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Late Jurassic-Early Cretaceous Alpine Deformation Events in the Light of Redeposited Sediments

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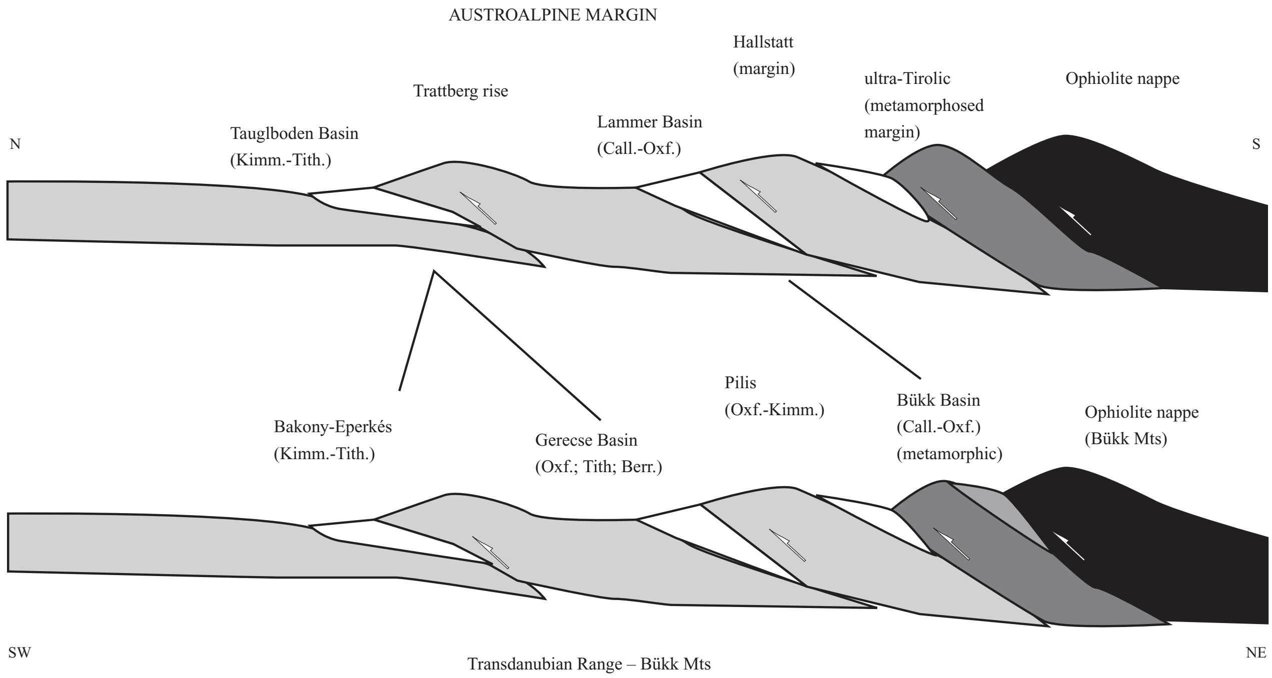
Sedimentologic and mapping work in the Alps (Gawlick et al. 1999, Mandl 2000, Schweigl and Neubauer 1997, Frisch and Gawlick 2003) evidenced an early Alpine, Late Jurassic-Early Cretaceous compressional deformation event affecting the southern Upper Austroalpine realm. There a Triassic-Jurassic passive margin was sheared into a north-vergent (present directions) nappe system inducing large scale slides, slumps and various sediment gravity flows. Late Jurassic and Early Cretaceous formations in Salzkammergut testify these events, however syn-depositional structures are hardly seen because of later strong deformation. Since Alpine units in Hungary were in close proximity of the aforementioned units, any sign of these deformations were thoroughly investigated here as well. Potential exposed areas range from Bükk Mts (N Hungary) to Gerecse and Bakony Mts (Transdanubian Range).

In Bükk Mts there is a widespread but thin olistostrome of micritic and radiolaritic matrix, incorporating different kinds of neritic and pelagic limestone clasts. The age of this formation is pre-Oxfordian and Oxfordian. Major olistoliths of hectometric size are mainly of Triassic Dachstein reef origin. This formation suffered subsequent latest Jurassic-earliest Cretaceous ductile deformation. It can be held as the equivalent of the earliest Salzkammergut redeposited sedimentary material.

In Gerecse Mts Late Jurassic intra-basinal gravitational redeposition is common in several formations. Thin olistostromes of Kimmeridgian age contain reworked pelagic limestones and



■ **Fig. 1.** Salzkammergut (simplified after Frisch and Gawlick 2003).

in some places big Dachstein limestone blocks. Sliding and/or slumping could have been initiated on still unconsolidated siliceous muds, resulting in erosion and short distance variation in thickness of Oxfordian radiolarite. Tithonian pelagic limestone hosts different extraclasts, including big blocks of Liassic limestones. In Berriasian a few metre thick blanket of deepwater redeposited conglomerate is widespread. The clast supported, often imbricated conglomerate is mostly composed of Dachstein limestone clasts, but also contains rounded, weathered basalts and radiolarites. Changes in thickness, facies, type of interfingering hemipelagites and observations on transport directions all suggest a source area from present N-NE. The same transport directions were measured in the overlying calcareous slope deposits, as well as in turbidites of deep sea fans (Fogarasi 1995, Sztanó 1990). These latter are unanimously held the equivalents of the Rossfeld formation of Salzkammergut.

In Bakony Mts there are very weak indications of Oxfordian redeposition. In Tithonian, however, at a few localities, major olistoliths of Dachstein and shallow water Liassic limestones occur together with other pelagic limestone clasts in micritic matrix. The big boulders must have a nearby origin, possibly from the NE. Barremian is mostly represented by marls, which are thick in local depressions, but are entirely missing from regional highs or interfinger with crinoid limestones towards these highs. Apto-(lower) Albian is represented by crinoid limestones of two different facies. On the regional highs they are of shallow water in origin, with large scale cross-bedding suggesting current pathways from the north. In deep basin segments between the regional highs breccia beds and turbidites comprised of redeposited crinoid sands were accummulated. Based on surface and subsurface data folds of NW-SE axis could have existed prior to deposition of the Apto-Albian crinoid limestone. The different basement, the often abrupt changes in facies and thickness of the crinoid limestone are interpreted as a syn-tectonic feature: growing (uplifting), partly eroded anticlinal hinges host shallow water sedimentation, while the growing (subsiding) synclinal areas host deeper marine, better preserved sections and eventually deep sea fan breccia bodies. A major and sharp erosional unconformity of Late Albian age tops the crinoid limestone. This part of the succession is better compared to the Southern Alps.

Structural, facies and paleomagnetic data and considerations constrain our Late Jurassic – Early Cretaceous reconstruction. Bükk, Gerecse and Bakony Mts were all members of the Dinaric shelf of the Vardar-Meliata ocean. Bükk was in more marginal, Bakony was in more landward position. As the structural evolution of the Dinarides suggests, a large sheet of ophiolite nappe derived from the Vardar ocean obducted the Dinaric margin by Late Jurassic. This event created a foredeep and imbrication, nappes in the overridden margin. Debris flows of Kallovian-Oxfordian age in the Bükk Mts are interpreted as the first indicators of this compressive/transpressive nappe formation. Most of the clasts are derived from even more marginal parts, i.e. the equivalents of the Hallstatt zone of Salzkammergut. This early foredeep formation was soon overridden and deformed by the advancing ophiolite nappe. This position is somewhat analogous to the Austrian Lammer basin.

Synchronous deposits of the Gerecse Mts (more landward in the reconstruction) show the first intra-basinal gravity driven redeposition in Oxfordian. The upwards increasing portion of older clasts (i.e. Triassic) in the Gerecse Late Jurassic/Early Cretaceous suggests a gradual emersion of nappes more to the NE, i.e. a more and more pronounced uplift due to thrusting and ramp folding. One member of this nappe system was made up of Dachstein limestone, i.e. local material (e.g. Buda Mts), but the other was formed by an ophiolitic nappe (possibly that preserved in Bükk Mts). An eventual third, crystalline nappe may be indicated by the heavy mineral spectrum of the Gerecse sediments (Árgyelán 1996, Császár and Bagoly Árgyelán 1994). The position of this unit is somewhat analogous to the Tauglboden basin in Salzkammergut.

In the Bakony Mts the Tithonian gravity flow deposits are interpreted as the distal indication of the foredeep propagation. A local thrust fault may be responsible for the large clasts = olistoliths in the deep marine setting. These local structural features seem to be reactivated in Barremo-Aptian-Lower Albian, when syn-depositional compression and ramp-folding above SW vergent thrust faults is suggested. The resulting basin and high configuration can explain the facies changes in Barremo-Aptian.

The three discussed areas all suggest that there is a SW-wards propagating compressional activity in Late Jurassic-Early Cretaceous. This model is compatible with an active margin NNE from Bükk Mts (present coordinates). The proposed nappe propagation is also compatible with the model set in Salzkammergut, but it expands its time limits until Late Albian. It is proposed that the major Late Albian unconformity is due to a change in shortening directions.

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Cooling History of Tatric Crystalline Basement of Nízke Tatry Mts. (Western Carpathians) Inferred from Apatite Fission Track and (U-Th)/He Analysis – Preliminary Results

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KEYWORDS: Western Carpathians; Fission track dating; (U-Th)/He dating; Thermal modeling; exhumation and burial.

Low-temperature thermochronology of apatites using both the fission-track (FT) and (U-Th)/He (He) methods has been used to investigate the cooling history of the Tatric crystalline basement in Nízke Tatry Mts. The methods are effectively sensitive to temperature range ~120–60 °C and ~85–40 °C, respectively, which allows to investigate final cooling periods of rocks in shallow crust levels. The samples of granitoids were collected from NW-SE trending profile crossing the main ridge of the mountain range.

Preliminary FT data yield apparent ages ranging from 40 to 43.9 Ma (Fig. 1), suggesting no significant vertical displacement within the crystalline block during exhumation. Mean horizontal confined track lengths in range of 12.0–13.1 μm along with

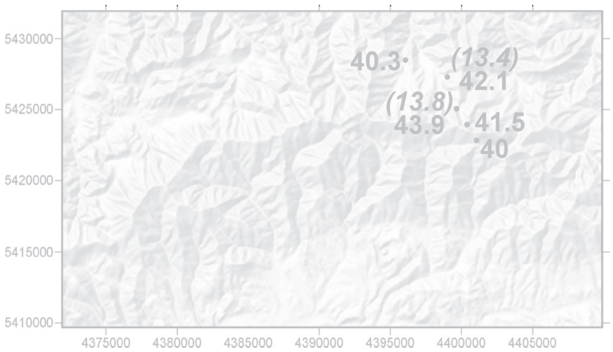

Fig. 1. Shaded DEM of the study area (Tatric part of Nízke Tatry Mts.) with sample localization (black dots) and measured (U-Th)/He and FT ages in Ma (He ages: numbers in brackets written in italic font; FT ages: normal font).