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SHORT COMMUNICATION

Exotic terrains in the Alps: a solution for a single Jurassic ocean*

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Abstract

The Briançonnais area is explained as a large scale exotic terrain separating from Europe during the opening of the Valais ocean. It's displacement history during the Alpine evolution allows to replace older concepts of mulitple oceans separating narrow strips of continental crust.

Keywords: exotic terrains, collision zone, Jurassic ocean, Briançonnais, Prealps.

Introduction

The concept of exotic terrain was introduced for the Prealps by Schardt a century ago (see MASSON, 1976). This concept implied large scale displacement of nappes but in terms of plate tectonics, it often means displacement of micro-continents or oceanic plateaux or seamounts across an ocean. These exotic blocks will then be incorporated into an accretionary prism.

Already in 1976, TRÜMPY (1976) has shown the importance of lateral displacement affecting large regions of the Alpine domain during the collision processes. More and more the Alps are regarded as an oblique collision zone due in part to the important rotation of the Adriatic plate during the Tertiary (MARCHANT and STAMPFLI, in press; STAMPFLI and MARCHANT, in press).

Recently we tried to demonstrate the presence of large scale exotic terrains in the Alpine domain: the Briançonnais terrain (STAMPFLI, 1993), whose exotism is not only due to tectonic displacement during the collision processes but to former migration across an ocean. We regard the Briançonnais area as formerly pertaining to the European margin. This margin was created by the opening of the Liguro-Piemont ocean during the middle Jurassic in connection with the opening of the central Atlantic. In late Jurassic / early Cretaceous the Briançonnais moved away from its European motherland as part of a newly individualized Iberic plate.

Exotic terrains and the duplication of ophiolitic sutures

The separation of the Briançonnais terrain from Europe was due to the opening of the Valais ocean, connected eastward with a remnant Piemont ocean (Penninic ocean) and westward with the Provence/Pyrenees domain and the Bay of Biscay / north Atlantic ocean. During the Eocene the Briançonnais collided with the Apulian margin after detaching itself from Iberia to get incorporated in the Apulian accretionary complex as an exotic terrain.

The eastward displacement of the Briançonnais relatively to Europe is of several hundred kilometers, creating a duplication of the former European Jurassic passive margin and thereafter a duplication of ophiolitic sutures (lower and upper Penninic suture zones).

In its western part, the complex lower Penninic suture consists of remnants of the Valais ocean s.str. (the Sion-Courmayeur zone) and remnants

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of the Piemont ocean northern margin (the Ferret and Sub-Mediane zones and the Bündnerschiefer). These European elements are now forming part of an accretionary prism containing some ophiolitic remnants, overthrusted by the middle and upper Penninic domains. Eastward, along the lower Penninic suture, Piemont elements will progressively dominate.

The upper Penninic suture is devoid of Valais ocean elements and consists mainly of an accretionary prism rich in ophiolitic remnants of mainly Jurassic age (Avers and Tsaté Schistes Lustrés; STAMPFLI and MARTHALER, 1990; DEVILLE et al., 1992) and late Cretaceous to Palaeocene flyschs (Gets, Simme, Gurnigel and Helminthoid). The Tauern "Schistes Lustrés" are similar to the Avers-Tsaté but they are an equivalent of both the upper and lower Penninic suture zone which we regard as a single suture in Austria: the Briançonnais intervening micro-continent not extending further East than the Engadine window.

The Austroalpine domain underwent also a significant westward displacement relatively to Apulia (FRANK, 1987; TRÜMPY, 1992) which is responsible for the duplication of paleogeographic elements of the southern margin of the Piemont ocean. This is the case for the Canavese and the Sesia / Dent Blanche domains separated by a narrow strip of basic and ultrabasic rocks representing trapped oceanic crust or denuded mantle of the south Piemont margin. This southern Apulian margin became an active margin since early Cretaceous, marked by HP/LT metamorphism (HUNZIKER et al., 1992) and accretionary processes (STAMPFLI and MARTHALER, 1990). Mixing of oceanic and continental elements took place during accretion and was further complicated by lateral displacement of terrains. In that context we regard now the internal massifs (Monte Rosa, Grand Paradis, Dora Meira) and exotic elements like the Margna nappe as pertaining to this former southern passive margin. During the transition from passive to active margin, these continental elements on the edge of the margin (belonging to the Jurassic rift) were either subducted and suffered HP/LT metamorphism or incorporated in the accretionary prism to form part of the prism back stop. In any case they have been mixed up with oceanic elements (like the Platta, Zermatt Saas or Antrona ophiolites). Each of these ophiolitic slabs or melanges does not represent a different ocean as often suggested. They all came from a single Jurassic Liguro-Piemont ocean extending up to Austria and the Carpathes. We call this ocean Alpine Tethys to differentiate it from the larger and more oriental Neotethys (STAMPFLI et al., 1991).

The geodynamic markers

In order to avoid models favouring a multiplication of former oceanic domains, one needs to develop a geodynamic evolutionary model of the continental margins involved in the collision. From early rifting to mature stages, continental margins are characterised by unambiguous sedimentological and thermal history (uplift/subsidence) patterns easy to recognize (FAVRE and STAMPFLI, 1992). Rheological properties of the lithosphere create constraints on the geometry of the margins (e.g., asymmetry) and on the size of micro-continents (larger than a few hundred kilometers). These constraints will tend to focus seafloor spreading in one area and will limit the number of oceans to one at a given time.

One of the best geodynamic markers is the uplift of the rift shoulders during the oceanization process. Only such a thermal event can effectively explain the erosion of thousands of meters of sediments and basement during the phase of early spreading. The duplication of such a marker on the European margin in the Alps led us to propose an exotic origin for the Briançonnais (STAMPFLI, 1993).

Another marker is the transition from continent to ocean where small tilted blocks (10 to 20 km wide) can be found resting on denuded mantle. This situation was generally regarded as representing a narrow ocean separating even narrower strips of continental crust. This complexity is inherent to the rifting processes and can be the source of even more complex situations if that type of margin is being subducted. And, this is all happening before the Tertiary continent/continent collision!

Conclusion

During the collision, new relationships between displaced and mixed terrains took place, creating a cylindristic pattern of nappes and tectonic elements. In the nappe pile ophiolites appear at several structural levels; however, as discussed previously, they might all belong to the same ocean. We think that this is the case for the Alps but with the important exception of the Valais oceanic domain which opened within the passive European margin during the early Cretaceous. Then we do not agree with a model where the whole Penninic nappe pile is regarded as a former accretionary prism of a single Penninic ocean as proposed by POLINO et al. (1990). The one ocean model is valid for the Jurassic. Through intracontinental rifting and subduction processes this single ocean will

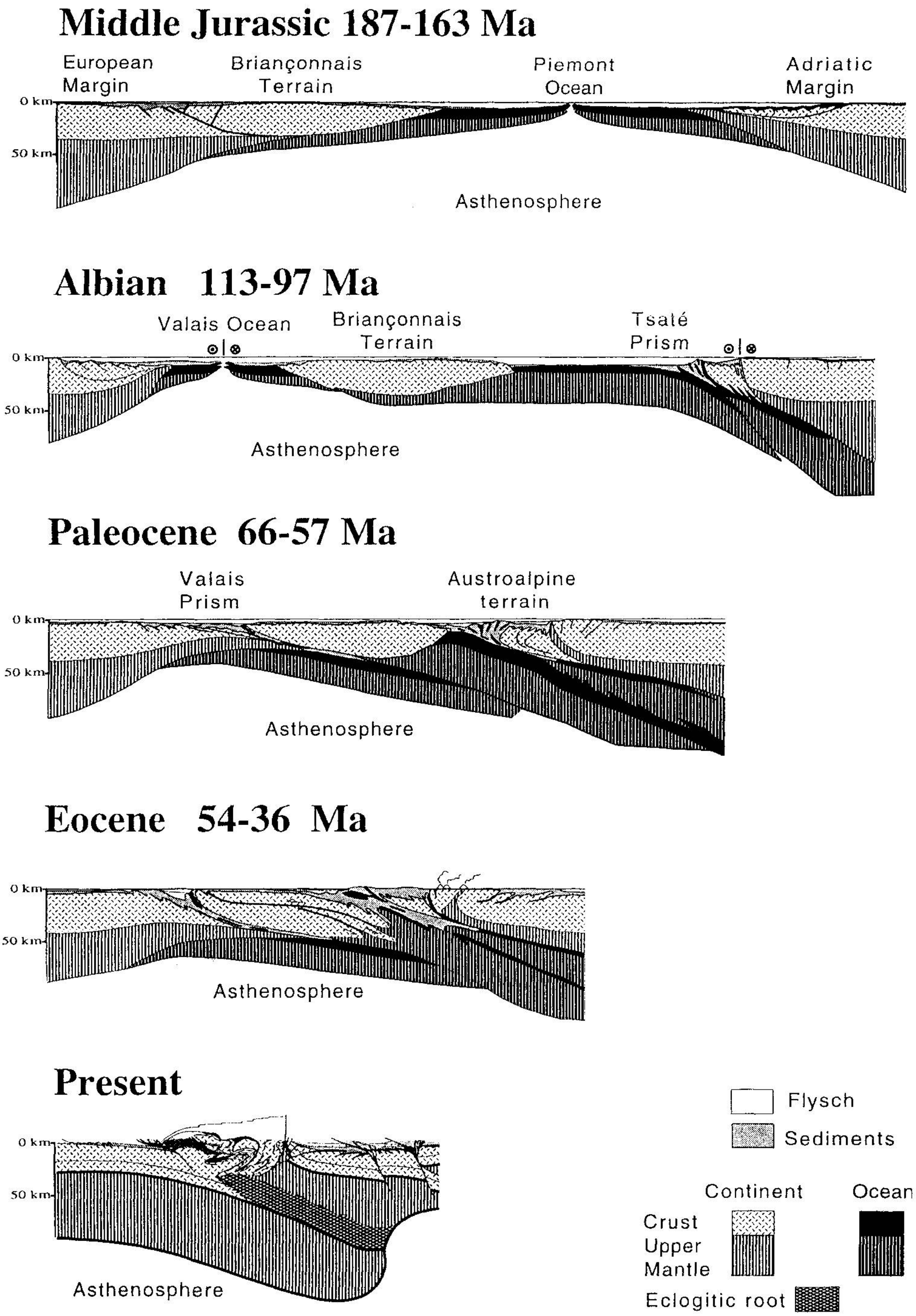

Fig. 1 Schematic evolution of the Alpine area from Jurassic to Eocene. The cross-section follows the Briançonnais terrain during its drifting, whereas the European plate moves westward and the Adriatic plate eastward. The foot of the Adriatic margin and the upper crustal part of the Briançonnais will eventually form crustal exotic blocks within a complex accretionary prism. The present day lithospheric section of the western Alps is from MARCHANT and STAMPFLI (in press).

evolve toward a complex situation as described above.

The former Piemont ocean passive margins suffered major deformation in early Cretaceous: the northern margin through extension, the southern margin through subduction. These deformations are constrained by the rheological properties of these thinned continental lithospheric elements. In both cases the rheologically weak point is certainly the zone of contrast between thinned and un-thinned lithosphere found somewhere around the former rift shoulder area. This explains the detachment of narrow slivers of continental crust from a former continental margin to form micro-continents (the Briançonnais) and the subduction of equally thin slivers of continental material (the internal massifs) in the case of an incipient active margin.

Until now it was considered by most Alpine geologists that the complexity of the present tectonic framework found its roots in a complex paleogeography. It can be shown that this was certainly not the case in Jurassic times implying that the complexity started in early Cretaceous with the subduction processes and the displacement of terrains. However the geometry of rifting and its asymmetry is already creating a complex situation at the boundary between the continents and the ocean. This boundary in not very well known because difficult to access in the present day ocean, but it is quite well exposed in the Alps at several places, though quite deformed (FROITZHEIM et al., 1994). To recognize it as such will mark the end of the concept of multiple narrow oceans separating even narrower strips of continental crust.

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