

Map of flow within the Earth's mantle finds the surface moving up and down 'like a yo-yo'

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A composite image of the Western hemisphere of the Earth. Credit: NASA

Researchers have compiled the first global set of observations of the movement of the Earth's mantle, the 3000-kilometre-thick layer of hot silicate rocks between the crust and the core, and have found that it looks very different to predictions made by geologists over the past 30 years.

The team, from the University of Cambridge, used more than 2000 measurements taken from the world's oceans in order to peer beneath the Earth's crust and observe the [chaotic nature](#) of [mantle](#) flow, which forces the surface above it up and down. These movements have a huge influence on the way that the Earth looks today - the circulation causes the formation of mountains, volcanism and other seismic activity in locations that lie in the middle of [tectonic plates](#), such as at Hawaii and in parts of the United States.

They found that the wave-like movements of the mantle are occurring at a rate that is an order of magnitude faster than had been previously predicted. The results, reported in the journal *Nature Geoscience*, have ramifications across many disciplines including the study of [oceanic circulation](#) and past climate change.

"Although we're talking about timescales that seem incredibly long to you or me, in geological terms, the Earth's surface bobs up and down like a yo-yo," said Dr Mark Hoggard of Cambridge's Department of Earth Sciences, the paper's lead author. "Over a period of a million years, which is our standard unit of measurement, the movement of the mantle can cause the surface to move up and down by hundreds of metres."

Besides geologists, the movement of the Earth's mantle is of interest to the oil and gas sector, since these motions also affect the rate at which sediment is shifted around and hydrocarbons are generated.

Most of us are familiar with the concept of plate tectonics, where the movement of the rigid plates on which the continents sit creates earthquakes and volcanoes near their boundaries. The flow of the mantle acts in addition to these plate motions, as convection currents inside the mantle - similar to those at work in a pan of boiling water - push the surface up or down. For example, although the Hawaiian Islands lie in the middle of a tectonic plate, their volcanic activity is due not to the movement of the plates, but instead to the upward flow of the mantle beneath.

"We've never been able to accurately measure these movements before - geologists have essentially had to guess what they look like," said Hoggard. "Over the past three decades, scientists had predicted that the movements caused continental-scale features which moved very slowly, but that's not the case."

The inventory of more than 2000 spot observations was determined by analysing seismic surveys of the world's oceans. By examining variations in the depth of the ocean floor, the researchers were able to construct a global database of the mantle's movements.

They found that the mantle convects in a chaotic fashion, but with length scales on the order of 1000 kilometres, instead of the 10,000 kilometres that had been predicted.

"These results will have wider reaching implications, such as how we map the circulation of the world's oceans in the past, which are affected by how quickly the sea floor is moving up and down and blocking the path of water currents," said Hoggard. "Considering that the surface is moving much faster than we had previously thought, it could also affect things like the stability of the ice caps and help us to understand past [climate change](#)."

More information: M. J. Hoggard et al, Global dynamic topography observations reveal limited influence of large-scale mantle flow, *Nature Geoscience* (2016). [DOI: 10.1038/ngeo2709](https://doi.org/10.1038/ngeo2709)

Provided by University of Cambridge

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