

Transatlantic tsunamis

If a flank of a volcano on the Canary Islands were to collapse, could it generate a devastating tsunami in the Atlantic Ocean? Dave Tappin and colleagues have found intriguing evidence on Bermuda which suggests that, if it were to happen, it would not be the first time.

Since the Boxing Day earthquake in 2004 tsunamis have been big news. The images from the Indian Ocean of unstoppable waves crashing against vulnerable coastlines seared our minds and confirmed the ever-present danger from this natural hazard. Yet earthquakes are not the only source of tsunamis. They may also be caused by submarine landslides and flanks of volcanoes collapsing into the sea on volcanic islands.

There is still a great deal of controversy over how large tsunamis from these sources could be, and whether the tsunami created could travel thousands of miles across an ocean to strike far distant shores. However, when scientists modelled a flank collapse in the Hawaiian islands, which took place 1.5 million years ago, they showed that the subsequent tsunami would indeed strike the west coast of North America, over 1000 miles away, with waves tens of metres high.

Here we reveal how, by taking an indirect path based on traditional geological techniques, we investigated sediment on the island of Bermuda in the western Atlantic. Bermuda is 700 miles away from the nearest land, so the objective was to see if the sediments had been deposited by a tsunami, and if so from where.

On Bermuda limestone gravels located in caves 18-28 metres above sea level have been variously suggested as the result of storms or as beach deposits laid down during extremely high global sea levels hundreds of thousands of years ago. An alternative explanation is a tsunami.

The sediment is graded, becoming finer-grained towards the top, a distinctive feature of tsunami sediments, because the suspended sediment in the tsunami wave is laid down when the water stops moving. If the sediment was an old beach deposit, the internal structure and shells within the sample would be similar to those in the modern tropical beaches; they are not.

Based on the shell remains of small creatures (foraminifera) it turns out that the sediments were from four different sources: the sea, the beach, the reef and the lagoon. Within the shells are tiny calcium carbonate crystals. The shapes of these crystals provides a fascinating history of the environments in which they were formed and preserved. Some of the carbonate crystals within the

Sediment found in a cave 22m above sea level.



shell chambers were created in marine conditions. However, careful examination showed that these shells are in rock fragments that contained other crystals on the outside which definitely formed in freshwater conditions. This compromises the beach origin theory. Some rock fragments were indeed formed on the coast, but were subsequently moved by an energetic process and deposited high above their original location. Most likely a tsunami struck Bermuda. Dating of the sediment indicates that this event was earlier than between 310,000 and 360,000 years ago.

Previous interpretations that the sediment may be a storm deposit, or laid down when sea level was much higher, can be discounted. We know that recent cyclones striking Bermuda do not create waves that reach above ten metres.

The tsunami source is uncertain, although there are a number of candidates. Earthquakes along the active Caribbean subduction zones are a possibility, as are collapses of volcanic edifices in the Caribbean island arc. Further afield we know that there have been giant submarine landslides along the margins of the eastern Atlantic. But there is very little information on the age of any of these features.

Perhaps significantly, the age of the sediments correlates with the giant lateral collapses of volcanoes in the eastern Atlantic such as those of the Canary Islands, El Julan on the island of El Hierro and Orotava on Tenerife. There has been a fierce controversy about whether the collapse of these volcanoes can in fact create destructive tsunamis. Recent work indicates that, like Hawaii, they can locally, but could an extremely large wave really cross an ocean? Modelling of the large Hawaiian collapses indicates that they can, but the modelling assumes a single catastrophic event. Volcanic collapses in Hawaii and the Canary Islands are infrequent, perhaps taking place every 100,000 years, so the hazard is small. Future research on sediments both in the Canary Islands and elsewhere in the Atlantic may help us to clarify just how small this is. ❖

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