

MICROEARTHQUAKES, STRESSES, CRUSTAL STABILITY, AND EARTHQUAKE WARNINGS

Ragnar Slunga

QuakeLook Stockholm AB, Sweden

Abstract

A new seismic network in Iceland was presented in the Blue Book in 1986. One of the main aims was to create a seismic network allowing analysis of very small micro-earthquakes. The results of the micro-earthquake analysis at the FOA network in Sweden 1979-1982 had shown that each earthquake give the same amount of information independent of size, at least in the magnitude range -1 to 5. The number of micro-earthquakes (giving crustal information) increases with a factor of 8 if the magnitude threshold is reduced one unit.

Sigurdur Th. Rögnvaldsson, to which this seminar is dedicated, was early to realize the power of micro-earthquake analysis and his excellent work was much too early interrupted. From the beginning the automatic micro-earthquake analysis that was implemented into the SIL network included location, extraction of signal parameters, estimation of source parameters including seismic moment and fault radius, and fault plane solutions. It turned out that statistical methods including foreshock activity rate worked rather well as earthquake warnings before the larger Hengill earthquakes 1997 and 1998. However, the June 17 2000 EQ was not proceeded by high foreshock activity. This indicated that a more physical approach was motivated.

The early paper by McKenzie (1969) stated that micro-earthquake source mechanisms could only put weak constraints on the stress tensor causing the slip. That conclusion is true only if the volume around the EQ contains just one fracture.

All micro-earthquake analysis (both FPS and high accuracy locations) show that the crust is very fractured. If McKenzie's conclusion is wrong it is possible to rely on Coulombs criterion instead of the weaker Bott's criterion when estimating crustal stresses. By relating the water pressure to the stress tensor it turned out that the absolute in situ stress tensor causing a micro-earthquake could be estimated. The results of such stress estimates has been shown in a number of presentations here in Iceland and in different European scientific meetings. The results show that the place of the June 17 2000 EQ was seen in the stress mapping years before and the later studies (the SAFER project) show that there were clear indications during the last weeks and days before the EQ.

In conclusion the extremely promising results of the estimation of the absolute crustal stress tensor field by use of micro-earthquakes show how correct the early ideas of the Blue Book were, earthquake warnings require in situ information and micro-earthquake analysis is the key. It would have been nice to discuss these matters with Sigurdur.