The lavas of the Zig-Zag Dal Formation of eastern North Greenland constitute a Mesoproterozoic tholeiitic flood basalt succession up to 1,350 m thick, extending >10,000 km2, and underlain by a sill complex. U–Pb dating on baddeleyite from one of the sills thought to be contemporaneous with the lava extrusion, gives an age of 1,382±2 Ma. The lavas, subdivided from oldest to youngest into Basal, Aphyric and Porphyritic units, are dominantly basaltic (>6 wt.% MgO), with more evolved lavas occurring within the Aphyric unit. The most magnesian lavas occur in the Basal unit and the basaltic lavas exhibit a generalised upward decrease in Mg number (MgO/(MgO + Fe2O3T)) through the succession. All of the lavas are regarded as products of variable degrees of olivine, augite and plagioclase fractionation and to be residual after generation of cumulates in the deep crust. The basaltic lavas display an up-section fall in the ratio of light to heavy rare-earth elements (LREE/HREE) but an up-section rise in Zr/Nb, Sc, Y and HREE. The older lavas (Basal and Aphyric units) are characterised by low Nd and Hf in contrast to higher values in the younger (Porphyritic unit) lavas. The Porphyritic Unit basalts are characterised by a notable enrichment in Fe and Ti. The Zig-Zag Dal succession is inferred to reflect an increase in melt fraction in the sub-lithospheric mantle, with melting commencing in garnet–lherzolite facies peridotites and subsequently involving spinel-facies mantle at increasingly shallow depths. Melting is deduced to have occurred beneath an attenuating continental lithosphere in conjunction with ascent of a mantle plume. Lithospheric contamination of primitive melts is inferred to have diminished with time with the Porphyritic unit basalts being products of essentially uncontaminated plume-source magmas. The high iron signature may reflect a relatively iron-rich plume source.