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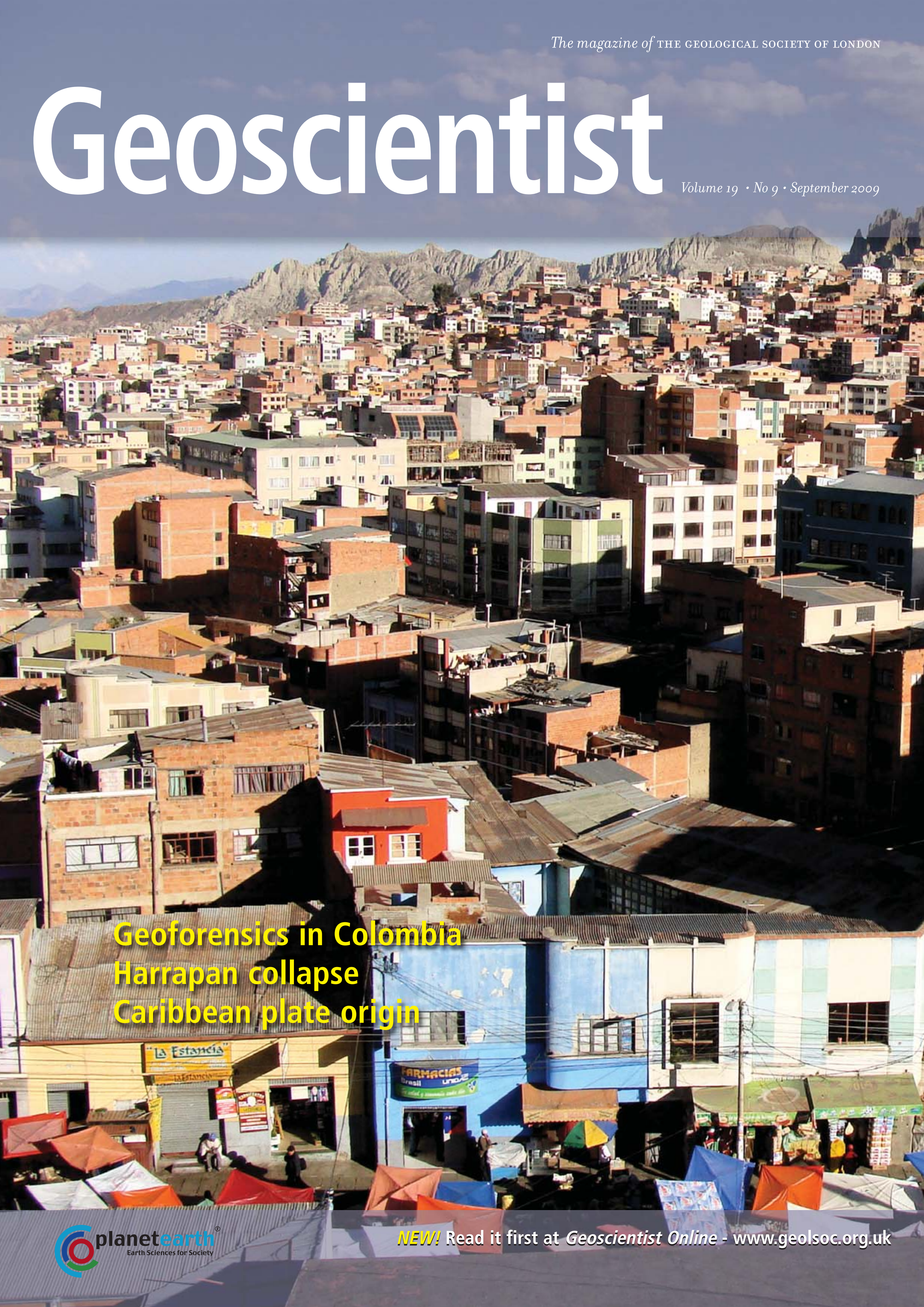

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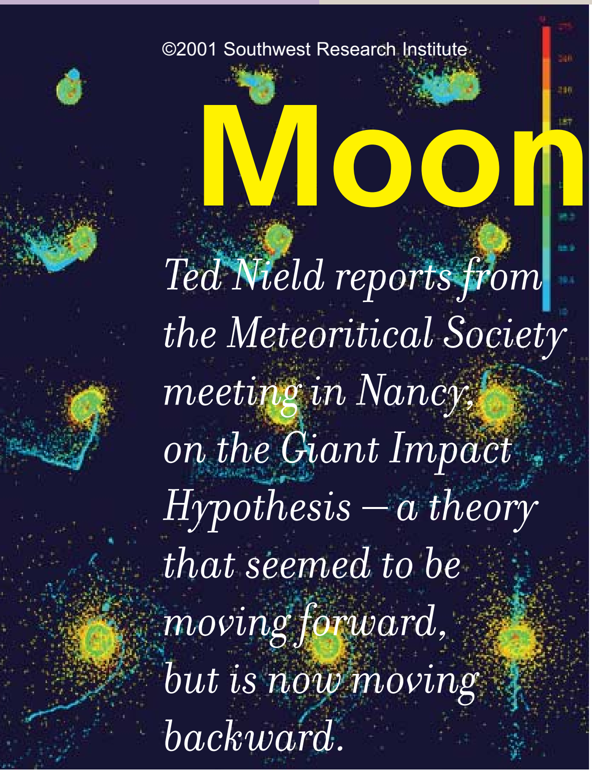

Moonwalk

Ted Nield reports from the Meteoritical Society meeting in Nancy, on the Giant Impact Hypothesis – a theory that seemed to be moving forward, but is now moving backward.

Ever since 1984, the chemical and isotopic similarities (and differences) between the Earth and its satellite all apparently lent broad support to the widely accepted hypothesis that our satellite was created by a giant impact, early in Earth history. However, isotope geochemists have now become so good at their jobs that they are now creating difficulties for theoreticians, Professor Jay Melosh (University of Arizona) told delegates at the Meteoritical Society's 72nd Annual Meeting, Nancy, France.

It used to be all so neat. The Giant Impact Hypothesis explained so much – from the angular momentum of the Earth-Moon system, to the lack of metallic iron in the Moon's makeup. The Moon, it was said, was exactly what you'd get if you took some Earth Mantle, vaporised it and allowed it to condense in the vacuum of space so that the volatiles were lost. The proposed giant impact created a magma disc, of perhaps two lunar masses - and from that the Moon condensed. Computer simulations suggested that 70% of the Moon's mass would have come from the impactor, while only 10% of the Earth's total mass was contributed by the interloper.

And it is from pulling at that last thread of evidence, that the theory has now begun to unravel, says Melosh. In 1984, our knowledge of the oxygen isotope composition of the Moon was such that the obvious similarities to Earth were not an embarrassment. Because if 70% of the moon came from the impactor, one would expect to see some dissimilarities. Oxygen isotope compositions vary widely between different solar system bodies, and it would be extremely unlikely that a wandering impactor would just happen to possess exactly the same oxygen isotope profile as the object it hit.

But then the isotope measurements got more accurate. Now they are accurate to five parts per million, and the similarities have not gone away. If anything, the increase in accuracy has only served to underline the common identity of the Earth and Moon's oxygen isotope profiles. So how can this be?

In 2007 Pahlevan and Stevenson, in an influential paper in *Earth and Planetary Science Letters*, sought to explain how the two bodies could have become isotopically homogeneous. They envisaged a turbulent "atmosphere" of vapour enveloping both proto-Earth and orbiting disc (the proto-Moon). This, they thought, might recycle material from the rapidly spinning Earth, through the vapour phase and into the disc – and back again, thus gradually homogenising the oxygen isotopes between the two. By the time the disc collapsed and the Earth and Moon became finally established, they would have become isotopically identical – while preserving their chemical differences. Hey presto: model saved.

Melosh isn't convinced. He thinks there is a snag with this idea – two snags, in fact, and they're big ones. His calculations suggest that nearly five disc masses of material would need to be exchanged in order to increase the similarity of isotope composition by a miserable one percent. Not only that, but exchange of mass on such a scale is surely impossible without proportional exchange of angular momentum. The Earth-Moon system has far too much angular momentum for this to have happened – unless there exists some presently unknown way of exchanging mass without angular momentum, of course. But that's a big ask.

The mechanisms so far imagined for equilibrating isotope composition seem impossibly ineffective, and may anyway be physically impossible, because of the angular momentum problem. In other words, it appears that the Giant Impact Origin model – once hailed as the answer to one of the oldest conundrums in planetary science, is turning out to be a bit of a *kaputschnik*.

Melosh told the Meteoritical Society that there were several possible ways forward (apart from employing the ostrich method, blithely assuming an isotopically identical impactor). As ever in physics, there is a potential problem with assumptions. The Smoothed Particle Hydrodynamics (SPH) models currently used to model the Grand Impact may not accurately reflect the actual mix of materials achieving orbit. Indeed, this seems more than likely because SPH methods are, says Melosh, notorious for underestimating degrees of mixing. Maybe, too, physicists are underestimating the momentum of a partly molten planet.

However, he concluded: "increasingly precise measurements of the isotopic ratios of element composing the Earth and Moon have brought us to a new crisis in the still unresolved problem of the Moon's origin". Melosh even wondered whether good old George Darwin, son of Charles, and originator of the "Moon spun from the Earth" hypothesis, might be waiting in the wings.

Fissiparturition anyone?

Refs

1. Pahlevan K and Stevenson D J, 2007: EPSL 262: pp438-449

This was one of a number of stories filed by Ted Nield throughout the Meteoritical Society meeting in July. To read more, go to Geonews at www.geolsoc.org.uk/geoscientist.