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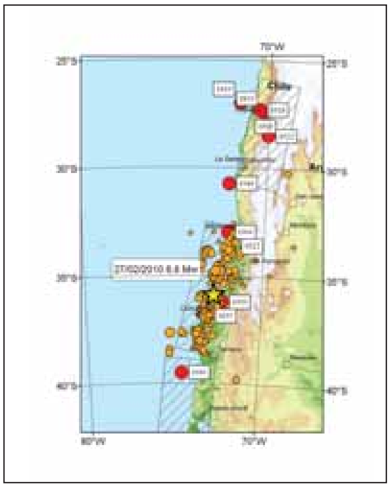
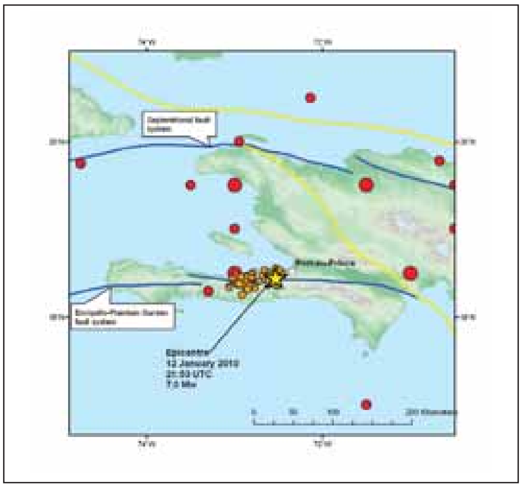
Why didn't scientists predict the earthquakes?

The earthquakes causing devastation in Haiti and in Chile at the beginning of 2010 have reminded us once more of the tremendous destructive power of nature.





The magnitude 7 Haiti earthquake is believed to have claimed 230,000 lives; in contrast estimates of fatalities caused by the magnitude 8.8 Chilean earthquake stand at less than 1000, even though the earthquake released 500 times the energy of the Haiti event. However, in both countries there has been destruction of homes, businesses and infrastructure on a huge scale creating a human and economic catastrophe.

After every damaging earthquake the question is asked "Why didn't scientists predict the earthquake?" Firstly, a definition of a successful prediction is needed. A prediction must demonstrate some level of skill There are around 900 earthquakes of magnitude 5 or more each year, so 'predicting' that there will be one somewhere in the world today is unlikely to be wrong. However, with around only 20 earthquakes each year of magnitude greater than 7 a successful prediction requires skill, and earthquakes of this size have the potential to cause considerable damage.

An earthquake prediction should give the location, magnitude, and timing of the earthquake each with some range of uncertainty. The uncertainties should be small enough such that a useful risk/impact assessment of the earthquake can be made. The risk assessment combines estimates of the distribution of ground shaking and knowledge of the distribution of vulnerable elements exposed to the shaking, including people and built infrastructure. To estimate the ground shaking local geology and ground conditions must be known in detail; the effects on buildings built on solid rock will be different to those built on jelly-like soft sediments.

Both the Haitian and Chilean earthquakes occurred at the boundary between two of the tectonic plates making up the Earth's surface. The plates are in constant motion and in places where they lock together, rather than slip past each other, huge forces build up. The boundaries may be hundreds or thousands of kilometres long and earthquakes happen when a locked section of the boundary suddenly gives way, slipping and releasing the strain energy that may have accumulated over hundreds of years. In the Haiti earthquake a 70km section of the boundary between the Caribbean and North American plates ruptured; in the Chile earthquake the rupture was around 700km long. The concept of an earthquake epicentre as being a point source of energy release is clearly wrong. A successful prediction needs to describe where a rupture starts and where and when it ends. The rupture area and slip controls the earthquake magnitude and energy release. Earthquake prediction is clearly a formidable problem and many scientists contend that the processes involved in earthquake generation are inherently unpredictable.

This is not to say that science cannot help; it definitely can. For example in both the cases of Haiti and Chile scientists had published reports drawing attention to the areas that actually failed – but these were forecasts rather than predictions. The key "hotspots" are all well known and data on likely recurrence of earthquakes at these locations are also known. However the problem is that people demand certainty where there can be none.

In the case of earthquakes, quite simple calculations can be carried out for plate boundary earthquakes. If one plate moves relative to another at 5cm/year and if there is evidence from past events that locked sections of the plate boundary rupture when strain has accumulated to prevent 5 m of slip, then this leads to an earthquake cycle of around 100 years. Today we have networks of seismometers recording earthquakes worldwide and giving the ability to monitor stress changes in the solid Earth. GPS stations and satellite observations are capable of monitoring slow ground deformations (but not beneath the oceans).

But the question is what action can be taken on the basis of what can only be at best a vague forecast such as "there is a 75% probability of a quake of magnitude exceeding 7.0 with its epicentre within a 200km radius of some location within the next five years". Clearly one cannot evacuate all the habitation within that area and wait for five or ten years until the quake has occurred.

Therefore the whole emphasis needs to be on preparation for the quake and above all for ensuring all buildings are constructed to the required standard to withstand quakes of the forecast magnitude.

The other major area of pre-preparation must be much improved contingency planning to deal with the aftermath of a major quake. The tragedy of Haiti must provide the key lessons for the future.

In the face of the inevitability of future potentially damaging events in regions prone to earthquakes it is better to ask "Are we well prepared for the next major earthquake that will affect us", rather than ask whether the earthquake can be predicted with accuracy.

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