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Slip rate variations on faults during glacial loading and postglacial unloading: Implications for the viscosity structure of the lithosphere

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Many active faults in extensional and contractional tectonic settings experienced a slip rate increase after the last glacial period when the volume of nearby glaciers and lakes decreased. This postglacial slip rate increase is caused by transient stresses that are generated by the unloading-induced rebound and superimposed on the tectonic background stress field. As the latter is different for normal and thrust faults, the response to loading and unloading should depend on the fault type. Here we use finite-element models including a fault in rheologically layered lithosphere to explore under which conditions both normal and thrust faults experience a postglacial slip rate increase (Hampel et al., J. Geol. Soc. London, in press). The results show that a postglacial slip rate increase occurs on normal faults if the lower crust is stronger than the lithospheric mantle, whereas thrust faults accelerate if the lower crust is weaker than the lithospheric mantle. These findings imply that the response of faults to mass fluctuations on Earth's surface may provide constraints on the rheological stratification of the lithosphere. We use our results to make predictions on the viscosity structure of the Basin-and-Range Province and northern Scandinavia, where palaeoseismological data document a pronounced increase in seismicity due to postglacial unloading and rebound. For both regions, our findings show a remarkably good agreement with viscosity estimates derived from geophysical data and/or forward modelling of transient deformation.