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Use of stress tensor field for earthquake warnings

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A new method for inverting microearthquake fault plane solutions into fields of the complete stress tensor has been developed. The method has been tested on Icelandic earthquake data from the years 1991-2005. The total number of microearthquakes with fault plane solutions is about 200,000. Two M 6.5 earthquakes occurred in June 2000 and a few earthquakes with M in the range 5-5.5 occurred in southern Iceland 1998-2003. This provided an excellent data set for the testing of the method. The observed stress tensor field before the two 6.5 earthquakes is in very good agreement with the stress tensor field theoretically computed from plate tectonics and the history of large earthquakes in the years 1700 - 2000 in southern Iceland (given by Roth (2005)). Both the observed (based on the microearthquakes) and the theoretical stress fields gave uniform stresses for the June 21 2000 epicentral area with large driving shear stresses and gave for the June 17 2000 earthquake a heterogeneous stress field with lower driving stress in the northern half of the fault than in the southern half. Both also gave the mean driving shear stress over the June 17 fault to be about half the mean driving stress of the June 21 fault. The observed total shear stresses were extremely large in the June 17 hypocentral volume, larger than anywhere else within the southern lowland area. Thus the two earthquakes were very different and this is also expressed in several ways, source time histories and aftershock distributions. However both the two earthquakes had extreme stress fields, large shear stresses for the first (June 17) and extremely low stability (N-S fault) for the second (June 21). The positions of these two earthquakes can be accurately pinpointed years before the events. All the other earthquakes with M exceeding 5 show large shear stresses similar to June 17. In addition the breaking of the asperity of the high shear stress earthquakes for hours or days before can be seen as the microearthquakes indicate that large shear stresses have been active. The use of the estimated stress tensor field can by identifying the critical volume reduce the false alarm rate for several proposed precursors and also add a physical

understanding of the premonitory processes leading to improved earthquake warnings. This direct physical approach also facilitates the interpretation of premonitary swarms and the very different appearances of some reported precursors. A physical approach has, due to the complexity of the earthquake process, a more general applicability than statistical approaches.