The day the world ended

La Palma Mega tsunami suffers a slight delay

Some recent TV documentaries have shown the western world being wiped out by the worst tidal wave ever witnessed by mankind, as half of La Palma, one of the Canary Islands, breaks away to disappear into the sea. However, a research group at TU Delft thinks the documentaries are overlooking a crucial fact. "The island is just very well constructed."

Maarten Keulemans

Jan Nieuwenhuis has a strange job: he is trying to bring about a natural disaster. For almost a year now the civil engineering professor emeritus has been attempting to generate a sky-high tsunami that will swamp the coasts of America, Europe and Morocco, wiping cities like New York, Boston, Lisbon and Casablanca off the map. The only problem is that try as he may, Nieuwenhuis just can't get the tidal wave to put in an appearance.

Together with one of his former students, Janneke van Berlo, and his colleagues Robert Jan Labeur and Dr Ronald Brinkgreve, Nieuwenhuis has been trying to push the south western flank of one of the volcanic Canary Islands, La Palma, into the sea. The result would be an immense tsunami that would wreak havoc in practically every place on earth that borders the Atlantic Ocean.

But La Palma just won't cooperate. Using computer simulations, the researchers have pumped the island full of water and magma, and even raised it by a couple of hundred metres – but to no avail; the island has simply refused to budge. And on the few occasions when La Palma did collapse, the result was a tidal wave hardly worthy of the name. It would indeed have displaced a considerable volume of water, causing plenty of trouble in the vicinity of the Canary Islands themselves, and flooding the low-lying coastal areas of America and Europe. Yes, it would have done all that, but it would hardly have been the devastating wall of water hundreds of metres high that some researchers predicted.

To the boil

Matters were rather different five years ago when Lord Sainsbury, the British Minister of Science, received a worrying letter from the London-based Benfield Greig Hazard Research Centre. Researchers Dr Simon Day, Dr Steven Ward and Professor Bill McGuire had calculated that La Palma was about to cause a mega tsunami. The researchers thought this would happen as soon as the dormant Cumbre Vieja volcano on the southern edge of La Palma came to life again. The rising magma would bring the ground water in the volcano to the boil, whereupon the steam pressure would push the south western flank of the volcano into the Atlantic Ocean. Ward and Day said this would launch a lump of rock some 150 to 500 cubic kilometres in size, big enough to create a tsunami with an initial height of 650 metres, moving at 800 kilometres per hour, and capable of obliterating the coastal agglomerations of Europe and the United States thousands of kilometres away. Would the Minister please be so kind as to come up with a contingency plan?

La Palma made instant headlines. A wall of water two Eiffel Towers high approaching with the speed of a jet plane; it certainly fired the imagination. By the time it reached New York the wall of water would still be 40 to 50 metres high. The colossal mass of water would crash dozens of kilometres inland, annihilating everything in its path. Only last year BBC Television had decided not to air a new, dramatised documentary on the disaster because the special effects sequences were considered too distressing.

Demolition team

Not so the special effects used by the TUD researchers. Nieuwenhuis, van Berlo, and Brinkgreve are the first to attempt to demolish the island using hard data and geotechnical knowledge.

To begin with, Janneke van Berlo processed the available geological data to produce three cross-sections of the volcano wall. The researchers fed these sections into a computer program, Plaxis, which uses a finite element model to simulate subsoil movement. In addition, the team performed lots of straightforward stability calculations. After that, it was all systems go! Van Berlo turned on the magma tap, raised the ground water level, pushed up the island, and smoothed the 'slide' along which the volcano wall was to disappear under the waves.

'The place is rife with disaster-averting restraints'

"In the end we did manage to break up the flank," Nieuwenhuis says, "but the place is rife with restraints that stop the disaster from happening. The truth of the matter is that the island is as stable as they come."

Take the boiling steam effect, for instance. There is no doubt that water trapped inside the volcano will try to force its way out when heated. Van Berlo and Nieuwenhuis think so too. The only thing is that rather than push the mountain outwards, it will tend to shoot out from the top. "Unless of course, the volcano has been fitted with a plug that even God himself couldn't push into place," Nieuwenhuis laughs.

Even so, things will begin to hot up as magma starts to rise in the crater zone. The sheer weight of the liquid rock will push outwards against the side of the volcano.

"If the magma were to form an elongated column, in theory it would be able to push the flank outwards," van Berlo says. On the other hand, all the conditions would have to be just right: the magma must stay liquid, the substrata should preferably consist of loose material, and the sides of the shifting flank must be smooth.

The scale of the forces involved is mind-boggling. The calculations by Nieuwenhuis show that a force of at least 12,000 to 28,000 giga newtons would be required to initiate the landslide. In everyday terms, that's equivalent to the thrust of 600 million jet engines.

The only way to see La Palma come down would be to wait, as the Cumbre Vieja volcano is still growing at a steady rate. As a volcano becomes higher, its walls become steeper and less stable. All it takes is ▸▸

Death to La Palma

Situation	Safety-factor
Current situation: volcano is dormant, only gravity pushes on the flank	1,70
Volcano is dormant, but the flank's substratum is less stable than geologists believe	1,44
The volcano is dormant, but 600 metres higher than at present	1,46
The volcano is dormant, but 1000 metres higher, and the substratum is less stable than believed	1,12
In the crater zone magma bubbles up. The magma does not solidify, and behaves like a fluid	1,27
Same, but with unexpectedly loose substratum	1,07

The safety factor is a measure of the stability of Cumbre Vieja's flank: it is the ratio of the forces pushing the wall outwards to the forces keeping the wall in place. If the safety factor reaches 1 or less, the situation becomes critical.

a bit of patience. Quite a bit, in fact. Based on the current rate of growth, van Berlo estimates that it will take at least another 10,000 years. The volcano probably needs to add a kilometre to its present height before it becomes really unstable.
And to think that in 1999 McGuire was quoted in The Observer as saying that "this huge rock mass hangs over the Atlantic Ocean, ready to slide into the sea at any moment." Nieuwenhuis blames theories like these on 'a complete lack of insight into the way soil mechanics work.'

It would take a force of at least 12,000 to 28,000 giga newtons to start the landslide, roughly equivalent to the thrust of 600 million jet engines.

"They represented the problem as if it involved a solid body coming out of the blue and smashing into the sea. It is as if the rest of the island simply does not exist."

Lava sheet

Launching the entire side of the mountain into the sea can be done, but it would take very special conditions indeed. For instance, the slope into the sea would have to be lubricated by a sheet of lava at least 640,000 square metres in size. Or, just before and during the eruption, the island would have to be hit by prolonged torrential rains that would cause it to become saturated with water that under pressure could become hot enough to seriously weaken the rock structure. Or, a bizarre turn of events could combine an extreme amount of rising magma and extreme amounts of water in the flank with a substratum that is less stable than geologists believe it to be.
"Based on what we now know, so much would have to go wrong, and worst case scenarios would have to be popping up all over the place, that the chances of a disaster occurring any time soon appear to be very, very remote," van Berlo says. "As it is, we have been assuming the worst, so things can only turn out for the better."
Even if things were to go wrong, contrary to all expectations, you wouldn't exactly have an enormous boulder hurtling into the sea, Nieuwenhuis explains.
"The mountain wall will simply disintegrate, and events will probably develop very slowly, a bit like a steam engine being set in motion. An enormous amount of friction will have to be overcome, so the first metre will probably take days." Added to that, the substratum may be uneven or dish-shaped.
"Chances are that the flank will simply subside and come to rest in a new, more stable configuration. This is generally what happens in the Netherlands when a section of a dike collapses."
Meanwhile, at the fluid mechanics section of the faculty of Civil Engineering and Geosciences, Robert Jan Labeur is pretending he is unaware of the objections. With a simple mouse click he launches the western flank of Cumbre Vieja into the sea, then settles back in his chair to calmly watch how the mother of all tidal waves fans out across the world's oceans on his computer screen.
"We do have a problem here, you know," he ▸▸

Robert Jan Labeur and Deepak Vatavani: "You can forget about the fifty metre high tsunami."

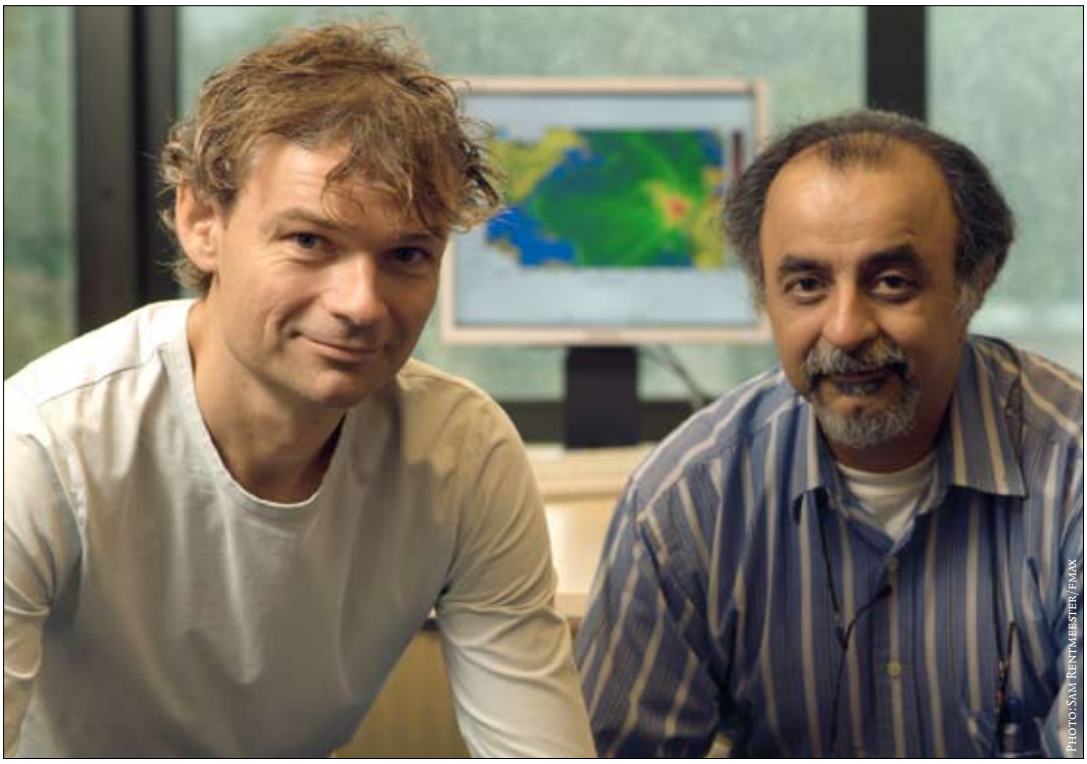


PHOTO: SAM ROENTGEN/FMAX

La Palma – facts en *fiction*

1994

Spanish vulcanologist Juan Carlos Carracedo notes that La Palma is in the early stages of destabilisation

1998

The disaster movie Deep Impact depicts a mega tsunami striking the U.S. coast following a meteor impact

1999

The Journal of Volcanology and Geothermal Research devotes a special issue to the dangers of collapsing island volcanoes

In his book Apocalypse geologist Bill McGuire devotes a chapter to the La Palma mega tsunami

A Spanish-British research steam discovers the remains of two previous landslides on the sea bed at La Palma

2000

Using a simple bath tub experiment, Hermann Fritz and his colleagues at ETH in Switzerland simulate the La Palma mega tsunami

BBC Television devotes a chilling episode of its Horizon programme to the mega tsunami

2001

Steven Ward (University of California) and Simon Day (University College London) describe the mega tsunami in Geophysical Research Letters

Numerous newspapers and popular magazines report on the 'imminent disaster'

2002

Tsunami expert George Pararas-Carayannis violently criticizes the mega tsunami theory presented by Ward and Day, saying that the tidal wave model is completely incorrect

2003

2004

Oceanologists Russell Wynn and Doug Masson (Southampton University) once more condemn the mega tsunami theory as exaggerated

On the silver screen another mega tsunami hits the U.S. This time it is caused by a hurricane in the movie The Day After Tomorrow

The tsunami threat becomes publicly recognised after the disaster in Asia, which leaves 230,000 dead

2005

The BBC postpones the airing of a new dramatised documentary about La Palma on the grounds that it would be too distressing

says as the wall of water rushes towards the Florida coastline.

Well, wall... Let's say the height of the wave reaching America would be about fifty centimetres, or perhaps even one metre high.

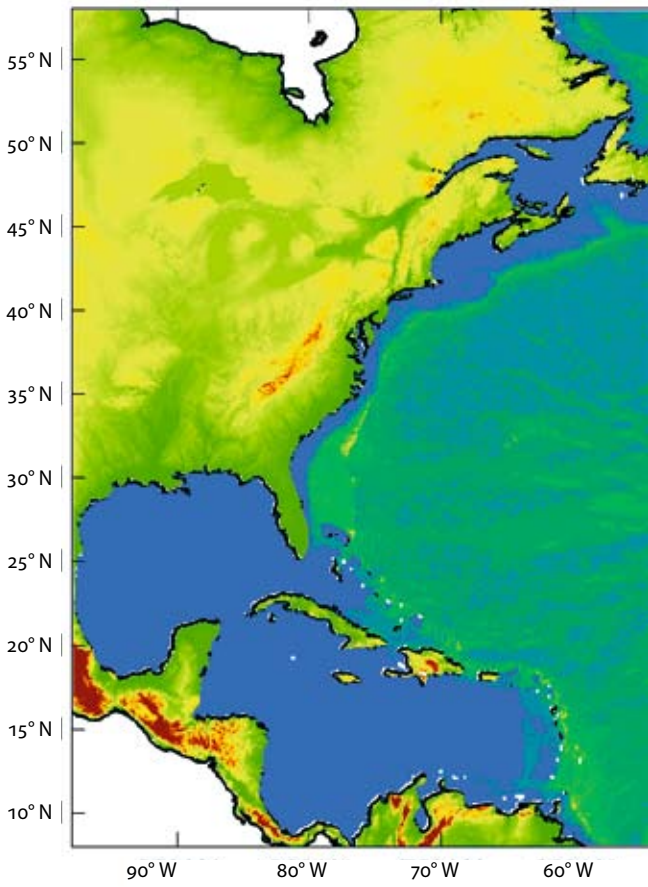
"You can forget about the fifty metre high tsunami. Not that we can simply ignore the problem. People in the lower coastal regions of the U.S. and Europe will certainly be affected."

'Let's stop talking about New York. The places to worry about Gran Canaria and Morocco."

At the request of Nieuwenhuis, Labeur together with a colleague, Ir. Deepak Vatvani of WL Delft Hydraulics, has been studying the way the La Palma mega tsunami would develop if, contrary to expectations, the volcano wall were to drop into the sea in a single mass. They have been using the same software used to simulate the Asian tsunami, among other phenomena.

Modelling the La Palma tsunami is a bit more complicated though, as Labeur explains. First of all, the volcano wall takes over twenty minutes to disappear into the sea.

"In other words, your tidal wave will be on its way



long before the rock mass finishes coming down."

Also, unlike its Asian counterpart, the Canary tsunami cannot be assumed to act as a simple two-dimensional phenomenon. In tech-speak, it is a non-hydrostatic wave phenomenon, characterised by wave lengths that are short relative to the depth of the sea and by a non-negligible vertical motion of the water.

"You really need to fully calculate this tsunami in three dimensions. Although this is not too hard to do for the direct vicinity of La Palma, it becomes a lot more difficult once you send the wave on its way across the Ocean towards Europe and the U.S."

Smashed to smithereens

To simplify matters, the researchers assumed that twenty kilometres out, the mega tsunami would continue as a normal wave sequence, spreading out across the ocean like ripples on the surface of a pond.

"Make no mistake about it," Nieuwenhuis warns.

"This is not your everyday wave like the ones you can see rolling onto the beach. The entire ocean gets lifted up and shifted along. It will be like high water running twenty to thirty kilometres inland. If a wave like that hits a Spanish harbour, everything will be smashed to smithereens."

The results of the calculations are just a rough estimate, full of simplifications, but they nevertheless predict a tidal wave that in the worst case would be two to three metres high when it strikes European countries like Portugal, Spain, France, and the south of England. Thanks to its protected location along the shallow North Sea, the Netherlands would escape most of the damage, with an estimated surge of only a few dozen centimetres.

And what about the United States? The skyscrapers and the Statue of Liberty wouldn't exactly be snapped off like matchsticks, but even so the lower coastal regions will see some wet feet, Nieuwenhuis expects.

"In the Carolinas and in Florida, the beaches will all be flooded. I don't think we'll see people drown, but you can be sure that the wave will not go unnoticed."

The place to witness apocalyptic scenes would be the Canary Islands themselves.

"I'm convinced events there will prove catastrophic; we mustn't underestimate the effect," Labeur says. "The sea will be in turmoil. Bays and sea-bed contours will cause enormous local amplification of wave heights. I think we should change our focus. Forget about New York. The places we should be worrying about are Gran Canaria and Morocco."

, All things considered, it's a good thing that La Palma is sturdily constructed.

"In the event, it will probably be a combination of substantial growth and eruption forces that will bring about a collapse," van Berlo writes in her research report, "and to obtain substantial growth along the full width of the flank will take a time scale in the order of magnitude of tens of thousands of years."

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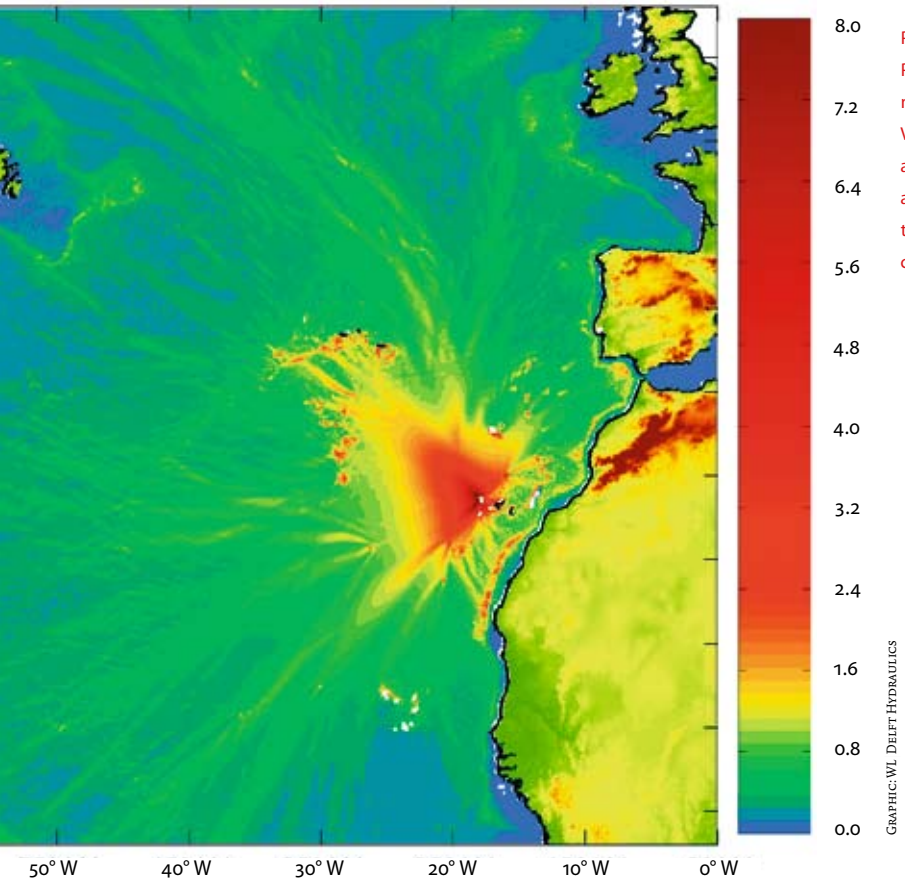

Graphic: WL Delft Hydraulics

Presumed scale of the La Palma tsunami in metres, as modelled by Labeur and Vatvani. The exact gulf altitudes at the Atlantic coast and beaches are not included: the models 'stop' short of the coast lines.