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Erosion history of Svalbard: evidence from low-temperature thermochronology, vitrinite reflectance and clay mineralogy

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Svalbard, situated at the hinge point of the two passive margins of the Eurasian Basin and the Norwegian-Greenland Sea, plays an important role for the tectonic reconstruction of the Arctic landmasses. Especially the reorganization of landmasses during the late Mesozoic-Cenozoic development of the North Atlantic and Arctic Ocean basins influenced the adjacent continental margins, e.g. by the Eurekan orogeny. Svalbard can be subdivided into three different areas: a northern part of predominantly Proterozoic to Devonian basement, the Central Tertiary Basin (CTB) comprising thick Paleozoic to Cenozoic sedimentary strata, and the Paleogene West Spitsbergen Fold Belt (WSFB) on the western rim of Svalbard.
Thick Cenozoic sediments have been deposited within the off-shore basins around Svalbard. Glacial erosion on the Barents Shelf is suggested to have contributed most of the Plio-Pleistocene strata. However, it is poorly constrained how much of the Paleocene to Miocene material was supplied by the sediment source areas on Svalbard.
To constrain the erosion history of Svalbard, apatite fission track (AFT) and apatite (U-Th-Sm)/He (AHe) analyses have been applied, allowing to reconstruct the thermal and exhumation history of the upper 6 to 1.3 km of the crust, and to calculate maximum net erosion. Both methods have been applied to basement samples from northern Svalbard and drill core samples from the center of the CTB. Basin data have been combined with maximum paleo-temperatures and burial depths derived from vitrinite reflectance and clay mineralogical analyses of Paleocene-Eocene deposits.
AFT and AHe data revealed that the northern Svalbard provinces (Albert I Land, Ny Friesland and Nordaustlandet) exhumed with a similar pattern, but differing rates and timing between early Jurassic and late Eocene. AFT dates range between 62 ± 5 and 214 ± 10 Ma which is surprisingly old compared to the much younger AFT dates by Blythe and Kleinspehn (1998) reporting Eocene/Oligocene exhumation of the WSFB. Mesozoic-Paleocene exhumation of northern Svalbard is most likely related to the formation of the Amerasian Basin. AHe data (47 ± 6Ma to 91 ± 10Ma) also showed that parts of northern Svalbard were affected by fault activities and post-40 Ma displacements presumably related to the Cenozoic basin formations and the Eurekan orogeny forming the WSFB along the western rim of Svalbard. Our data support the assumption that the Mesozoic to Paleocene sediments of the CTB were derived from northern Svalbard (Harland, 1997). However, about 1.3km of exhumation of northern Svalbard remain for the last $\sim$40 to $\sim$90 Ma. It is unclear where the eroded material was deposited as the strata of the CTB records a change in sediment source area to the west around 55 Ma.
Coal beds within the Paleocene-Eocene strata of the CTB indicate considerable burial (or elevated geothermal gradient) during deposition. However, our thermochronology data from the drill cores of the central CTB showed only partial resetting of the AFT system but complete resetting of the AHe system (18 ± 3 Ma) indicating maximum temperatures between 70 and 110°C for the uppermost Eocene deposits (Aspelintoppen Fm.). This is in good agreement with paleo-temperatures derived from vitrinite reflectance (92-125°C) and clay mineralogy (80-120°) of the cores. Maximum burial depths of the Aspelintoppen Formation can be restricted to $\sim$2.1, and the base of the Cenozoic strata to $\sim$2.9km resulting in a maximum paleothermal gradient of 42°C/km. This is also in agreement with the vitrinite reflectance data by Manum and Throndsen (1978) derived from the outer rim of the basin. Deposition within the CTB ceased during mid Oligocene, which means net erosion within the CTB can be restricted to $\sim$2 km during the last 30Ma. Because the current erosional surface is also Eocene, we conclude that Eocene/Oligocene deposits must have been 2 km thicker than what is preserved today.

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