Plate Tectonics, Deterministic Chaos and Earthquake Forecasting

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Forty years ago the earthquake was seen as a tool for probing the Earth, as a phenomenon with certain well-defined statistical properties, and as a cause of unheralded catastrophes. The geographical distribution of earthquakes had been mapped in great detail, and shown to be associated with topography, volcanism and gravity anomalies. Earthquake prediction was the domain of charlatans and soothsayers, with occasional bold but premature attempts by scientists. Future earthquake activity was assumed to follow, on average, the historical record. The discovery of plate tectonics, to which seismology made a large contribution, raised the earthquake phenomenon to a new level of understanding. Wadati-Benioff zones were attributed to subduction, and mid-ocean seismicity to the creation of plates. The grand system of slowly moving plates explained the occurrence of a diversity of tectonic and seismic provinces. But it also seemed to support the view that major earthquake occurrence was well-organised and predictable, with permanent fault segments, characteristic magnitudes, and periodicity. Such regularities of scale are excluded by deterministic chaos. Fractals, which are ubiquitous in seismology (as in geology), have no characteristic scale. A comparison can be made with meteorology, from which the concepts of deterministic chaos arose. The long-term process by which a major earthquake is generated can be compared with that for a tropical hurricane. The onset of the process is unpredictable, but, once started, it can in principle be monitored and its culmination forecast by means of precursory phenomena. Thus plate tectonics and deterministic chaos together provide the key to scientific earthquake forecasting.