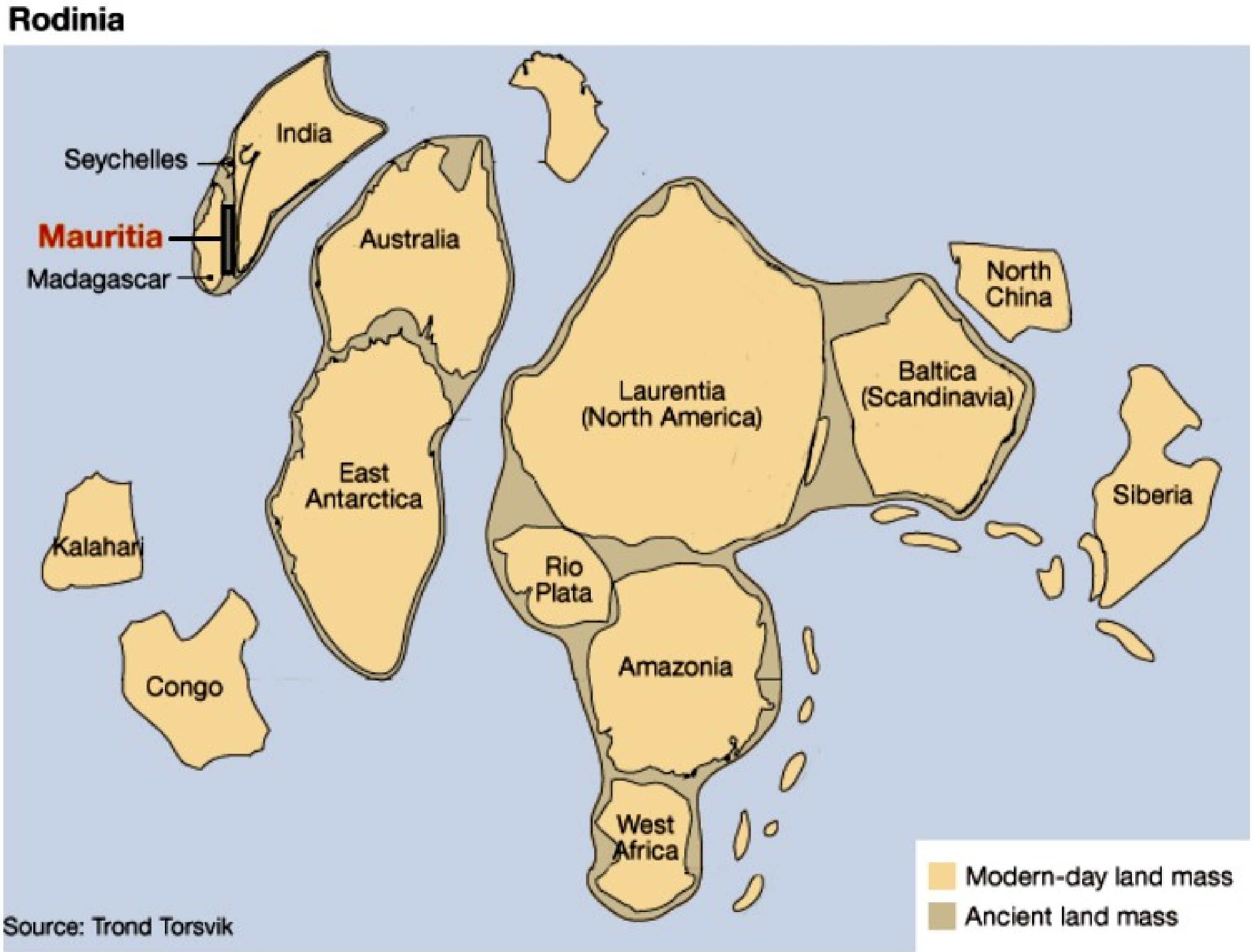
Rodinia

Fragments of ancient continent buried under Indian Ocean

By Rebecca Morelle, 25 February 2013



Land on Earth was once gathered together in a supercontinent known as Rodinia, shown here as it was during its break-up 750 million years ago. Now scientists believe they have found a fragment of it buried under the Indian Ocean

Fragments of an ancient continent are buried beneath the floor of the Indian Ocean, a study suggests. Researchers have found evidence for a landmass that would have existed between 2,000 and 85 million years ago. The strip of land, which scientists have called Mauritia, eventually fragmented and vanished beneath the waves as the modern world started to take shape. The study is published in the journal Nature Geoscience.**

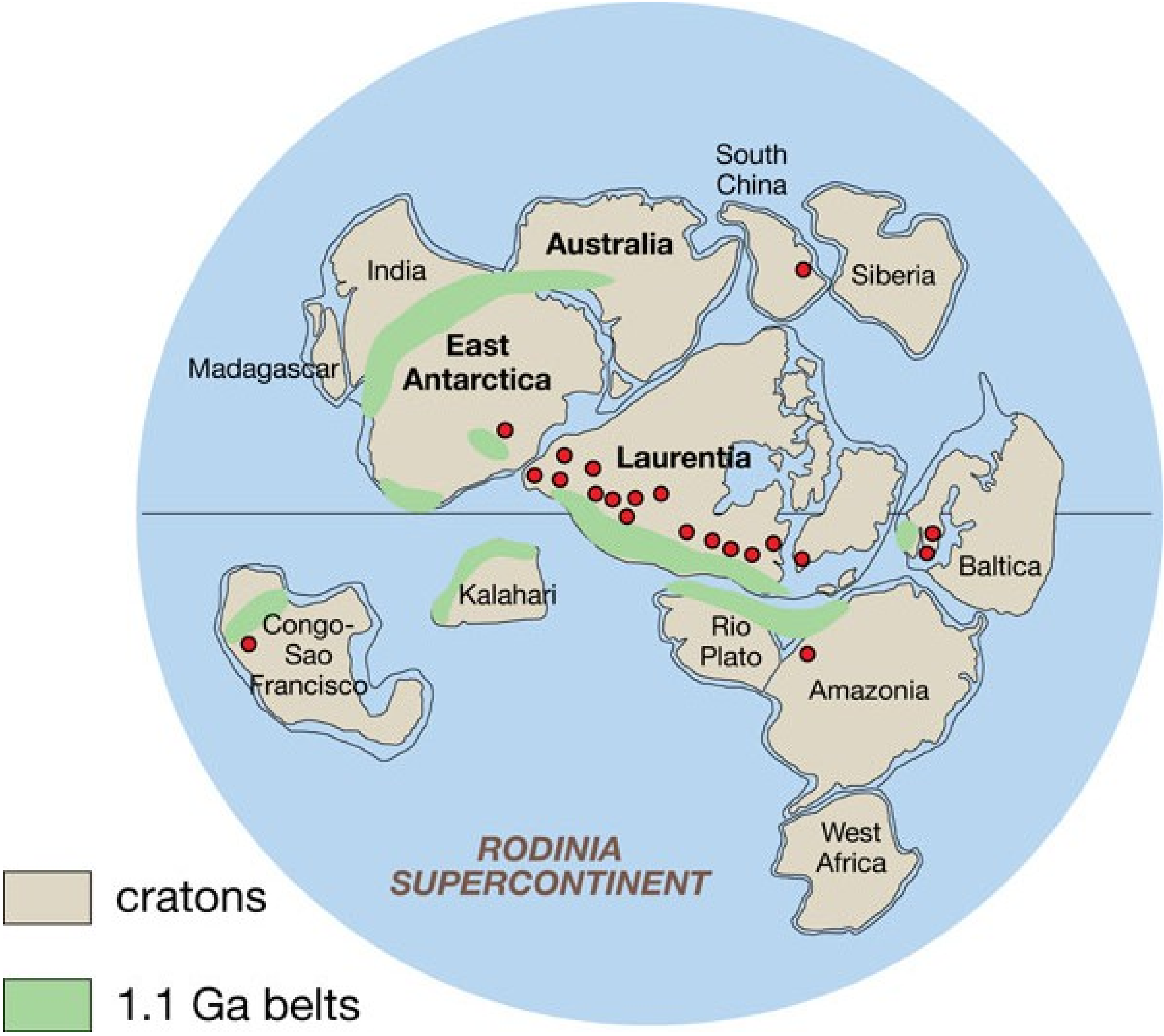
Until about 750 million years ago, the Earth's landmass was gathered into a vast single continent called Rodinia. And although they are now separated by thousands of kilometres of ocean, India was once located next to Madagascar.

Now researchers believe they have found evidence of a sliver of continent - known as a microcontinent - that was once tucked between the two. The team came to this conclusion after studying grains of sand from the beaches of Mauritius. While the grains dated back to a volcanic eruption that happened about nine million years ago, they contained minerals that were much older. Professor Trond Torsvik, from the University of Oslo, Norway, said: "We found zircons that we extracted from the beach sands, and these are something you typically find in a continental crust. They are very old in age." The zircons dated to between 1,970 and 600 million years ago, and the team concluded that they were remnants of ancient land that had been dragged up to the surface of the island during a volcanic eruption.

Prof Torsvik said that he believed pieces of Mauritia could be found about 10km down beneath Mauritius and under a swathe of the Indian Ocean. It would have spanned millions years of history, from the Precambrian Era when land was barren and devoid of life to the age when dinosaurs roamed the Earth. But about 85m years ago, as India started to drift away from Madagascar towards its current location, the microcontinent would have broken up, eventually disappearing beneath the waves.

However, a small part could have survived. “At the moment the Seychelles is a piece of granite, or continental crust, which is sitting practically in the middle of the Indian Ocean,” explained Prof Torsvik. “But once upon a time, it was sitting north of Madagascar. And what we are saying is that maybe this was much bigger, and there are many of these continental fragments that are spread around in the ocean.”

Further research is needed to fully investigate what remains of this lost region. Prof Torsvik explained: “We need seismic data which can image the structure... this would be the ultimate proof. Or you can drill deep, but that would cost a lot of money.”



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** **Nature Geoscience (2013)** doi:10.1038/ngeo1736

Received: 10 August 2012. Accepted: 18 January 2013. Published online: 24 February 2013.

A Precambrian microcontinent in the Indian Ocean

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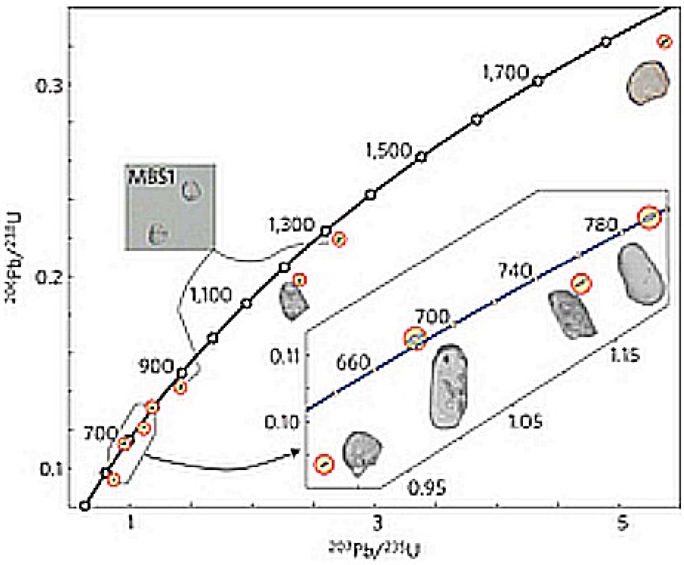
The Laccadive–Chagos Ridge and Southern Mascarene Plateau in the north-central and western Indian Ocean, respectively, are thought to be volcanic chains formed above the Réunion mantle plume over the past 65.5 million years. Here we use U–Pb dating to analyse the ages of zircon xenocrysts found within young lavas on the island of Mauritius, part of the Southern Mascarene Plateau. We find that the zircons are either Palaeoproterozoic (more than 1,971 million years old) or Neoproterozoic (between 660 and 840 million years old). We propose that the zircons were assimilated from ancient fragments of continental lithosphere beneath Mauritius, and were brought to the surface by plume-related lavas. We use gravity data inversion to map crustal thickness and find that Mauritius forms part of a contiguous block of anomalously thick crust that extends in an arc northwards to the Seychelles. Using plate tectonic reconstructions, we show that Mauritius and the adjacent Mascarene Plateau may overlie a Precambrian microcontinent that we call Mauritia. On the basis of reinterpretation of marine geophysical data, we propose that Mauritia was separated from Madagascar and fragmented into a ribbon-like configuration by a series of mid-ocean ridge jumps during the opening of the Mascarene ocean basin between 83.5 and 61 million years ago. We suggest that the plume-related magmatic deposits have since covered Mauritia and potentially other continental fragments.



Data are shown with 2σ error ellipses (Supplementary Table S1) surrounded by yellow circles. Corresponding zircon grains are shown in microscope view before analysis. The two largest grains, which give concordant to nearly concordant results…

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A Precambrian microcontinent in the Indian Ocean

Trond H. Torsvik[1,2,3,4,5★†], Hans Amundsen[6], Ebbe H. Hartz[1,7], Fernando Corfu[4], Nick Kusznir[8], Carmen Gaina[1,2,4†], Pavel V. Doubrovine[1,2†], Bernhard Steinberger[1,2,9], Lewis D. Ashwal[5] and Bjørn Jamtveit[1]

The Laccadive–Chagos Ridge and Southern Mascarene Plateau in the north-central and western Indian Ocean, respectively, are thought to be volcanic chains formed above the Réunion mantle plume[1] over the past 65.5 million years[2,3]. Here we use U–Pb dating to analyse the ages of zircon xenocrysts found within young lavas on the island of Mauritius, part of the Southern Mascarene Plateau. We find that the zircons are either Palaeoproterozoic (more than 1,971 million years old) or Neoproterozoic (between 660 and 840 million years old). We propose that the zircons were assimilated from ancient fragments of continental lithosphere beneath Mauritius, and were brought to the surface by plume-related lavas. We use gravity data inversion to map crustal thickness and find that Mauritius forms part of a contiguous block of anomalously thick crust that extends in an arc northwards to the Seychelles. Using plate tectonic reconstructions, we show that Mauritius and the adjacent Mascarene Plateau may overlie a Precambrian microcontinent that we call Mauritia. On the basis of reinterpretation of marine geophysical data[4], we propose that Mauritia was separated from Madagascar and fragmented into a ribbon-like configuration by a series of mid-ocean ridge jumps during the opening of the Mascarene ocean basin between 83.5 and 61 million years ago. We suggest that the plume-related magmatic deposits have since covered Mauritia and potentially other continental fragments.

Intra-plate magmatic activity is commonly attributed to melting associated with an upwelling mantle plume. Mantle plumes may also trigger continental break-up and continental fragments may hence be placed along an oceanic hotspot track. A dozen hotspot volcanoes—including Réunion (Fig. 1)—and most reconstructed large igneous provinces since Pangaea assembly (~320 Myr BP) are thought to be sourced by deep plumes from the edges of the two large low shear-wave velocity provinces at the core–mantle boundary[5,6]. Recent volcanics erupted at the island of Réunion show geochemical signatures indicative of homogeneous mantle domains[7], whereas lavas from Mauritius show much more heterogeneous isotopic compositions. Mauritian basalts[8,9] are divided into Older (8.9–5.5 Myr BP), Intermediate (3.5–1.9 Myr BP) and Younger (1–0.03 Myr BP) series that are geochemically and isotopically distinct, and have been proposed to form from a variety of source components, including variably enriched and depleted peridotites, as well as pods of more enriched material, possibly pyroxenites and/or eclogites[9–11].

Here we report Precam[redacted] beach sands on Mauritius, [redacted]

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crust (Madagascar). Some twenty zircon grains were recovered from two basaltic sand samples from the northwest (Sample E04-1) and southeast (Sample MBS1) coast of Mauritius. The use of sand samples avoids potential contamination from rock-crushing apparatus. The zircons are generally subhedral to anhedral, show diversity in shape and presence of inclusions, and range in size from 50 to 300 μm. The zircons were analysed for U and Pb isotopes by thermal ionization mass spectrometry (Fig. 2 and Supplementary Table S1). Sample E04-1 from the Intermediate Series yielded fifteen zircon grains; six were selected for analysis. Sample MBS1 from the Older Series had fewer zircons and two were used for age determination. Most results are discordant (Fig. 2), but all data indicate a Proterozoic age of the grains. The oldest grain has a minimum age of 1971 Myr. Three grains yield ages between 1,400 and 900 Myr. Four grains are Neoproterozoic, two grains showing discordant $^{207}Pb/^{206}Pb$ ages of ~840 Myr, one grain yielding a concordant age of 790 Myr, and another grain showing a reversely discordant age of ~690–660 Myr (Supplementary Table S1). Their presence in exclusively basaltic detritus suggests that they were brought up by mafic magmas that assimilated underlying sialic crust, probably at relatively shallow levels. There is no clear-cut geochemical or isotopic signature of continental crust in the Mauritian basalts, although some of their variability in ε_{Nd} values (3.9–6.1; refs 9,10) could indicate variable crustal contamination. We suggest that a crustal signature need not be detectable in basaltic lavas that carry xenocrystic zircons. Although small amounts of zircon have been found as crystallization products in young oceanic mafic volcanics and intrusives[12,13], older xenocrystic zircons have been reliably documented only from oceanic gabbros drilled at the Mid-Atlantic Ridge[14]. The young Mid-Atlantic Ridge gabbros that contain old xenocrystic zircons have lower Zr concentrations[14] (mean ~20 ppm) than Mauritian basalts[9] (mean ~145 ppm), and also lack geochemical indicators of continental crust assimilation.

To identify regions in the northwest Indian Ocean that may be underlain by continental crust, we determined crustal thicknesses by gravity anomaly inversion incorporating a lithosphere thermal gravity anomaly correction[15]. The gravity inversion predicts contiguous crust of thickness >25–30 km beneath the Seychelles and northern Mascarenes, which extends southwards towards Mauritius (Fig. 1). Sensitivity tests (Supplementary Fig. S1) show that predicted crustal thicknesses from gravity inversion under the Seychelles, Mascarenes, Mauritius, Laccadives, Maldives and Chagos are not significantly dependent on break-up and ocean [redacted] sphere thermal gravity [redacted] termined from gravity

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