Tsunamis in Lake Geneva

Lake monsters

A millennium-and-a-half ago, Geneva was destroyed by a giant wave. Recent research suggests it could happen again

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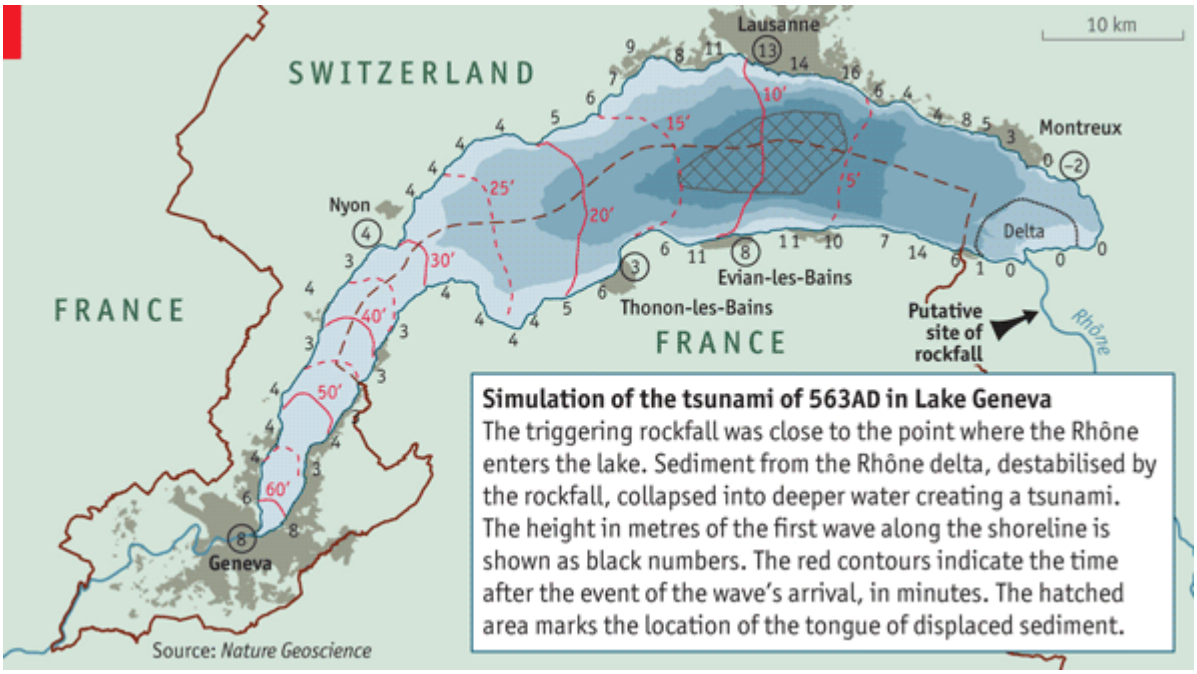
IN 563AD a tsunami devastated Geneva. Two accounts of the disaster, one by Gregory of Tours and the other by Marius of Avenches, have survived. What caused the wave, and the extent of the damage that resulted, have been matters of conjecture for centuries. But over the past decade several groups of scientists have pieced together the sequence of events and one of those groups, led by Katrina Kremer of the University of Geneva, has now created a computer model of what happened. Unfortunately for the 1m people who live around the lake's shore, the conclusion of this research is that something similar could easily happen again.

The tsunami of 563 started at the opposite end of the lake from Geneva, at the point where it is fed by glacial meltwater carried into it by the Rhône. Both accounts say the wave began with a massive rockfall on what was then called Mount Tauredunum (this has led to the tsunami becoming known as the

Tauredunum event). Tauredunum is thought to be a mountain now called the Grammont, which is located near the river mouth.



In the past, one favoured theory was that this rockfall created a natural dam across the Rhône, which held the waters back until it could no longer sustain the pressure. When the dam burst, the resulting wave swept the length of the lake. A one-off event, in other words. But a paper just published in *Nature Geoscience* by Dr Kremer and her colleagues offers a different and more worrying explanation.

Canyon diabolo

Dr Kremer thinks that the rocks crashed down onto soft sediments which had accumulated at the river mouth because of the slowing of the river's flow when it enters the lake. These sediments form an underwater delta that has several canyon-like channels. When the falling rocks hit the delta they destabilised the sediments and caused the canyons to collapse. It was this collapse that created the tsunami.

It is a plausible theory. What suggests it is true is that the sediment from such a collapse would have been propelled towards the lake's centre, forming a large tongue of material on the lake bed. And, using sediment cores and an instrument called a pinger, which analyses the reflections of sound waves that

can penetrate the material of the lake bed, Dr Kremer thinks she has found this tongue.

Her discovery is a bed of what is known geologically as turbidite. This is sediment that, because it is laid down by rapid water movements, is not sorted by grain size. The turbidite Dr Kremer found is a mixture of sand and silt roughly 10km (6 miles) long and 5km wide. On average, it is 5 metres deep, and it seems to have formed in a single event. By carbon-dating leaves and other organic material trapped within it, she has shown that it is about the same age as the Tauredunum event.

The discovery of this turbidite means it is possible to work out what happened in 563. The result is not pretty. The team's computer modeller, Guy Simpson, has reconstructed the tsunami that would have been generated by the amount of material in the tongue. Within 15 minutes of the collapse, a wave 13 metres high would have reached Lausanne, a city on the northern shore of the lake. But Lausanne is built on steep slopes, so most of it would have been spared. The damage would have been much greater when, 55 minutes after that, an 8-metre wave reached Geneva, at the other end of the lake. Geneva is a lower-lying city than Lausanne and, to make matters worse, the lake narrows here, funnelling water to the point where the Rhône becomes a recognisable river again. It would similarly have funnelled the wave.

Using information revealed by archaeology about the layout of sixth-century Geneva and the lake's level at the time, the team were able to work out how the city would have stood up to the onslaught. The wave, they believe, would have passed over the city walls, and wiped out watermills and a bridge across the Rhône, just as the two accounts say it did. En route, as Marius wrote, it would have destroyed many lakeshore villages, "with humans and cattle and even churches".

The crucial element in this explanation is the accumulation of sediment in the underwater delta. That is a continuous process. Once enough sediment is there, it just needs a trigger to set it going. That could be a rockfall, an earthquake (though this part of the world is not particularly seismically active) or even a violent storm. Moreover, Dr Kremer's pinger shows evidence of four layers deeper in the lake bed which also look like turbidite.

The formation of these might or might not have triggered tsunamis. But they are a worrying sign.

Though the basin in which Lake Geneva sits is ancient, the modern lake is a product of the end of the last Ice Age. Exactly when it formed is unclear. The whole area was still buried under ice 19,000 years ago. By 13,000 years ago the glaciers had retreated at least as far east as Lausanne. But the age of the current delta is still unknown. That five layers of turbidite may have formed in this time gives a rough sense of how frequently tsunamis might happen. The details will remain obscure, though, until the older beds are examined closely, and core samples taken from them.

Several things thus need to be done. The most urgent is to survey the delta, to see how close to collapse it looks. Both Switzerland and France are good at big civil engineering projects, so if it did need dredging, they could then get to work quickly. Second, the older turbidite beds need to be examined properly, to see how frequently tsunamis actually occur. Third, it might behove the authorities in Geneva and elsewhere around the lake to assess which areas would be inundated if there were another tsunami, and how they might react if there was one—for if a tsunami did happen, the Genevese would have just over an hour to evacuate their city before its centre was obliterated.

Dr Kremer's work also raises the question of whether other lakes are at risk of generating tsunamis. Some might be. In 1806, for example, a landslide into Lake Lauerz, farther east in Switzerland, triggered a tsunami 20 metres high. From Loch Ness in Scotland to Tele in Congo, lakes breed legends of monsters lurking beneath the surface. Perhaps, in some cases, these legends are based on real events.