3 Questions: Bradford Hager on Haiti's coming quakes

The MIT geophysicist expects more earthquakes could hit the region relatively soon.

Morgan Bettex, MIT News Office

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Bradford Hager, the Cecil and Ida Green Professor of Earth Sciences
Photo: Patrick Gillooly

Bradford Hager, MIT's Cecil and Ida Green Professor of Earth Sciences, studies problems that involve the deformation of Earth, including the strain that occurs before, during and after an earthquake. By analyzing the patterns of strain caused by the faults that make up plate boundaries, geophysicists like Hager try to identify where earthquakes or other catastrophic events could happen based on the characteristics of the preceding seismic event.

In an interview with MIT News, Hager said the devastating Jan. 12 earthquake in Haiti will likely lead to others in the area relatively soon. He also discussed why a stretch of Southern California is overdue for a major seismic event.

Q. Does the Haiti earthquake raise the risk for an even more catastrophic seismic event at some point in the future and, if so, how?

A. Fortunately, the faults that make up the plate boundaries do not break all in one earthquake. They tend to break in patches, or segments, that are usually tens to hundreds of kilometers long. Individual earthquakes stop when the fault rupture runs into a barrier resulting from a change in direction of the fault or a region where the stress has been released previously by another earthquake or by slow, aseismic fault creep. When one fault patch breaks, it transfers stress to the adjacent segments of the fault at each end of the rupture. This loading by stress transfer makes it more likely that the adjacent fault segments will break some time "soon." By "soon," I mean in a short amount of time compared to the average time between earthquakes on a given fault segment, which is a few centuries in the region where the Haiti earthquake occurred.

The last time the fault segment that caused the Haiti earthquake broke was in 1770. This fault segment was the last of four dominoes that fell. The three fault patches to the east ruptured in sequence in 1751. Similarly, on the north side of the island of Hispaniola, a sequence of earthquakes broke a substantial length of the plate boundary in 1943, August 1946, October 1946, 1948, and 1953. Again, the times between this series of earthquakes were much shorter than the multi-century length of the seismic cycle on an individual fault segment - only a couple of months in one case.

The largest fault segment to rupture anywhere on Earth in recent history is the one off

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Sumatra that generated the great tsunami in December 2004. The fault ruptured over a length of about 1,000 kilometers, resulting in a 9.3-magnitude earthquake. Only three months later, a 300 kilometer long fault patch immediately to the southwest of the "Great Sumatra earthquake" generated a magnitude 8.6 earthquake. Fortunately the next tsunami that resulted was directed to the south, away from any populated areas, and dissipated in the open ocean.

Q. Were there clues that an earthquake of this magnitude would hit Haiti?

A. There have been many major earthquakes in historical times associated with the boundary between the Caribbean and North American Plates, just not so many in the past couple of decades. The Caribbean plate is moving to the east-northeast past the North American plate at about 20 millimeters per year, about half the rate of motion across California. Because of the shape of the Caribbean plate boundary in the vicinity of Hispaniola and Puerto Rico, most of the motion is strike-slip, like the San Andreas. But part of this motion has one block of crust underthrusting the other, which tends to lead to larger earthquakes. In 1751, an earthquake with an estimated magnitude of 8.0 (there were no instrumental records then) occurred on the fault just south of the Dominican Republic where the Caribbean plate underthrusts Hispaniola. It was followed that same year by two earthquakes just to the west along the fault system, both estimated at magnitude of about 7.5. Then, in 1770, another earthquake with an estimated 7.5 magnitude occurred on the same fault that broke in the M = 7.0 event two weeks ago.

The earthquakes in this area are about the same size as those in California. But since the plate motion rate across Hispaniola is about half that in California, the strain takes about twice as long to build up, so the intervals of relative quiet between earthquakes is longer. Given the seismic history in this region, I wouldn't be surprised if the near future will see a lot more activity than the recent past.

Q. Are there other areas of the world that are similarly overdue for such an event?

A. First, I wouldn't say that Haiti was overdue. The recent earthquake was not as large as the estimated sizes of the events in 1751 and 1770, so it looks as though not as much strain had been built up since these earthquakes as was released in them. Although it is not surprising that the recent earthquake occurred, it might easily have been the case that strain continued to build up for another century before being released.

The example of an overdue earthquake with which I am most familiar is the southern section of the San Andreas Fault in California. The segment from near Palm Springs to the Salton Sea has not broken in historical times — at least 325 years. Strain is accumulating on the southern San Andreas about three times faster than on the fault that broke near Port-au-Prince. It is as though the earthquake in Haiti had not happened this year and still had not happened by the year 2500. That's what I call long overdue!