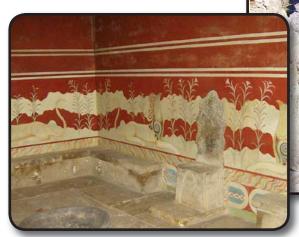
NEW EVIDENCE OF SANTORINI'S FAR REACH

ometime during the Late Bronze Age, about 3,600 years ago, Santorini, a volcano that is also one of the Greek islands, erupted violently. It set off a tsunami that devastated nearby areas, includ-

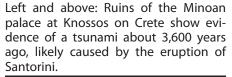
ing the northern coast of Crete, where it is thought to have wiped out the flourishing Minoan society. Scientists have long wondered whether the tsunami was large enough to have also reached the eastern edge of the Mediterranean Sea — but until now, they have been unsuccessful in finding physical evidence on the heavily populated coastline. But by analyzing core samples from shallow offshore locations in Israel, scientists have finally found the evidence they've been looking for.





Left and above: Evidence from sediment cores from the continental shelf off Caesarea, Israel, in the Mediterranean, revealed that the tsunami caused by the eruption of Santorini 3,600 years ago reached across the Mediterranean.

The study, led by marine geoarchaeologist Beverly Goodman of the University of Haifa in Israel, marks the first time that scientists have taken cores from a continental shelf for the purpose of analyzing tsunami deposits. Goodman and her colleagues collected four cores offshore of the Israeli seaport Caesarea at depths of 14 to 20 meters below the sea. Each core contained tsunami deposit layers, some as thick as 40 centimeters, and various methods of dating placed them at the time of the Santorini eruption, between 1630 and 1550 B.C. The



cores also showed evidence of two later tsunamis in A.D. 115 and 551.

The cores reveal an excellent record of the tsunamis, Goodman says. Offshore cores have a few advantages over terrestrial ones. "You're not going to get the disturbance from people," she says. "Humans are really good at manipulating the landscape, moving dirt, and changing the appearance of things. When you find a tsunami deposit in the underwater setting, you can pretty safely say that it hasn't been changed by people since it was deposited."

Another advantage of offshore deposits is that they filter out storm signals. Basically, the larger the wave, the deeper its impact on the sea bottom. So by collecting the cores far enough offshore, the water is deep enough that only tsunami waves, and not storm waves, could have left deposits, Goodman says. Additionally, the deposits come from both directions, showing both inflow and outflow, which is further evidence of tsunamis and not storms.

These findings are very exciting, says Jelle de Boer, a retired professor of earth sciences at Wesleyan University in Middletown, Conn., who started some of the initial research at Santorini when its eruption was first dated. "This paper now very clearly shows that we are coming to a fuller picture of what



the destruction actually entailed." The deposit for the massive eruption 3,600 years ago suggests a large magnitude for the event. Although scientists have found scraps of information about the tsunami before, allowing them, for example, to link it to the destruction of the Minoan society, the tsunami's extent "never was really a clear-cut case" until now, de Boer notes.

Perhaps equally exciting is how Goodman illustrated that offshore cores can help determine the extents of previous tsunamis, de Boer says. He is looking forward to using this method elsewhere, particularly off the coast of Portugal to see the extent of the 1755 earthquake and tsunami that largely destroyed Lisbon. By learning the extents of previous tsunamis, he says, it should be easier for scientists to assess the risk to populated coastal areas.



Santorini today reveals layer upon layer of volcanic eruptions. The islands that form Santorini form the rim of the volcanic crater.

Next, Goodman plans to look at continental shelf deposits closer to Santorini, where more terrestrial evidence exists, to compare characteristics of the underwater deposits with established facts about the magnitude of the catastrophic tsunami 3,600 years ago. She's hoping to do similar work in the Indian Ocean to see what offshore deposits look like in recently stricken areas.

"The method and the technique will ... help fill out tsunami records anywhere in the world," Goodman says. Furthermore, she says, "we'll be able to get a better sense of the occurrence of tsunamis and their magnitude," especially in the Mediterranean. People don't always think of the Mediterranean as a tsunami hazard zone, she adds, but there have been many tsunamis there. And in the past, they've been large enough to wipe out entire civilizations.

Bernard Langer



EARTH January 2010 • **19**