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Late Cenozoic geodynamics in Svalbard: interplay of glaciation, seafloor spreading and mantle convection

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In late Cenozoic time Svalbard experienced tectonic reactivation including regional uplift, volcanism and fault movements associated with ongoing intraplate seismic activity. Previous studies attributed this reactivation to thermal and/or mechanical effects related to the proximity to the Mid-Atlantic Ridge and/or small-scale mantle convection. However, it has remained unclear i) how these effects could affect a large region over a distance of >500 km and ii) why the tectonic activity has apparently accelerated over time while the mid-ocean ridge occupied a progressively more distant location due to the crustal accretion. In this work, seismological models of the upper mantle, satellite gravity measurements, spatiotemporal characteristics of earthquakes, and relative sea level data for the Holocene are interpreted in terms of the late Cenozoic - recent lithosphere evolution in Svalbard applying geodynamic constraints. The thermally attenuated lithosphere roughly corresponds to a triangular-shaped region including Spitsbergen and Nordaustlandet. The thermal weakening of the Svalbard upper mantle can be resolved from the relative sea level data suggesting that the viscous relaxation times significantly decrease over a distance of 500 km toward the margin. The lateral heat conduction from the Knipovich Ridge is only significant within a thermal diffusion distance of <100 km from the margin, and is not sufficient to explain significant thermal erosion/removal of the lower lithosphere beneath Svalbard suggested by geophysical data and geochemical composition of basalts at the Knipovich and Gakkel ridges. A thermal kinematic model including hot asthenosphere channeled from Iceland along the plate boundary is more consistent with the observations. The low shear velocity anomalies in the asthenosphere and long-wavelength gravity anomalies form a similar pattern of channelized lobes which are, however, misaligned with respect to the Mid-Atlantic Ridge north of Iceland. A net rotation of the lithosphere relative to the lower mantle during the past 30 My explains this misalignment of seismic and gravity anomalies with respect to the plate boundary. The lubrication theory scaling relations imply that the hotspot channeling along the Mohn and Knipovich ridges could be favored by extremely low extension rates off the western Svalbard margin in the Miocene. However, the dynamic relations of brittle deformation in the elastic lithosphere and the viscous flow in the asthenosphere are not clear from the data.