ZIRCON FISSION TRACK ANALYSIS

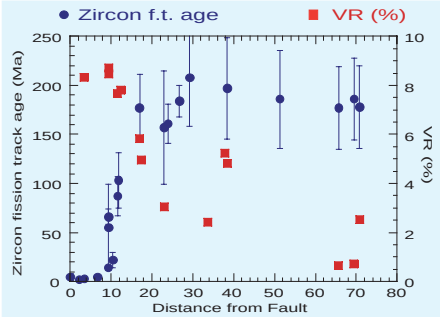
Like apatites, zircons are a common detrital constituent of medium to coarse-grained clastic sediments. The zircon grains originate as accessory minerals in igneous or metamorphic rocks, and as they are very stable during erosion and transport, they are a common sedimentary constituent. Zircons contain trace amounts of uranium (up to 1000 ppm) and thus fission tracks form within the crystal lattice over time, the density of which is proportional to the uranium content of the zircon.

ANNEALING KINETICS

As in apatite, fission tracks in zircon shorten when heated, but significant effects require much higher temperatures than in apatite. The annealing kinetics of fission tracks in zircon are less well known than for apatite, but recent experimental annealing studies have shown that the kinetics in the two minerals are of the same general form.

Technical difficulties relating to anisotropic etching and the effects of alpha-recoil damage in zircon mean that interpretation of experimental data is not straightforward. Studies of annealing kinetics in geological situations offer some promise, but are limited by the rarity of present-day settings where temperatures are high enough to produce observable effects. Data from very deep wells, including the Kola Peninsula Superdeep Drillhole SG-3 which penetrates over 12 km of Precambrian rocks, and reaches a temperature of 216°C at TD, show that temperatures well over 200°C are required to produce detectable annealing.

Additional information on fission track annealing kinetics in zircon is available from comparison of ZFTA data with vitrinite reflectance (VR) data from sedimentary sequences which have been subjected to profound geological heating. Our research in South Island, New Zealand, has shown that the onset of significant fission track age reduction in zircon correlates with VR values of ~6%, while total annealing is equivalent to ~8% $R_O$max or higher (see Figure), implying temperatures of around 300°C (i.e. Greenschist grade metamorphism).



APPLICATIONS

Thermal history applications of ZFTA are currently limited to the evaluation of fission track age data. The nature of most zircon grains is such that track length measurements cannot be routinely carried out, as they are in apatite. Combined with uncertainty over the exact form of the annealing kinetics, detailed thermal history modelling of ZFTA data is not, as yet, possible.

ZFTA can be applied to sediments in which the vitrinite reflectance is very high (> 6%) to determine the timing of cooling from a high temperature event. In conjunction with AFTA® and a vertical vitrinite reflectance profile, ZFTA may provide unique information on the timing of high temperature events due to igneous activity, elevated heat flow or deep burial.

Due to the high thermal stability of tracks in zircon, ZFTA can also be used as a simple dating tool in stratigraphic applications where conventional radiometric techniques are inadequate. For example, direct determinations of the age of highly weathered igneous rocks and tuffs are possible because zircon is resistant to severe weathering conditions. Altered basaltic intrusions that do not contain zircon may be dated by analysing zircons from the adjacent contact metamorphic zone in suitable rock types (e.g. sandstones, granite).

In sediment provenance studies, ZFTA may be used to identify regions contributing detritus to a basin. As a conservative guide, if the regional vitrinite reflectance level is less than 2% in the formation of interest, then the ZFTA results from a sediment can be interpreted simply in terms of the time of cooling below ~300°C in the provenance terrain from which the zircons were eroded. Different components within a spectrum of fission track ages can then be related to different source terrains.

MORE INFORMATION?

Geotrack offers a zircon fission track analytical program and interpretation as a part of its thermal history reconstruction services. Consultation at the commencement of a project will enable us to assess the validity of the analysis in the specific geological setting, and to recommend a cost-effective sampling strategy appropriate to the problems to be addressed.

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