FROM EARTHQUAKE PREDICTION RESEARCH TO USEFUL WARNINGS AHEAD OF EARTHQUAKES

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Abstract

Since 1988, the south Iceland seismic zone (SISZ) has been a significant multinational test area for earthquake prediction research. A scientific approach was taken to concentrate on studying the physics of processes leading to large earthquakes; this has yielded results showing that there is an observable crustal process on individual faults tens of years ahead of large earthquakes. Studying these ongoing processes makes it possible to establish, via real-time monitoring and ongoing modelling, a basis on which to extrapolate the processes into the future. This means that, in many cases, methods of prediction will be learnt from ongoing processes at each place, rather than identifying precursors common to all large earthquakes. This will help us to overcome the problem that no earthquake is the same, especially when considering micro-scale pre-earthquake processes. The processes that we have studied in the SISZ and the earthquake cycle that we have described illustrate that the approach to practical warnings has to be gradual; i.e. from finding places of preparatory activity, hopefully years before the earthquake occurs, and towards studying and modelling the dynamic processes using multidisciplinary observations.

The micro-earthquake technology that has been applied to the SISZ test area is the basis of this approach as well as the new multidisciplinary model, the 'F–S' model, which explains that near-lithostatic pore-fluid pressures can effectively migrate along lanes from below up into the seismogenic crust of the SISZ in response to strain to modify fracturing conditions there, on both long and a short time scales.

According to experience and theory all large earthquakes in Iceland can be expected to have an observable pre-process. By use of historical evidence, sensitive geophysical observations, evaluations of inter-seismic and likely pre-seismic processes, and real-time modelling, it is probable that all large earthquakes can be predicted to a significant degree. The request made 20 years earlier, in designing the SIL system, was to record and evaluate in real-time all earthquakes down to magnitude zero. Experience shows that, especially in the short-term, significantly more information is gained from even smaller earthquakes at seismogenic depths in a volume close to the target fault.

Recent progress in earthquake prediction research shows us that a scientifically well-organized watching system is required, which can cope with the gradual approach to prediction. The development of such a system, which analyses in real-time all relevant observations, has started to some extent but the work must be accelerated during the coming years. The build-up of such a system is a large undertaking, comparable to the development of the SIL system in Iceland. Such a system is a necessary condition for being able to make use of all the pre-earthquake processes already found for providing useful warnings ahead of earthquakes.