Geophysical Research Abstracts
Vol. 18, EGU2016-10058, 2016
EGU General Assembly 2016

The High Arctic Large Igneous Province Mantle Plume caused uplift of Arctic Canada

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The Sverdrup Basin is an east–west-trending extensional sedimentary basin underlying the northern Canadian Arctic Archipelago. The tectonic history of the basin began with Carboniferous–Early Permian rifting followed by thermal subsidence with minor tectonism. Tectonic activity rejuvenated in the Hauterivian–Aptian by renewed rifting and extension. Strata were deformed by diapiric structures that developed during episodic flow of Carboniferous evaporites during the Mesozoic and the basin contains igneous components associated with the High Arctic Large Igneous Province (HALIP). HALIP was a widespread event emplaced in multiple pulses spanning ca. 180 to 80 Ma, with igneous rocks on Svalbard, Franz Josef Island, New Siberian Islands, and also in the Sverdrup Basin on Ellef Ringnes, Axel Heiberg, and Ellesmere islands. Broadly contemporaneous igneous activity across this broad Arctic region along with a reconstructed giant radiating dyke swarm suggests that HALIP is a manifestation of large mantle plume activity probably centred near the Alpha Ridge. Significant surface uplift associated with the rise of a mantle plume is predicted to start ∼10-20 my prior to the generation of flood basalt magmatism and to vary in shape and size subsequently throughout the LIP event (1,2,3) Initial uplift is due to dynamical support associated with the top of the ascending plume reaching a depth of about 1000 km, and with continued ascent the uplift topography broadens. Additional effects (erosion of the ductile lithosphere and thermal expansion caused by longer-term heating of the mechanical lithosphere) also affect the shape of the uplift. Topographic uplift can be between 1 to 4 km depending on various factors and may be followed by subsidence as the plume head decays or become permanent due to magmatic underplating. In the High Arctic, field and geochronological data from HALIP relevant to the timing of uplift, deformation, and volcanism are few. Here we present new evidence based on stratigraphic correlation that show thinning of strata in the northeastern part of the basin. The Isachsen Formation (Valanginian or Hauterivian to late Aptian) is a sandstone unit with interbeds of mudstone, coal, volcanic, and volcaniclastic/tuffaceous rocks attributed to HALIP. Isachsen Formation has a fairly consistent thickness over most of the Sverdrup Basin, ranging from ∼120 m at basin margins to 1370 m on western Axel Heiberg Island but is generally > 400 m thick, even over the large salt domes that rose almost to the surface immediately prior to its deposition. The thickness of the formation decreases from over 400 m thick at Ellef Ringnes Island and southern Axel Heiberg Island to less than 120 m across a broad area of central Ellesmere Island. We interpret NE thinning of these strata to be the result of topographic uplift associated with initial mantle plume activity of HALIP. However, the rejuvenation of Sverdrup Basin formation (nearer the plume centre) in the Hauterivian–Aptian reflects complexities in the uplift pattern.

References: 1-Griffiths, R.W. and Campbell, I.H. 1991 JGR 96: 18295–18310. 2-Campbell, I.H. 2007. Chem. Geol., 241: 153-176. 3-Ernst, 2014. LIPs. Cambridge U. Press, 653 p.