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Observation of repeating earthquakes during the nucleation of the 1999 Mw 7.6 Izmit earthquake

Michel Bouchon (1), Hayrullah Karabulut (2), Mustafa Aktar (2), Serdar Özalaybey (3), Jean Schmittbuhl (4), and Marie-Paule Bouin (5)

(1) ISTERRE, CNRS-UJF, Grenoble, France, (2) Bogaziçi University, Kandilli Observatory and Earthquake Research Institute, Istanbul, Turkey, (3) TUBITAK, Marmara Research Center, Gebze-Kocaeli, Turkey, (4) IPGS, Université de Strasbourg/EOST, CNRS, France, (5) Observatoire Volcanologique et Sismologique de la Guadeloupe, France

The existence or not of a detectable nucleation phase before earthquakes is understandably a fundamental question in earth science. While it is well established that some earthquakes are preceded by foreshocks, nothing so far distinguishes these foreshocks from regular earthquake occurrences, so there is no objective way to identify these events as foreshocks until they are followed by a larger earthquake. On the other hand, the presence or not of a nucleation phase of short duration (a few seconds or less) on some earthquake records, which would indicate the growth of a slip instability on the fault before the earthquake has been strongly debated and remains open. Laboratory and theoretical models of earthquake nucleation predict that slip instability should indeed occur before earthquakes, but whether that instability is large enough to be detected in real Earth conditions and of long enough duration to be helpful is unknown. In this context, we report that the 1999 Izmit earthquake, which is the largest well recorded strike-slip earthquake to date, was preceded by a nucleation phase, clearly identifiable as such on seismic records and of relatively long duration. This phase, which is unlike other seismic signals, shows that the fault had begun to slip at the base of the brittle crust 44 minutes before the earthquake.