Earthquake's early warning signals detected for the first time

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The 1999 Izmit earthquake in Turkey is one of the best recorded in the world. For the first time, researchers from CNRS, Kandilli Observatory (Istanbul) and the Tubitak research center observed that the earthquake was preceded by a preparatory phase that lasted 44 minutes before the rupture of the fault. This phase, which was characterized by a distinctive seismic signal, corresponds to slow slip at depth along the fault. Detecting it in other earthquakes might make it possible to predict some types of earthquakes several tens of minutes before fault rupture. These findings are published in the 18 February 2011 issue of the journal *Science*.

A large earthquake has a magnitude of 7 or more on the Richter scale. In the twentieth century, nine earthquakes of this type occurred along the North Anatolian fault, one of the most active large faults in the world. The 1999 Izmit earthquake had a magnitude of 7.6 and devastated part of northwest Turkey, not far from Istanbul. It was caused by a strike-slip fault that separates the Anatolian plate, which is moving westwards, from the eastward-moving Eurasian plate, and was one of the best-recorded large earthquakes in the world. Since 1999, a team of CNRS researchers, in collaboration with Turkish seismologists, has been studying this earthquake-prone region.

The scientists recently analyzed seismic recordings obtained close to the epicenter of the Izmit earthquake. They detected a highly distinctive seismic signal that had never been previously observed, just before the fault ruptured. More specifically, the recordings revealed a succession of repeated similar vibrations that lasted for a period of 44 minutes. Although this ground motion was almost continuous, it was too faint to be felt by the population. It continued right up until the earthquake, with steadily increasing intensity. Analysis of the signal shows that it was caused by slow, discontinuous slip of the fault in the region where the earthquake occurred. The signal shows that the fault began to slip at depth 44 minutes before rupture occurred. The slip then continued, steadily accelerating, up until the earthquake.

The Izmit earthquake thus began with the slow slip of the fault at the base of the brittle part of the Earth's crust, at a depth of around 15 kilometers. The signal detected by the researchers, a clear seismic signature of slow slip, indicates the preparatory phase of the earthquake. Although this was predicted by theory and by laboratory experiments, it had never been demonstrated until now. Measuring instruments at GPS stations located near the fault were not sensitive enough to measure the process directly, which partly explains why the signal went unnoticed at the time. Only a very detailed analysis of the recordings has now made this possible. In addition, the researchers were able to base their work on an exceptionally well-recorded earthquake whose mechanism was more or less ideally suited to detecting a possible preparatory phase. According to the scientists, this phase is likely to exist in other earthquakes, especially of the Izmit type. Both its relatively long duration (44 minutes) and the fact that it emitted a highly distinctive signal are encouraging factors. If new observations support the existence of this preparatory phase in other earthquakes, it might at last become possible to predict some earthquakes tens of minutes before the rupture of the fault.

More information: Extended Nucleation of the 1999 Mw 7.6 Izmit Earthquake. Michel Bouchon, et al. *Science*. 18 February 2011.

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