A figure comparing the results of earlier turbidite correlation research to results calculated by an algorithm developed at The University of Texas at Austin. Credit: Zoltan Sylvester.
Photo: Jackson School

EARTHQUAKE OR SOMETHING ELSE?

Researchers are applying a well-known algorithm in an innovative way to investigate whether turbidites are a reliable record for earthquakes in Cascadia.

BY MONICA KORTSHA

The Cascadia subduction zone in the Pacific Northwest has a history of producing powerful and destructive earthquakes that have sunk forests and spawned tsunamis that reached all the way to the shores of Japan.

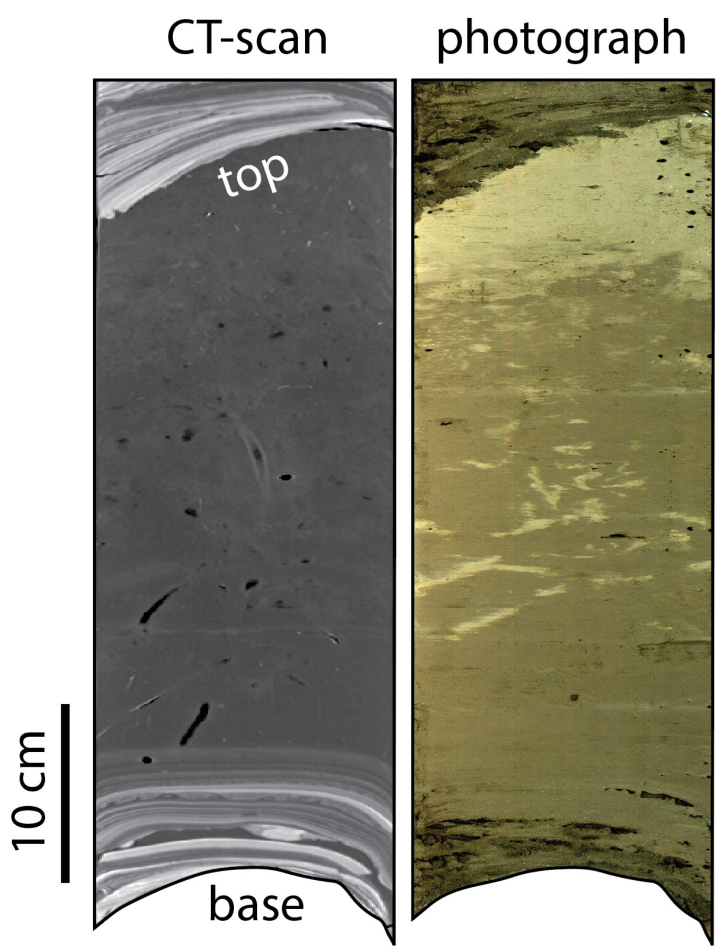
The most recent great earthquake was in 1700. But it probably won't be the last. And the area in the potential path of destruction now contains bustling metropolises that are home to millions of people.

Figuring out the frequency of earthquakes — and when the next "big one" will happen — is an active scientific question that involves looking for signs of past earthquakes in the geologic record in the form of shaken up rocks, sediment and landscapes.

Research Professors Zoltán Sylvester (left) and Jacob Covault in the core viewing facility at The University of Texas as Austin's Bureau of Economic Geology. Examples of turbidites from Cascadia are shown on the screen behind them.
Photo: Jackson School

However, a study by scientists at The University of Texas at Austin and collaborators is calling into question the reliability of a commonly cited earthquake record that covers thousands of years, a type of geologic deposit called a turbidite that's found in the strata of the seafloor.

Understanding the earthquake record of the Cascadia subduction zone can help cities near the zone, such as Seattle, prepare for future disasters. *Photo: Steve Ginn / Flickr*



Co-author Jacob Covault, a research professor at the UT Jackson School of Geosciences, said the algorithm offers a quantitative tool that provides a replicable method for interpreting ancient earthquake records, which are usually based on more qualitative descriptions of the geology and their potential associations.

“This tool provides a repeatable result, so everybody can see the same thing,” said Covault, the co-principal investigator of the Quantitative Clastics Laboratory at the

Jackson School's Bureau of Economic Geology. "You can potentially argue with that result, but at least you have a baseline, an approach that is reproducible."

A photograph and CT scan of a turbidite layer in a geologic core sample collected during a scientific cruise studying the geology near the Cascadia subduction zone. The Cascadia zone can create large, damaging earthquakes. Researchers are interested in clarifying how the turbidite layers relate to the past earthquake record.
Credit: Zoltan Sylvester using data from Goldfinger et al.

The results were published in the journal GSA Bulletin. The study includes researchers from the USGS, Stanford University and the Alaska Division of Geological & Geophysical Surveys.

Turbidites are the remnants of underwater landslides. They're made of sediments that settled back down to the seafloor after being flung into the water by the turbulent motion of a landslide rushing across the ocean floor.

The sediment in these layers have a distinctive gradation, with coarser grains at the bottom and finer ones at the top.

But there's more than one way to make a turbidite layer. Earthquakes can cause landslides when they shake up the seafloor. But so can storms, floods and a range of other natural phenomena, albeit on a geographically smaller scale.

Currently, connecting turbidites to past earthquakes usually involves finding them in geologic cores taken from the seafloor. If a turbidite shows up in roughly the same spot in multiple samples across a relatively large area, it's counted as a remnant of a past earthquake, according to the researchers.

Although carbon dating samples can help narrow down timing, there's still a lot of uncertainty in interpreting if samples that appear at about the same time and place are connected by the same event.

Getting a better handle on how different turbidite samples relate to one another inspired the researchers to apply a more quantitative method — an algorithm called “dynamic time warping” — to the turbidite data. The algorithmic method dates back to the 1970s and has a wide range of applications, from voice recognition to smoothing out graphics in dynamic VR environments.

This is the first time it has been applied to analyzing turbidites, said co-author Zoltán Sylvester, a research professor at the Jackson School and co-principal investigator of the Quantitative Clastics Laboratory, who led the adaption of the algorithm for analyzing turbidites.

“This algorithm has been a key component of a lot of the projects I have worked on,” said Sylvester. “But it’s still very much underused in the geosciences.”

The algorithm detects similarity between two samples that may vary over time, and then determines how closely the data between them matches.

For voice recognition software, that means recognizing key words even though they might be spoken at different speeds or pitches. For the turbidites, it involves recognizing shared magnetic properties between different turbidite samples that may look different from location to location despite originating from the same event.

“Correlating turbidites is no simple task,” said co-author Nora Nieminski, the coastal hazards program manager for the Alaska Division of Geological & Geophysical Surveys. “Turbidites commonly demonstrate significant lateral variability that reflect their variable flow dynamics. Therefore, it is not expected for turbidites to preserve the same depositional character over great distances, or even small distances in many cases, particularly along active margins like Cascadia or across various depositional environments.”

The researchers also subjected the correlations produced by the algorithm to another level of scrutiny. They compared the results to correlation data calculated using synthetic data made by comparing 10,000 pairs of random turbidite layers. This synthetic comparison served as a control against coincidental matches in the actual samples.

The researchers applied their technique to magnetic susceptibility logs for turbidite layers in nine geologic cores that were collected during a scientific cruise in 1999. They found that in most cases, the connection between turbidite layers that had been previously correlated was no better than random. The only exception to this trend was for turbidite layers that were relatively close together — no more than about 15 miles apart.

The researchers emphasize that the algorithm is just one way of analyzing turbidities and that the inclusion of other data could change the degree of correlation between the cores one way or another. But according to these results, the presence of turbidities at the same time and general area in the geologic record is not enough to definitively connect them to one another.

Although algorithms and machine learning approaches can help with that task, it's up to geoscientists to interpret the results and see where the research leads.

"We are here for answering questions, not just applying the tool," Sylvester said.

Read the Study

Turbidite Correlation for Paleoseismology

GSA Bulletin – doi.org/10.1130/B37343.1 (http://doi.org/10.1130/B37343.1)

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