VITRINITE PALEOGEOTHERMOMETERS: COMPARATIVE APPLICATION AND TIME TEMPERATURE MODELING IN THE ALPINE OROGEN (GRAUBÜNDEN, SWITZERLAND)

FERREIRO MÄHLMANN, R.

Mineralogisch-Petrographisches Institut der Universität Basel, Bernoullistr. 30, CH-4056 Basel

Two of the most accepted methods of numerical maturity modeling from diagenesis to incipient metamorphism are compared. In the Central Alps of Graubünden (Switzerland) the »time temperature index of maturity« (TTI) of LOPATIN (1971), modified by PETSCHICK (1989), and the »EASY%R_o-program« of SWEENEY & BURNHAM (1990), allow to deduce time-dependent vitrinite reflection paleogeothermometers. Based on an extensive data set of vitrinite reflection (VR) measurements and a time-temperature calibration with illite-»crystallinity« values, fluid inclusion data, radiometric illite-muscovite ages, and mineral parageneses, it is possible to model the geothermal history of the Upper and Lower Austroalpine in the Mittelbünden area and in the Oberhalbstein valley. Comparing different scenarios of metamorphic histories, maturity modeling clearly favoures multistage heating, proposed by FERREIRO MÄHLMANN (1995, 1996) with moderate to high average heating rates. It is shown that TTI and EASY%R_o are precise modeling instruments to reconstruct orogenic temperature histories in nappe tectonic settings through time. Both methods are in good agreement with abouve mentioned methods for the determination of heating duration and rock maturation. This is valid under different thermo-tectonic conditions, such as burial, volcanothermal, diastathermal and orogenic metamorphism. Therefore, these methods can elucidate not only simple thermo-tectonic regimes (grabens and basins), but also very complex polymetamorphic conditions. TTI- and EASY%R_o maturity modeling allow to present a paleotemperature map and to predict burial depth, erosional overburden, metamorphic temperature and heat flux in different tectonic stockwerks of the studied area in Graubünden.

The TTI%R_o(random reflectance)-%R_{max}(maximum reflectance) correlation yields reflectance, temperature and burial depth values that are considerably greater than those calculated for the Arrhenius based method for isogeothermal conditions, particularly at higher thermal flux. By contrast, heat flux is mostly underestimated. Also comparison of isogeothermal gradients emphasize time-dependent differences for maximum temperature and VR between the methods at particular heat flux. An overestimation of predicted VR, even more evident at high heating-rates, is commonly known (MORROW & ISSLER, 1993). During long time heating, at intervals >20 Ma, the time-dependency of TTI is reduced and both methods predict nearly identical burial depth-T°C-VR-heat flux (gradient)-values. The combination of the more time-dependent TTI-index and the more maximum-temperature-dependent EASY%R_o-method show that the level of organic maturity is almost entirely a product of temperature and time. In Mittelbünden, the extraordinarily complex temperature history could be decoded, because results from TTI and EASY%R_o-modeling complement each other. Using the same calibration set the accuracy of TTI and EASY%R_o are comparable, making them

a valuable tool in developing thermal models to fit sets of tectonic data. This is not only realized in the Alpine foreland (TODOROV et al., 1993; SCHEGG, 1994) and in Alpine Late Tertiary basins (SACHSENHOFER & LITTKE, 1993), but also in the internal part of the Alpine orogen. Modeling also shows that duration of maximum temperature (metamorphism) plays a very important role in the alteration of organic matter. The functional time-temperature relationships listed in this work yield calculated VR and temperature, that differ by amounts that are measurable over a geologically reasonable range of metamorphic histories. Therefore, TTI and EASY%R_o are precise modeling instruments to reconstruct orogenic temperature histories through time and a good basis for further work on diagenetic to incipient metamorphic histories in the Central Alps and nappe tectonic settings in general.

In the Alpine hinterland, VR measurements and numerical maturity determinations, combined with thermal modeling, can elucidate a thermal maturity pattern in Mittelbünden and the Oberhalbstein reflecting the complex tectonic history of the region. The amalgamation of nappes from different paleogeographic origins with different thermal and uplift histories produced a patchwork of sharply contrasting thermal maturity between the Upper and Lower Austroalpine and the Austroalpine and Penninic realms.

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