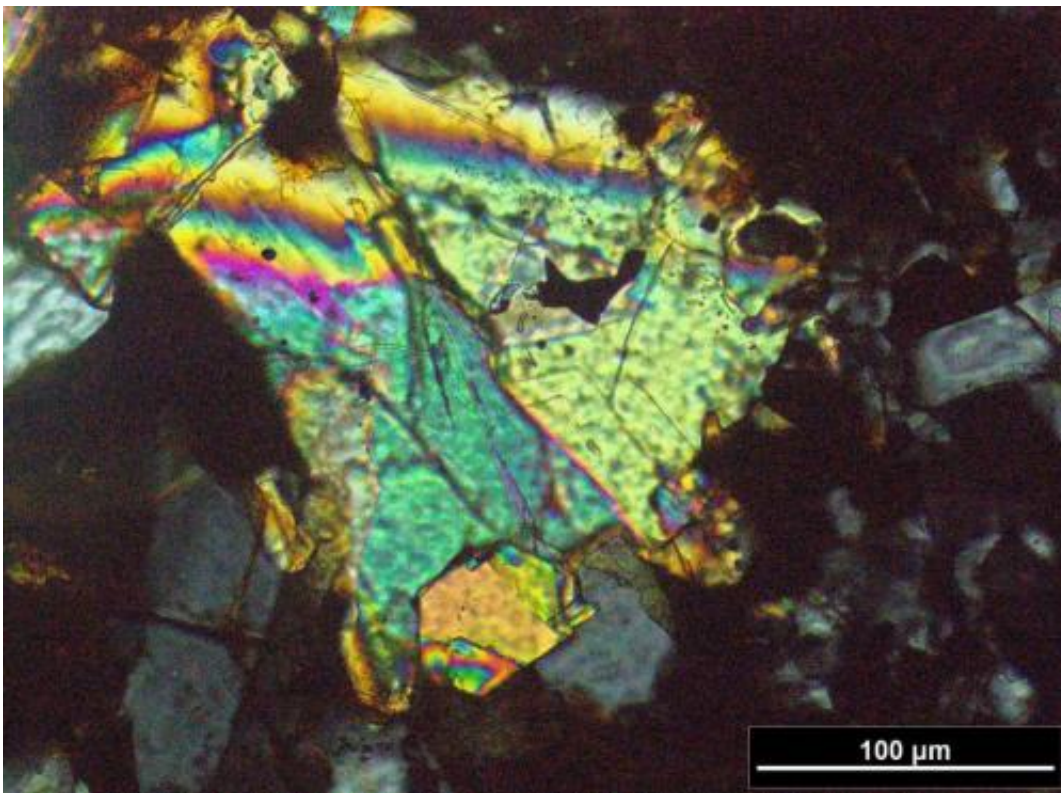


# New isotopic evidence supporting moon formation via Earth collision with planet-sized body

June 5 2014

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Thin section of an enstatite chondrite fragment from the asteroid Almahatta Sitta (official name: 2008 TC3). This fragment was observed on 7 October 2008 in the Nubian Desert, Sudan. Credit: Addi Bischoff, Westfälische Wilhelms-Universität Münster

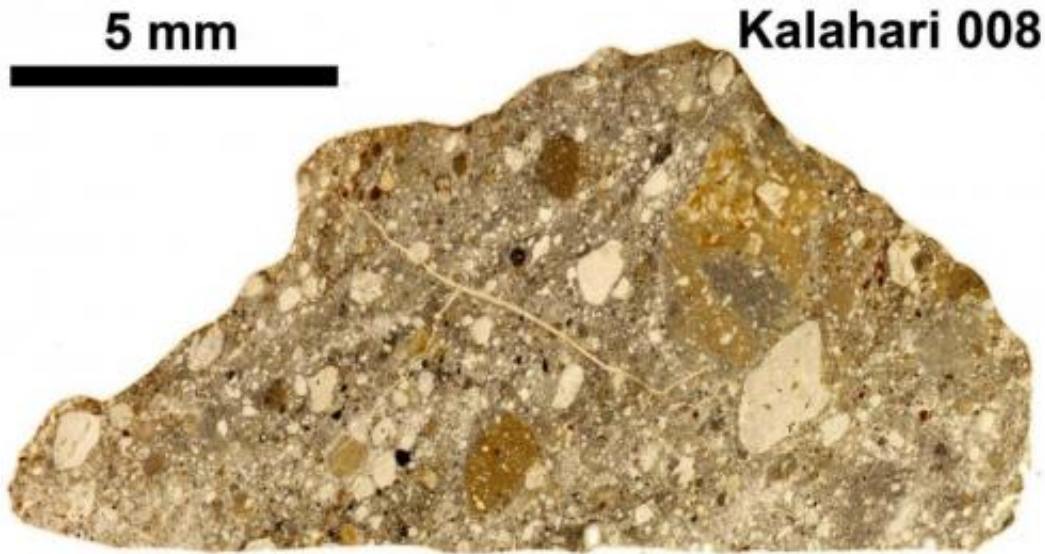
A new series of measurements of oxygen isotopes provides increasing

evidence that the Moon formed from the collision of the Earth with another large, planet-sized astronomical body, around 4.5 billion years ago. This work will be published in *Science* on June 6, and will be presented to the Goldschmidt geochemistry conference in California on 11th June.

Most [planetary scientists](#) believe that the Moon formed from an impact between the Earth and a planet-sized body, which has been given the name Theia. Efforts to confirm that the impact had taken place had centred on measuring the ratios between the isotopes of oxygen, titanium, silicon and others. These ratios are known to vary throughout the solar system, but their close similarity between Earth and Moon conflicted with theoretical models of the collision that indicated that the Moon would form mostly from Theia, and thus would be expected to be compositionally different from the Earth.

Now a group of German researchers, led by Dr. Daniel Herwartz, have used more refined techniques to compare the ratios of  $^{17}\text{O}/^{16}\text{O}$  in lunar samples, with those from Earth. The team initially used [lunar samples](#) which had arrived on Earth via meteorites, but as these samples had exchanged their isotopes with water from Earth, fresher samples were sought. These were provided by NASA from the Apollo 11, 12 and 16 missions; they were found to contain significantly higher levels of  $^{17}\text{O}/^{16}\text{O}$  than their Earthly counterparts.

Dr Herwartz said "The differences are small and difficult to detect, but they are there. This means two things; firstly we can now be reasonably sure that the Giant collision took place. Secondly, it gives us an idea of the geochemistry of Theia. Theia seems to have been similar to what we call E-type chondrites\*\*. If this is true, we can now predict the geochemical and isotopic composition of the Moon, because the present Moon is a mixture of Theia and the early Earth. The next goal is to find out how much material of Theia is in the Moon".



Lunar meteorite Kalahari 008. Impacts on the Moon can eject lunar material, which may then fall to the Earth. Kalahari 008 is an approximately 600g meteorite from the Moon that was collected in 1999 in the Kalahari Desert, Botswana. Credit: Addi Bischoff, Westfälische Wilhelms-Universität Münster

Most models estimate that the Moon is composed of around 70% to 90% material from Theia, with the remaining 10% to 30% coming from the early Earth. However, some models argue for as little as 8% Theia in the Moon. Dr Herwartz said that the new data indicate that a 50:50 mixture seems possible, but this needs to be confirmed.

The team used an advanced [sample](#) preparation technique before measuring the samples via stable isotope ratio mass spectrometry, which showed a 12 parts per million ( $\pm 3$  ppm) difference in  $^{17}\text{O}/^{16}\text{O}$  ratio between Earth and Moon.

**More information:** "Identification of the giant impactor Theia in lunar rocks," by D. Herwartz et al. *Science*, 2014.

[www.sciencemag.org/lookup/doi/.../1126/science.1251117](http://www.sciencemag.org/lookup/doi/.../1126/science.1251117)

Dr Daniel Herwartz will present "The elevated  $\Delta^{17}\text{O}$  composition of the Moon relative to the Earth" to the Goldschmidt conference, Sacramento, California, on 11th June at 09.45, Eastern Time.

Provided by European Association of Geochemistry

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