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Understanding intraplate earthquakes in Sweden: the where and why

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The Swedish National Seismic Network (SNSN) underwent a rapid expansion and modernization between the years 2000 - 2010. The number of stations increased from 6 to 65, all broadband or semi-broadband with higher than standard sensitivity and all transmitting data in real-time. This has lead to a significant increase in the number of detected earthquakes, with the magnitude of completeness being approximately ML 0.5 within the network. During the last 15 years some 7,300 earthquakes have been detected and located, which can be compared to the approximately 1,800 earthquakes in the Swedish catalog from 1375 to 1999.

We have used the recent earthquake catalog and various antropogenic sources (e.g. mine blasts, quarry blasts and infrastructure construction blast) to derive low resolution 3D P- and S-wave velocity models for entire Sweden. Including the blasts provides a more even geographical distribution of sources as well as good constraints on the locations. The resolution of the derived velocity models is in the 20 km range in the well resolved areas. A fairly robust feature observed in the Vp/Vs ratio of the derived models is a difference between the Paleoproterozoic rocks belonging to the TIB (Transscanidinavian Igneous Belt) and the Svecofennian rocks east and north of this region (a Vp/Vs ratio about 1.72 prevail in the former compared to a value below 1.70 in the latter) at depths down to 15 km.

All earthquakes occurring since 2000 have been relocated in the 3D velocity model. The results show very clear differences in how earthquakes occur in different parts of Sweden. In the north, north of approximately 64 degrees latitude, most earthquakes occur on or in the vicinity of the Holocene postglacial faults. From 64N to approximately 60N earthquake activity is concentrated along the northeast coast line, with some relation to the offset in the bedrock from the onshore area to the offshore Bay of Bothnia. In southern Sweden earthquake activity is more widely distributed, with a concentration in a band across Lake Vänern, following the boundary between the TIB and the Sveconorwegian orogenic belt. We identify a number of earthquake lineaments in the country and relate these to very different geological units and boundaries, from old Paleoproterozoic features to the youngest postglacial faults. We show how earthquake depths vary in the different seismically active regions, and identify events occurring down to 40 km depth in the crust.

Focal mechanisms show that in much of Sweden strike-slip faulting dominates at seismogenic depths. There are however systematic variations within the country. Inverting the mechanisms for the stress field indicates that the maximum horizontal stress direction is NW-SE, in agreement with ridge-push, in much of the country. We will discuss other possible driving mechanisms, such as the ongoing postglacial rebound.