Geophysical Research Abstracts
Vol. 19, EGU2017-13817, 2017
EGU General Assembly 2017


# Interpretation of thermochronological cooling ages using thermal modelling: an example from shallow magma intrusions from the Kerguelen archipelago

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Low temperature thermochronology on plutonic rocks is traditionally used to calculate erosion rates over large time scale. However, this method requires a good knowledge of the local or regional geology and particularly the thermal structure and evolution of the crust. The Kerguelen Islands (48-50°S, 68/5-70.5°E, Indian Ocean) are the emerged part of a vast oceanic plateau and are mostly made up of Oligocene basaltic traps that are cross cut by a dense network of large and deep valleys. Numerous plutonic complexes of various age (20-4.5 Ma) locally intrude theses traps and cover about 15% of the main island's surface. The Rallier du Baty peninsula is the largest plutonic complex, it is mainly constituted of syenites and is divided into two adjacent circular plutonic complexes whose centres are distant of 15 km. The southern part has a laccolith structure with satellites plutons and was emplaced at shallow depth (about 1 to 3 km) between 13.7 ± 0.3 and 8.0 ± 0.2 Ma. The northern part was emplaced later between 7.8 ± 0.25 and 4.5 ± 0.1 Ma.

The Kerguelen Islands are of particular interest to understand the impact of Cenozoïc climatic variations on the long-term geomorphological evolution of emerged reliefs at mid-latitudes. To understand the erosion of the area, we conducted the first study on the Kerguelen Islands using the biotite 40Ar/39Ar (BAr), apatite and zircon (U-Th)/He thermochronometers (AHe and ZHe). In the southern part, the BAr ages for the various intrusions of the complex range from 9.44 ± 0.13 Ma to 13.84 ± 0.07 Ma. These ages are identical to high-temperature crystallisation ages (U-Pb on zircon) indicating an extremely rapid cooling between ∼700 and ∼300°C. The mean ZHe ages range between 7.1 ± 2.3 and 8.8 ± 1.4 and the mean AHe ages range between 4.4 ± 0.3 Ma and 7.4 ± 0.7 Ma. The AHe ages of the southern complex are similar to the crystallization ages of the northern part of the complex. The mean AHe ages in the northern part are much younger and range from 1.4 ± 0.7 Ma to 0.8 ± 0.1 Ma.

Combined with the thermochronological approach, the thermal structure of the crust beneath the Kerguelen Plateau was established by inverse modelling of gravity, geoid and topography data. The results suggest a mean current thermal gradient of ∼40°/km for the Kerguelen Plateau. Moreover, thermal modelling allows reconstructing heat diffusion in 1D after successive sill intrusions (vertically and horizontally) in order to confirm AHe data can be interpreted as exhumation ages in both complexes. In this case, the mean thermal gradient can be considered to convert the cooling rates in erosion rates.