Geophysical Research Abstracts
Vol. 20, EGU2018-3560, 2018
EGU General Assembly 2018

Wavelet analysis of magnetic anomaly data: constraining thermal structure of western Canadian lithosphere

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The Curie depth (z_C) is the point at which crustal rocks lose their magnetization above a critical temperature, which corresponds to ∼580 ˚C for magnetite. Curie depth estimates therefore provide quantitative constraints on lithospheric geotherms and surface heat flow. Crustal magnetization can be modeled using three parameters: 1) β, the power-law exponent of fractal magnetization; 2) z_t, the depth to the top of the magnetized layer; and 3) z_C, the depth to the bottom of the layer, which corresponds to the Curie depth. These three parameters affect the shape of the power spectrum of the resulting magnetic anomalies; Curie depth can therefore be estimated from the spectral analysis of magnetic anomaly data. In this study, we test the recovery of z_C using a continuous wavelet transform by synthesizing magnetic anomaly data using various models of crustal magnetization. Extensive tests are carried out using uniform parameters and spatially-variable z_t and/or z_C. We show that: 1) correcting for the power-law exponent of crustal magnetization β is essential to recover the correct layer parameters; 2) the wavelet transform is able to retrieve the patterns of the crustal magnetization models when z_t is fixed to its correct value. This method is then applied to magnetic anomaly data in western Canada, in a region that encompasses the Canadian Cordillera and parts of the Canadian Shield. The Curie depth varies widely across the study area, and is consistent with high surface heat flow and Moho temperatures in the allochtonous part of the Cordillera, in contrast to much lower values in the Shield. The average z_C is ∼14 km west of the crustal-scale transform Tintina Fault and ∼28 km east of the Rocky Mountain Trench. Calculated surface heat flow from the average Curie depth in the Cordillera indicates that a β parameter of 2.5 best fits measured surface heat flow data. The contrast in thermal structure between the Canadian Cordillera and Shield is a result of vastly different tectonothermal evolutions. For instance, low-temperature thermochronological studies show that the Cordillera is characterized by rapid, large-scale cooling events in the Cretaceous to Eocene, in contrast to the craton which records Permian stabilization. These results provide useful constraints for the structure and evolution of the craton margin.