Fission-track Analysis (FTA) as a Tool to Reveal Thermal Evolution of Rocks: First Application in the Czech Republic

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Fission-track analysis has been used for many years on rocks from crystalline basement where substantial contributions to the knowledge of orogenic chains have been made. Earliest applications of this technique relied exclusively on the evaluation of fission-track ages in zircons and apatites separated from the igneous or metamorphic rocks.

More recent detailed investigations, however, have revealed that apatite fission tracks contain significantly more information than simply the apparent fission-track age. The apatite age is reduced during annealing largely as a result of a reduction in the etchable range of fission tracks and, since this is revealed in the length of *confined* fission tracks, this parameter offers also a fundamental source of *paleotemperature information*. The coincidence between the temperature range in which fission tracks in apatite are annealed, over times of the order of 1 to 100 my, and that in which liquid hydrocarbons are generated has led to the emergence of Apatite Fission-Track Analysis (AFTA) as one of the most promising tools in the appraisal of subsidence and thermal history in sedimentary basins. Besides offering information on maximum paleotemperature, AFTA gives direct information on timing of thermal events and also provides semi-quantitative estimates of the variation of paleotemperature through time. In fact, the continuous production of fission tracks with time gives the AFTA system the additional advantage of recording the entire thermal history in a single sample. AFTA can be applied to sequences of all ages including early Paleozoic and even Precambrian rocks. Finally, besides the chronostratigraphic and paleothermal applications, AFTA offers a powerful tool for identifying sedimentary provenance.

Since 1998, the application of the method of the fission track-analysis has been systematically prepared at the Institute of Geology, Academy of Sciences (Prague). Over fifty samples were collected from various sedimentary, metamorphic and igneous complexes of the Czech Republic and processed at the Fission-Track Laboratory of the Max-Planck Institute (MPI) of Nuclear Physics in Heidelberg, Germany.

Encouraging preliminary results have already been obtained on five pilot samples that come from the Barrandian area of central Bohemia (Lower to Upper Paleozoic). Apatite grains separated from selected Silurian, Ordovician and Carboniferous rocks were irradiated and processed at FT Stage System (Kinetek Corporation). Preliminary computer-aided modelling with Invert-1 algorithm was carried out to decipher time-temperature history (T-t diagram) of the samples. As a result, two distinct groups of apatite grains that reflect two contrasting time-temperature paths were distinguished. The samples taken from the northwestern part of the Barrandian Basin (Ordovician greywacke from Levín and Westphalian volcanic tuff from Ovčín near Radnice) revealed pool ages of 259±10 Ma and 257±1 Ma, respectively. The samples collected from the southeastern flank of the basin (Ordovician tuff from Chlustina and Silurian metabasalt from Lištice near Beroun) are characterised by pool ages of 324±16 Ma and 313±35 Ma, respectively. Fifth sample of apatite grains, that comes from the Ordovician greywacke from Tobolka-1 deep borehole of central Barrandian, yielded a wide spread of single grain ages that point to pool age of 182±10 Ma. These preliminary data can be interpreted in terms of variations of heat flow and/or exhumation rate in different parts of the basin. In the near future, our results will be further refined and integrated with numerical models of organic matter maturation to supply reliable time-temperature constraints on the history of the Barrandian Basin.

For 1999-2000, an extensive sampling from other igneous and sedimentary units of the Czech Republic is scheduled. Our present experience indicates that the data can significantly improve the present knowledge of the geological evolution of the Bohemian Massif. Obtaining and processing of the fission-track data on rigorous, quantitative basis will be made possible through the ongoing cooperation with Heidelberg MPI fission-track dating laboratory. In addition, since mid-1999, a new equipment for fission-track counting will be introduced at the Institute of Geology AS CR, Prague, that will allow to expand our research.