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Climato-environmental controls on clay mineralogy of the Hettangian–Bajocian successions of the Mecsek Mountains, Hungary: An evidence for extreme continental weathering during the early Toarcian oceanic anoxic event

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ABSTRACT

Clay mineralogy has been successfully used in palaeoclimatic interpretation of Jurassic rocks. In the Mecsek zone (Hungary), the clay mineral assemblages of the Hettangian–Sinemurian fluvial and shallow marine coal-bearing siliciclastic rocks (Gresten facies, Mecsek Coal and Vasas Marl Formations) comprise predominantly illite/smectite (I/S) mixed-layer minerals, illite (ill), and kaolinite (kao) with the presence of berthierine and/or chlorite. These clay mineral suites suggest a humid-subtropical climate with short-term climate changes of high and low rainfall and a high supply of terrigenous clastics to the basin. In the Pliensbachian part of the sequence studied, which is composed of predominantly hemipelagic mudstones (Allgäu facies) with intercalations of redeposited sandstone and limestone bodies, the Hosszúhetény Calcareous Marl, Mecseknádasd Sandstone and Kecskehát Limestone Formations are predominantly made up of illite and very little kaolinite and I/S mixed-layer minerals (kao/ill<1). Based on these results, the Pliensbachian time interval is interpreted to represent warm and seasonally humid (monsoon-like) climatic conditions and a moderate input of terrigenous clastics relative to the underlying formations. Towards the Toarcian, kaolinite becomes the dominant clay mineral (Óbánya Siltstone Formation; kao/ill>1) suggesting a humid climate and intense continental weathering possibly related to the oceanic anoxic event. In contrast, rocks of the Bajocian Komló Calcareous Marl Formation contain high proportions of I/S mixed-layer mineral and illite with sparse occurrence of kaolinite (kao/ill=0 or kao/ill<1). This clay mineral assemblage reflects a warm climate with a seasonal (monsoon-like) contrast in humidity and a minor input of terrigenous clastics from a relatively distant source area.

1. Introduction

Clay mineralogy is widely considered to be a powerful tool for interpreting weathering conditions and palaeoclimate in the source area (Chamley, 1967; Hallam, 1984; Chamley, 1989; Chamley, 1997; Ruffell et al., 2002; Ahlberg et al., 2003; Deconinck et al., 2003; Fürsich et al., 2005). Early studies often considered inheritance from the continent as against authigenesis within the marine basin. Furthermore, differential settling of clay minerals during sedimentation processes was thought to explain the illite and smectite enrichment of clay minerals away from the major river deltas and estuaries (Chamley, 1967).

With the development of the oceanographic research projects during the sixties and seventies, it appeared that clay mineral distribution in recent oceans shows a latitudinal pattern and marine clays have been interpreted as quantitatively derived from soils (Biscaye, 1965). Nevertheless, in several sites, a significant increase of smectites appeared away from the continents, which was commonly regarded as a result of differential settling of clay minerals: kaolinite and illite settling in the nearshore settings and smectites transported along marine currents (Chamley, 1989).

Recently, research into this area has taken a step in another direction. First, the changes in the clay mineral distribution in pelagic sediments have been interpreted in terms of variations in the climatic conditions prevailing in the source areas (Chamley, 1967; Singer, 1988). Then, studies took the inheritance relationship between marine clay and soil clay as demonstrated and used in reconstruction of palaeoclimate and continental palaeoenvironments (Hallam, 1984; Chamley, 1989; Hallam et al., 1991; Chamley, 1997; Ruffell et al., 2002). Thus, it was concluded that marine clays may reveal global climatic fluctuations and clay mineralogy has been successfully used in palaeoclimate interpretations especially of Mesozoic rocks (e.g. Deconinck and Bernoulli, 1991; Duarte, 1998; Ruffell et al., 2002; Ahlberg et al., 2003; Deconinck et al., 2003; Fürsich et al., 2005).

In this paper, results of a clay mineralogical study of the Hettangian–Bajocian successions from southern Transdanubia (Mecsek Mountains, Tisza mega-unit, SW Hungary) are presented (Fig. 1). Previous research

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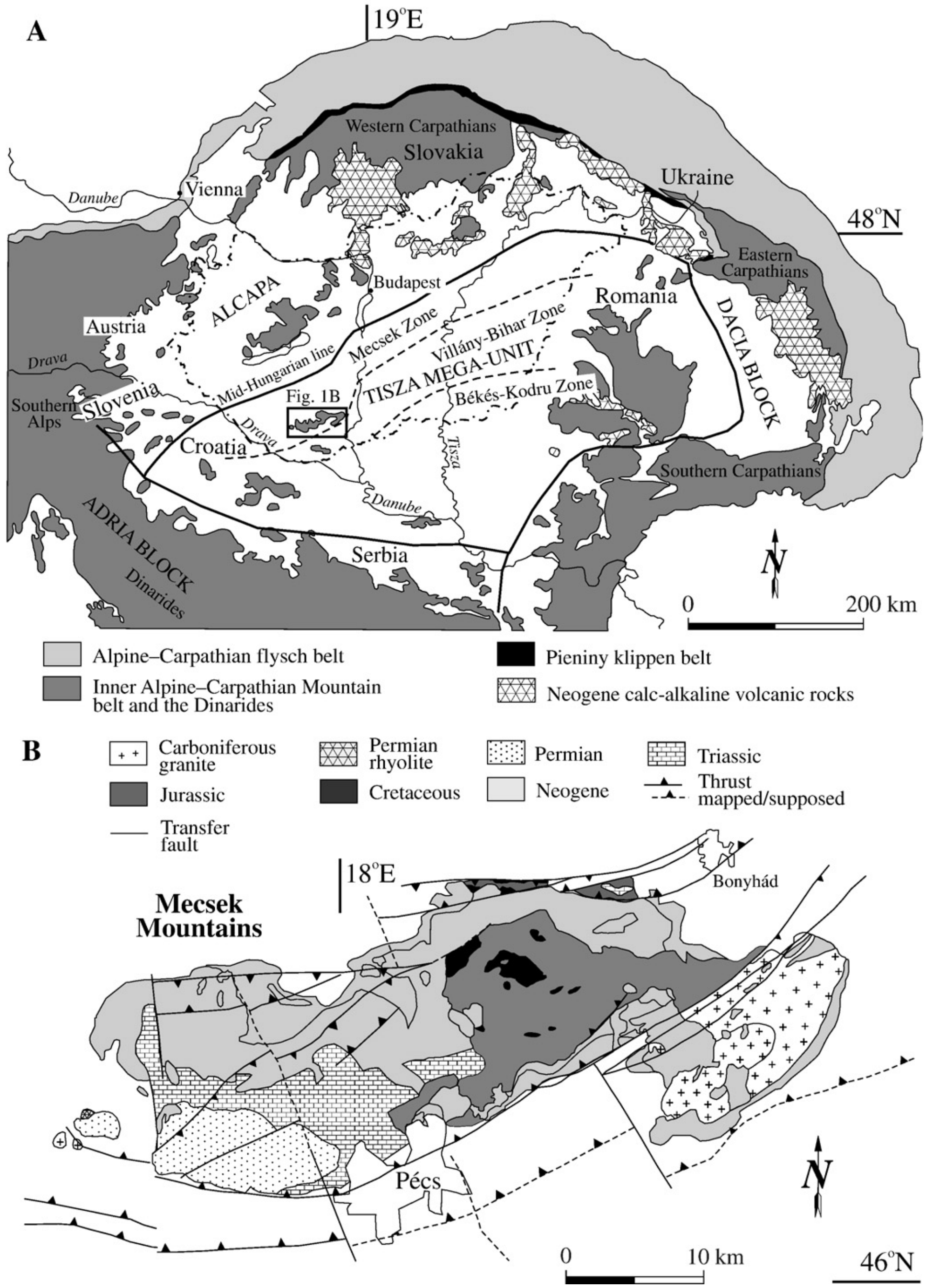

Fig. 1. (A) Geological framework and major tectonic units of the Carpathian–Pannonian area after Csontos et al. (1992, 2002) and Haas et al. (1999). Box indicates map in subpanel B. (B) Generalized geological map of the Mecsek Mountains showing the occurrence of Jurassic formations. Modified after Nagy (1968) with structural geological data of Csontos et al. (2002).

on Lower to Middle Jurassic sedimentary rocks in the Mecsek Mountains has mainly been restricted to conventional sedimentological and palaeontological analyses (Némedi Varga, 1998, and references therein). On the other hand, there is no palaeoclimatic work related to changes in clay mineralogy of marine successions from this part of the western Tethys. For this reason, this study was aimed at providing a contribution to a database on the clay mineralogical composition of the Lower to Middle Jurassic sedimentary rocks in this region. Analysis of trends of changes in Jurassic clay mineralogy from the Mecsek area is useful for gathering information about weathering conditions and reconstructing the palaeoclimate of the Jurassic southern margin of the European plate (Fig. 2).

2. Geologic setting and palaeogeographic framework

Hungary is located in the central part of the Carpathian–Pannonian area (Fig. 1A). The Mid-Hungarian line divides its pre-Tertiary basement in two major tectonic units of different provenance: (1) Alcapa (Alpine–West Carpathian–Pannonian) block in the north and (2) Tisza mega-unit (Tisza–Dacia block) in the south which is an Intra-Carpathian terrane composed of Late Cretaceous north-vergent nappes (Csontos et al., 1992; Haas et al., 1999; Csontos et al., 2002). The Mecsek Mountains (Fig. 1B) form part of the lowermost known nappe of the Tisza mega-unit (Csontos et al., 1992, 2002). Jurassic rocks can be found only in the eastern part of the Mecsek Mountains