THE EXPLAINER

WHY CAN'T WE PREDICT EARTHQUAKES?

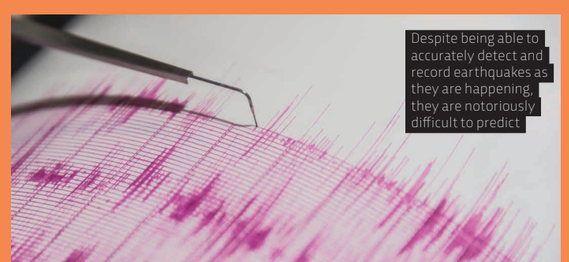
Earthquakes are caused by the massive amounts of energy released as tectonic plates scrape past each other

WHAT CAUSES AN EARTHQUAKE?

As the Earth's tectonic plates push and pull each other, they generate strain that accumulates on lines of weakness in the crust known as faults. When this strain reaches a critical level, a fault will break and the rock masses on either side scrape past one another, releasing a huge amount of energy that causes the ground to shake. Every year, there are more than three million earthquakes; California alone experiences more than 10,000. Most are too small to detect, except by seismometers, but around 15 a year are major shocks of magnitude seven and above, capable of causing major damage and loss of life.

WHY ARE EARTHQUAKES SO DIFFICULT TO PREDICT?

The problem with earthquakes is that – unlike volcanic blasts – they typically happen without consistent warning signs. In the 1980s, seismologists constructed what was touted as the world's most detailed and sophisticated network of monitoring sensors, around the Parkfield segment of California's San Andreas Fault. An earthquake was expected to happen, they had calculated, sometime between 1988 and 1993, and the sensors were designed to pick up precursory physical changes in the crust that could form the basis of an earthquake prediction model. In the end, the magnitude 6.0 quake arrived late, in 2004, with no forewarning or physical precursors whatsoever.



Despite being able to accurately detect and record earthquakes as they are happening, they are notoriously difficult to predict

HOW CLOSE CAN WE GET?

To qualify as a success, an earthquake prediction would have to provide data on the timing, size and location of an event, sufficiently in advance so that action could be taken to limit injury and loss of life. This has never been accomplished. However, earthquakes on most faults have characteristic return periods, so that on one fault they may happen every decade; on another, every century; and so on. The frequency depends upon how much strain a fault can accommodate before it ruptures. This relationship means that earthquakes can be 'forecast'. Forecasts are less precise than predictions but are useful in evaluating the level of risk. So, if there has been no quake for 120 years on a fault that breaks, on average, every 100 years, then there is a high probability that a quake is imminent.

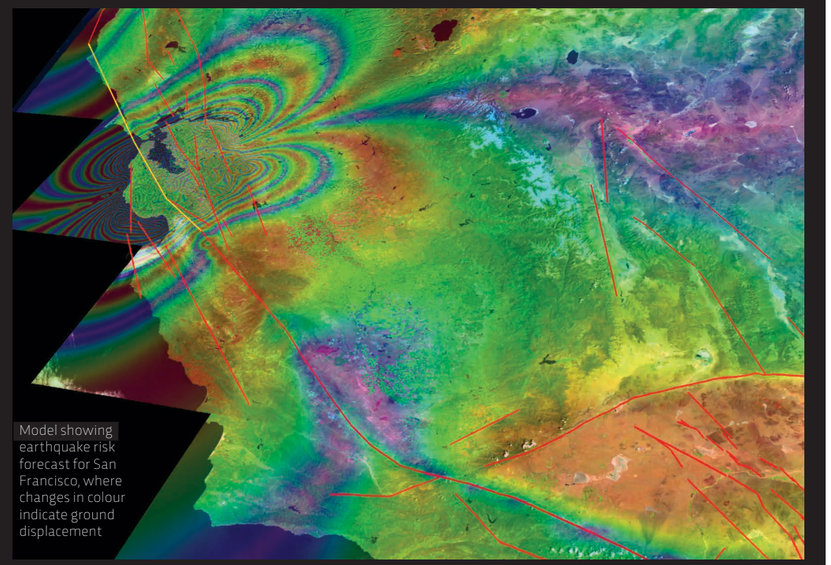
ARE THERE ANY ADVANCES IN THE PIPELINE?

The ability to predict earthquakes has been claimed for all sorts of things, from odd animal behaviour and changes in rock properties, to electromagnetic signals in the crust, and so-called 'earthquake lights' – electrical discharges that have been observed in the sky before some earthquakes. None have proved to be up to the job. But there may be light on the horizon. Scientists monitoring the Cascadia Fault, off the west coast of the US and Canada, have given a machine-learning algorithm their data, with the hope that it can find patterns in the seismic record that could help predict the fault's next big quake.

Aerial view of the San Andreas Fault, running through the Carrizo Plain in California

WILL WE EVER BE ABLE TO PREDICT EARTHQUAKES?

Some seismologists consider true earthquake prediction to be intrinsically impossible because the Earth's crust is in a state of so-called 'self-organised criticality'. If this is the case, it would mean that any tremor – however small – has some probability of ballooning into a major shock. Others argue that prediction is difficult, but we will eventually find a way. If prediction is ever to have any use at all, however, it will have to be accurate, and it will have to be right every time. False alarms would lead to widespread public anger and disillusionment, and they could also mean that people ignore the correct call when it comes, leading to unnecessary deaths.



Model showing earthquake risk forecast for San Francisco, where changes in colour indicate ground displacement

San Francisco lies on a system of significant fault zones, including the San Andreas Fault, meaning there is a high risk of earthquakes

GETTY X3, ALAMY, SUPERSTOCK, NASA/JPL

WOULD ACCURATE PREDICTION BE A GOOD THING, ANYWAY?

What if we knew that a large magnitude earthquake was going to strike a major city – say San Francisco – in exactly three months' time? Making such a prediction public would cause widespread panic and a mass exodus from the city. Businesses would close and shift their stock out – many perhaps for good. Shares in local companies would plummet. California state authorities would need to set up camps for the hundreds of thousands fleeing the city, and feed them for months. Much better, say many seismologists and earthquake engineers, is to forget prediction, and focus instead on making buildings 'life-safe'. In other words, construct them well enough so that they don't fall down when a quake strikes, and bring old buildings up to a similar standard (retrofitting). This way, damage is minimised, the death toll is massively reduced, and the economy and infrastructure little affected.

by PROF BILL MCGUIRE
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