Earthquakes happen because the Earth is alive

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A tug boat is among debris in Ofunato, Japan, following a 9.0 magnitude earthquake and subsequent tsunami. Credit: US Navy

It is well known that the surface of our planet is made up of a number of tectonic plates that are much like a massive global jigsaw puzzle. These plates move constantly and are always in contact with each other. When that motion is sudden, the result can be what happened in Japan on March 11 - a devastating earthquake.

But why do the plates have to move? We asked U of T geology professor Andrew Miall to explain.

Why do the tectonic plates move?

The movement of the plates has to do with the Earth's internal heat

engine. This is what is called the earth's mantle, which is several thousand kilometres deep and encircles the entire planet under the crust.

The mantle contains dispersed radioactive elements, such as uranium and thorium. It is constantly decaying and, thus, generating heat. This is why the earth is still a live planet, unlike the Moon, which is dead. There is nothing happening in the interior of the Moon.

But the Earth is still alive. This heat escapes out to space in two main ways. One is by conduction through the surface. There is a measurable heat flow that can be measured at the surface by sensitive instruments. It's why the earth gets warmer as you go into the interior, why the subway is always above freezing and why mines several hundred feet down are warm.

But more importantly from a point of view of earth surface processes, the mantle is in a slow convective transfer of heat, much like the way water boils in a pot on top of the stove, just at a slower rate. These convective currents bring hot mantle to the surface, commonly in the middle of ocean floors.

There is, for example, what's called a "spreading centre" that runs down the middle of the Atlantic Ocean and it creates volcanic activity under the water that is happening all the time.

As these convective currents spread out laterally, they push the continents away from each other, so, for example, North America is retreating from Europe at a rate of about three to four centimetres a year. And this means that all continents are under this relative lateral motion.

It also means that in some places, the plates are brought together. And that's what's happened in Japan. It's a process that's been going on for

hundreds of millions of years. This process is called "subduction" - where plates come together. Where there's an oceanic plate involved, in this case, the Pacific, it turns downward and it descends beneath the overriding continent. The compression between the Pacific plate and Japan has been building steadily and the earthquake was a sudden release of that stress in the form of a sudden snap eastward by two or three metres.

And there is simply no way of predicting this with accuracy in terms of place or time?

We can identify areas where large earthquakes are probable. We've been able to do this for some time now. The Pacific Rim region, which includes Vancouver and Vancouver Island, is within this earthquake-prone zone. But we can't predict when or where they will occur with precision.

Japan, of course, has a history of large earthquakes and it's well known now it is because of the plate tectonics explanation we discussed earlier. The good thing is that Japan has very good building codes and Japan has the best engineering for earthquakes in the world. Any modern buildings constructed in the 1990s or later could withstand a great deal of the expected shock.

Are you surprised by the massive destruction caused by this earthquake and the resulting tsunami?

The earthquake itself was very large. It's now regarded as the fourth largest the earth has ever experienced so, from the Japanese point of view, it counts as "the big one." That doesn't mean we won't get another one of this size in the next few decades. It certainly could happen. But the strength of the earthquake and its position was entirely predictable in

general terms although, as I've said, we can't predict precise location or timing. But now that it's happened, it falls well within expectations.

The tsunami is another thing altogether. There is very little that can be done to protect against tsunamis. There are barriers along parts of the Japanese coasts which are designed to absorb and deflect some of the wave energy but that really only works for small tsunamis and it certainly couldn't handle the one that just hit the Japanese coast last week.

What lessons are being learned from this that could be applied in Canada?

The west coast of Vancouver Island and Vancouver itself could face potentially the same kind of earthquake disaster, although the buildup of stress seems a little slower. So we may be ok for another number of decades or even a few hundred years. Still, there is a definite need for earthquake preparedness and I don't think we've gone as far here as they have in Japan where it's down to individual people having stocks of food in their homes so they could be independent for some time. This has helped enormously in Japan. But I don't think there is the same level of preparedness in Vancouver.

As it turns out, Toronto is one of the safest places in the world to live in terms of natural hazards. You look at all major things that could happen - earthquakes, high tides, rising sea level, floods, hurricanes, and volcanoes and Toronto is way down the list of where you would expect to see a problem.

Provided by University of Toronto