ILLITE-SMECTITE AS A PALAEOGEOTHERMOMETER

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Fifty years have passed since Kübler and Weaver first observed that 001 XRD peak of illite changes systematically with depth and ascribed this change to improving "crystallinity" at higher temperatures. In the late sixties the nature of this change was described in terms of layer ratio and ordering in mixed layer illite-smectite and the techniques for measuring this ratio were developed. In 1979 Hoffman and Hower first proposed to use % smectite (%S) in illite-smectite in shales as a palaeogeothermometer. Based on the then available field evidence they suggested that the transition from random to ordered interstratification takes place at about 100°C and from the nearest neighbor to longer range ordering at about 170°C. In the following years some investigators followed this approach but many criticised it, proposing instead various kinetic expressions, relating %S to a number of factors besides temperature (time, chemistry of pore water, type of ordering, chemistry of original smectite).

Despite very abundant literature on the smectite illitisation in shales accumulated since Hower times, its validity for solving this controversy remains limited for two reasons:

- the %S measurement in shales is difficult and the numbers have to be examined critically before using them;
- the burial history of investigated section often is not reported, so only the present-day temperatures and not the maximum palaeotemperatures are available.

The examination of the published data, taking these two aspects into account, makes the present author believe that John Hower was right. Particularly convincing is the evidence of Price and McDowell (1993), who found randomly interstratified clays in Proterozoic shales from the Lake Superior basin, which have never been deeply buried. %S profile of the East Slovak Basin (Šucha et al., 1993) has been used in the following studies to calibrate palaeotemperatures.

Three regional studies of the present author and his coworkers seem to support Hower's palaeogeothermometer and suggest that it is more reliable than widely used organic indices.

1) The Cambrian clays of Estonia, which have never been buried more than 1000 m contain cca. 20%S illite-smectite, and this occurrence was used as an argument in favour of low-temperature time-dependent illitisation. Organic indices support this conclusion. However, K-Ar dating of illite-smectite from Estonian bentonites revealed short-lasting illitisation event, coincident with the Caledonian orogeny (cca. 390–400 Ma).

2) The Carboniferous shales of the Upper Silesia Coal Basin contain R > 0 illite-smectite at the present-day erosional surface, which is inconsistent with R_o data for never deeply buried E part of the basin. K-Ar dating indicates Cretaceous heating event in the E part and the apatite fission track (AFT) dating supports IS against R_o evaluation of the palaeotemperatures (> 125°C).

3) %S in the Oligocene shales of Podhale flysch basin evolve gradually NW to SE from > 60 to < 15%S. 110–120°C palaeotemperature isoline based on %S is coincident with the line of total resetting of the detrital AFT ages (125°C). R_o numbers are erroneous because of overwhelming detrital vitrinite contamination.

References

HOFFMAN, J., HOWER, J. (1979): Society of Economic Paleontologists and Mineralogists, **26**, 55–79.

PRICE, K. L., MCDOWELL, S. D. (1993): Clays and Clay Minerals, **41**, 134–147.

ŠUCHA, V., KRAUS, I., GERTHOFFEROVA, H., PETES, J., SEREKOVÁ, M. (1993): Clay Minerals, **28**, 243–253.