

K-Ar and fission track dating: thermal histories and tectonics of igneous rocks in Chile and Argentina

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The different temperature ranges at which fission tracks are stable in the minerals sphene, zircon and apatite yields the possibility to obtain a better understanding of the thermal history by dating the different minerals present in a rock. The retention temperatures of the fission track mineral systems lay below 300°C and link up with the closure temperatures of K-Ar and Rb-Sr mineral dating systems. Therefore fission track dating together with other mineral dating methods is a powerful tool to reconstruct the crystallisation and emplacement history of igneous rocks and contribute valuable information to the understanding of the evolution of the regional geology.

Concordant mineral ages of an igneous rock are characteristic for a process of rapid cooling and important conclusion can be drawn about the geotectonic development and setting of a magmatic event. Discordant mineral dates of igneous rocks are practically always the result of the thermal history of the rock. A regular decrease of the different accessory mineral ages is characteristic for a post-emplacement cooling history. A significant time-gap between different mineral dates mostly points to the influence of a younger thermal event.

Because the apatite fission track dating system is very sensitive to elevated temperatures, i.e. above some 125°C fission tracks in apatite anneal or are not registered, the obtained apatite fission track dates can be considerable younger than the crystallisation or even the post-emplacement/cooling age. Interpreting mineral dates in terms of time-temperature relations, instead of just dates, important and significant information over the thermo-tectonic history of igneous rocks and therefore the region is obtained.

In the Central Andes of Chile and Argentina the formation of igneous rocks is the result of geological activities that started in Cambrian times and episodically continued to recent times. K-Ar and fission track mineral age determinations were performed on several plutons, which together form a cross-section around the 23°S latitude running from the Coastal Cordillera of Chile to the Cordillera Oriental of northwestern Argentina. The structural evolution of the area is strongly influenced by several periods of subduction regimes at an active continental margin. Magmatic activities are related to both the Paleozoic Hercynic Cycle or the Meso-Cenozoic Andean Cycle. The obtained spectrum of mineral dates of the different plutons, ranging from 530 to 30 Ma, fit the present general ideas about the tectonic and magmatic evolution of the Central Andes of Chile and northern Argentina. However, different minerals in one rock may reveal completely different ages, like for instance a pluton of the Cordillera Oriental with a Cambrian age for the K-Ar biotite system (532 ± 21 Ma) and a mid-Tertiary age for the apatite fission track system (30.3 ± 3 Ma). A careful interpretation of particularly this kind of data may give important indications over processes of thermal doming, extension tectonics, subsidence etc. In the studied area several of these examples have been found.

A group of Jurassic sheared metagranites of the Coastal Cordillera of Chile yielded concordant Early Cretaceous mineral dates. It will be discussed that these ages must be interpreted as reflections of the geotectonic evolution and setting of the Jurassic-Early Cretaceous magmatic arc system. The mineral ages point to a considerable vertical uplift movement of some 12 kilometers during the Early-Cretaceous.

Still another group of plutons also give concordant, but Early-Tertiary mineral ages, reflecting the position of the Late Cretaceous-Paleogene arc in the Chilean Precordillera (Sierra de Moreno and Cordillero Domeyko). Fission track analysis on apatites clearly show that these igneous rocks intruded at shallow depth in the crust and cooled very rapidly to surface temperatures. The consequences of these findings will be discussed in connection with the development of the magmatic arc system.