Remotely Triggered Earthquakes

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A number of studies have illuminated the role of static stress transfer in controlling the timing of aftershocks as well as subsequent earthquakes following a large mainshock. The role of dynamic stress change is less well understood. A growing body of evidence reveals that dynamic stresses do generate so-called remotely triggered earthquakes at distances well beyond a traditional aftershock zone. Such events commonly occur immediately following the arrival of the highest amplitude S/surface waves at a site, although remotely triggered earthquakes can also occur days and even weeks following a mainshock. The most straightforward explanation for delayed triggered events is that they result from local perturbations caused by an initial disturbance by mainshock, for example an initial triggered earthquake followed by its own local aftershock sequence. Early studies suggested that remotely triggered earthquakes occur only following large (M>7) mainshocks, and preferentially (or entirely) in active geothermal and volcanic regions. New evidence, however, reveals that triggering occurs pervasively, generally at low levels, following moderate and even small mainshocks. Earthquakes as small as M3 are thus followed by not only aftershocks within a few rupture lengths of the mainshock but also triggered events at distances of 10 or more mainshock rupture lengths. A consideration of seismicity rate changes following 30 moderate earthquakes in California reveals evidence for persistent triggering out to a distance of at least 200 km, and further suggests that there is indeed a physical distinction between aftershocks and remotely triggered earthquakes.

The pervasiveness of remote triggering has important implications for not only earthquake source physics and hazard, but also public perception of earthquake hazard once a large earthquake has occurred. To discuss these briefly in turn, results from California provide support for recently proposed models that involve faults that are brittle—i.e., statically strong but dynamically weak. Within this framework, triggered earthquakes would be expected to occur in locally weak faults, but not along locked segments of major faults such as the San Andreas fault or the North Anatolian fault. Investigations of triggered earthquakes in Turkey would be useful to test this hypothesis. The hazard implications result from the fact that, while triggered earthquakes are generally small events, they can be large enough to cause damage.

Even when remotely triggered earthquakes remain small, they frequently capture the attentions of the media and public (and sometimes scientists), which leads to concern for possible future large events. While triggered earthquakes can pose a hazard in their own right, the recognition of remote triggering can provide an explanation for seismicity patterns that might otherwise appear alarming.