Greenland rocks provide evidence of Earth formation process

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View of the Isua range (south-west Greenland) taken in August 2010 during the sampling mission. Credit: Hanika Rizo

(Phys.org)—Rocks dating back 3.4 billion years from south-west Greenland's Isua mountain range have yielded valuable information about the structure of the Earth during its earliest stages of development. In these rocks, which witnessed the first billion years of Earth's history, a French-Danish team led by researchers from the 'Magmas and Volcanoes' Laboratory (CNRS) have highlighted a lack of neodymium-142, an essential chemical element for the study of the Earth's formation. This deficit supports the hypothesis that between 100 and 200 million years after its formation, the Earth was made up of an ocean of molten magma, which gradually cooled. The work, which was carried out in collaboration with the Laboratoire de Géologie de Lyon (CNRS) and the University of Copenhagen, was published on 1 November 2012, in the journal *Nature*.

The Earth is believed to have formed 4.58 billion years ago, by accretion of material in the Solar System. The heat produced by the accretion process, as well as by the decay of radioactive elements, caused this material to melt. As a result, 100 to 200 million years after its formation, the Earth must have been made up of an ocean of molten magma, in the center of which a metallic core formed. The ocean gradually cooled. The Earth's crust then appeared, and the process of continental drift began. The crystallization of the molten magma is likely to have been accompanied by the chemical layering of the Earth: concentric layers with distinct chemical compositions became differentiated. It is the signature of these primordial inhomogeneities that the researchers found in the Isua rocks.

The scientists were interested in a key chemical element, the isotope neodymium-142, formed by the decay of a now vanished radioactive isotope called samarium-146. The abundance of neodymium-142 is almost identical in all terrestrial rocks. Only two exceptions have been discovered to date, in Canada and Greenland, in certain rocks dating back 3.7 billion years. The composition of these rocks shows evidence of the primordial inhomogeneities that formed as the magma ocean crystallized.

Aerial view of the Isua range (south-west Greenland) taken in August 2010 during the sampling mission. Credit: Hanika Rizo

In 2003, for the first time, two groups of French researchers observed an excess of neodymium-142 in certain rocks in the same region. If such excess can be found in some layers of the primordial Earth, it means that other layers must be depleted in this isotope. However, until today's findings by the French-Danish team, such neodymium-142 deficits remained hypothetical for nine years. Using a sophisticated method, thermal ionization mass spectrometry, the researchers carried out a very detailed analysis of the concentration of neodymium-142 in Isua rock samples. They discovered a neodymium-142 deficit of 10.6 parts per million, which lends weight to the 'magma ocean' theory.

These findings should help to improve models of the internal dynamics of the Earth during its early stages of development. By discovering a neodymium-142 deficit in relatively young rocks, formed around a billion years after the crystallization of the magma ocean, the researchers have shown that the primordial inhomogeneities persisted longer than predicted before being eliminated by convective motion in the Earth's mantle. In order to obtain more comprehensive data, the scientists now intend to study the composition of other rocks of similar age outcropping for example in Canada, South Africa and China.

More information: Rizo, H. et al., The elusive Hadean enriched reservoir revealed by 142Nd deficits in Isua Archean rocks. *Nature*, November 1, 2012.

Provided by CNRS

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