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PERMO-TRIASSIC EVOLUTION OF THE ADRIA MARGIN IN NORTHERN ALBANIA

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SUNTO. – Nell'Albania settentrionale e nell'adiacente Montenegro affiorano rocce che possono essere intrepretate come parti del margine orientale del promontorio di Adria verso l'Oceano della Neo-Tetide. Secondo le più recenti interpretazioni palinspastiche, la Piattaforma Dinarica è contornata durante il Triassico da aree a tendenza bacinale, quali Budva e Cukali. La zona di Cukali sarebbe adiacente alla zona di Korabi, che costituirebbe l'estremo lembo di litosfera continentale verso l'oceano. Le ofioliti della Zona della Mirdita, alloctone, traggono la loro origine dalla fascia di litosfera oceanica del Vardar. L'oceano della Neo-Tetide iniziò ad aprirsi lungo il margine di Adria nelle Albanidi nell'Anisico superiore (Triassico medio).

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ABSTRACT. – In the northern Albania and surrounding Montenegro are cropping out rocks that may be referred to the eastern margin of Adria promontory, facing the Neo-Tethys Ocean. According to present palinspasthic interpretation, the Dinaric Platform is surrounded by areas (Budva and Cukali zones) with basinal trend during the Triassic. The Cukali zone in this interpretation is situated nearby the Korabi zone, who represents the easternmost sector of continental lithosphere towards the ocean. The ophiolites of the Mirdita zone are allochtonous and originate from the oceanic lithosphere of Vardar. The early opening of the Neo-Tethys Ocean along this sector of the Adria margin is dated to the late Anisian (Middle Triassic).

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1. Introduction

Albania and surroundings areas contains good exposures to analyse the Permian and Triassic evolution of the Adria continental margin. A cross-section may be restored west to east. Moving from the zones of Adriatic Carbonate Platform and Budva, cropping out in the nearby Montenegro, the section go through the Dinaric Carbonate Platform exposed in the Albanian Alps, the Cukali and Korabi zones, and the distal part of the continental margin preserved in the sole of the Mirdita nappe, with its original source in the Vardar zone and its ophiolites.

2. The isopic zones (*Fig. 1*)

2.1 Adriatic Carbonate Platform/Kruja zone

Oldest rocks cropping out near the island of Vis are referred to the Middle Triassic Porphyrite-Chert Formation (Radoicic & D'Argenio 1999; Tari 2002). They are overlain by anhydrites possibly of Carnian age, in turn followed by peritidal dolostone of the Lisani Supersequence (Čadjenović *et al.* 2008) of Norian age.

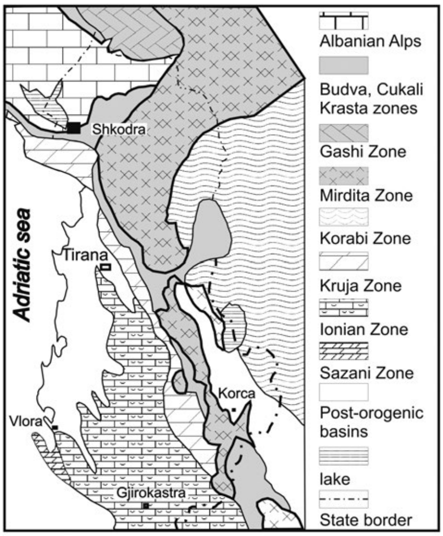

Fig. 1 – Index map.

2.2 *Budva zone*

Recognized first by Bukowski (1927) as Budva-Cukali, it was always considered as a basin-prone area, with older outcrops of Early Triassic age (Dimitrijević 1997). However, recently Krystyn *et al.* (2014) reported the presence of Upper Permian deep-water sediments with conodonts, pushing back to the latest Palaeozoic the evidence for the existence of a basinal succession.

Bottom to top the succession is as follows:

- Uppermost Permian. Mixture of bioclastic layers and fine grained siliceous sponge bearing wackestone of deeper water character (Krystyn *et al.* 2014).
- Lower Triassic. Sandstone, marl, dolostone and oolitic limestone; thickness of about 200 m (Dimitrijević 1997). The age of overlaying "Anisian Flysch" of Dimitrijević M. (1967) should be reconsidered, being possibly Early Triassic in age (Gaetani *et al.* 2015).
- Middle Triassic. With the incepting of Anisian, terrigenous inputs decreased and volcanics outpoured (basalts overlain by andesites and dacites). Bulog Limestone locally occurs as well as radiolarites and cherty limestone, with a total thickness around 200 m.
- Upper Triassic. Cherty limestone with Halobiids and conodonts (Cafiero & De Capoa Bonardi 1980 a,b).

2.3 *Albanian Alps*

They represents the southern tip of the Karst Zone (Auboin *et al.* 1970), presently known as Dinaric Carbonate Platform or included in the wider Adriatic/Dinaric Carbonate Platform (Karst Zone/ Dinaric Carbonate Platform (Auboin *et al.* 1970; Dimitrijevic MD 1997; Radoicic and d'Argenio 1999; Gawlick *et al.* 2012). They stratigraphy has been recently revised (Gaetani *et al.* 2015).

Bottom to top, the succession is as follows.

- Middle Permian. Shallow water massive calcarenite, with fusulinids, microproblematica, and occasionally conodonts. Severely disrupted by tectonics, thickness at least 100-150 m.
- Upper Permian. Presently not recognized.
- Lower Triassic. Very thick succession of shale and siltstone, with four major conglomerate intercalations. Locally, oolitic limestone lenses. Thickness not less than 500 m.

– Middle Triassic. During the Anisian the area was gradually transgressed by a carbonate ramp, with initially still some shaly intercalations. The ramp drowned to deeper condition around the boundary Pelsonian/Illyrian (i.e. middle to late Anisian). Some volcanic effusion occurred nearby, but no lavas have been detected, only tuffitic layers are intercalated in the cherty limestones. Towards the end of the Ladinian, sediments gradually filled the basinal area and the carbonate platform spread over all the area, continuing for the remaining part of Triassic,
– Only during the earliest Carnian, locally an intraplatform depression was filled by black limestone and dolostone, with slumpings and breccias, testifying to still active extensional movements.

2.4 Cukali Zone

The outcropping succession starts with debris flows (few tens of m thick) with semiconsolidated blocks containing middle Anisian (Pelsonian) foraminifers (Theodhori 1988; Meço and Aliaj 2000). It is overlain by a succession suggesting the drowning to deep waters during the late Anisian and continues in open sea conditions through the whole Triassic (Gjata *et al.* 1987; Theodhori 1988; Marcucci *et al.* 1994; Chiari *et al.* 1996; Meço and Aliaj 2000). Volcanics outpouring is also Middle Triassic. Meço (2005, text-fig. 10) quotes a section in which Norian platy limestone are tectonically overlying thick limestone with fusulinids of Permian age. Is this an evidence that Cukali zone was in shallow water conditions during the Permian or is just a block fallen in the basin from the margin of the carbonate platform?

The overall picture for the Cukali Zone is therefore of an area that was already in basinal conditions at least since the Anisian and continued in basinal condition through all the Triassic.

2.5 Korabi Zone

A very complex zone because of the heavy tectonics dismembering the zone, due to the overthrusting movements of the Mirdita above the Korabi (Collaku *et al.* 1992). Several subzones have been detected, in which Palaeozoic sediments are prevailing. According to Meço and Aliaj (2000) in the Caja subzone, the Devonian succession is unconformably covered by about 100 m of conglomerate and sandstone (?Permian/Triassic), in turn overlain by up to 400 m thick sandstone to pelitic successions with limestone intercalations, bearing Olenekian/early Anisian conodonts. No younger Triassic rocks are known from that area (Meço and Aliaj 2000). In the Korabi Highland subzone, instead, a mostly terrigenous Lower Triassic is overlain by a mixed volcanic/carbonatic succession, with platy and cherty limestone of open sea environment. Ladinian and Carnian conodonts have been etched out (Meço 2010).

2.6 Mirdita Zone

In the marginal area of the Mirdita Zone it crops out the Rubik Complex, also named sub ophiolite mélange (Bortolotti *et al.* 2005). Within the blocks forming the sole of the nappe, slabs of Olenekian-Middle Triassic succession are recognized in many places (Kçira, Qerreti, Rubiku, Miraka among others) (Shallo 1992; Kellici and de Wever 1994; Muttoni *et al.* 1996; Chiari *et al.* 1994, 1996; Germani 1997; Gawlick *et al.* 2008). The pelagic deposition started in the Spathian (late Olenekian) (Muttoni *et al.* 1996; Germani 1997), and volcanics outpoured since the middle Anisian, with picritic basalts as pillow-lava. Evidence of new oceanic crust starts from the late Anisian (Chiari *et al.* 1996; Gawlick *et al.* 2008).

Ophiolite units thrust on the Rubik complex. In the ophiolites are recognized Western and Eastern units, according to their geological and petrochemical features (Shallo 1992; Beccaluva *et al.* 1994; Bortolotti *et al.* 1996, 2006). The Western unit is characterized by thrust slices including, bottom to top, the metamorphic sole, lherzolitic mantle tectonites, mafic–ultramafic cumulates, a discontinuous sheeted dyke complex, and a volcanic sequence (Beccaluva *et al.* 1994; Saccani *et al.* 2004). The volcanic sequence is the most spread (Nicolas *et al.* 1999).

The Eastern unit shows a sequence up to 10 km thick, including, at the base, harzburgitic mantle tectonites with well-developed metamorphic sole at their base, a thick intrusive sequence, a sheeted dyke complex and a volcanic sequence (Shallo 1992; Beccaluva *et al.* 1994; Bortolotti *et al.* 2006; Saccani *et al.* 2004).

3. Conclusions

The geological evolution summarized in the previous chapter may be interpreted as the evolution of a continental margin that underwent extensional movements (*Figs. 2 and 3*). These rifiting movements were active during latest Middle Permian, Early Triassic (mostly Olenekian), and around the boundary Pelsonian/Illyrian (i.e. middle/late Anisian). The acme of the extensional movements was reached during the Olenekian. However, it cannot be excluded that a transcurrent component was active during the Olenekian. Could we start to consider the Scutari-Pec transversal zone (Dercourt 1967) in some way already active during the Early Triassic? In a single ocean model, the extension is strictly related to the incepting of oceanization that started in the Middle Triassic (Bortolotti *et al.* 2005; Gawlick *et al.* 2008; Xhomo *et al.* 2008, amongst others).

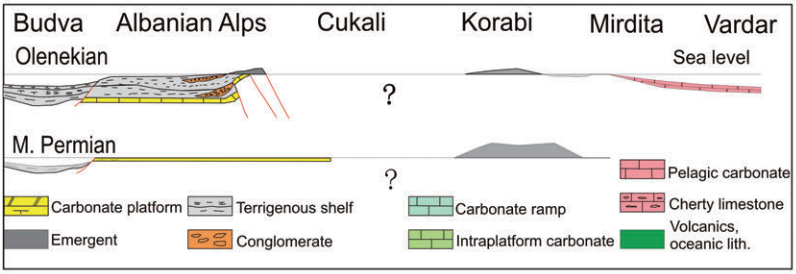

Fig. 2 – Palinspastic interpretation of the Adria margin evolution from Middle Permian to Early Triassic

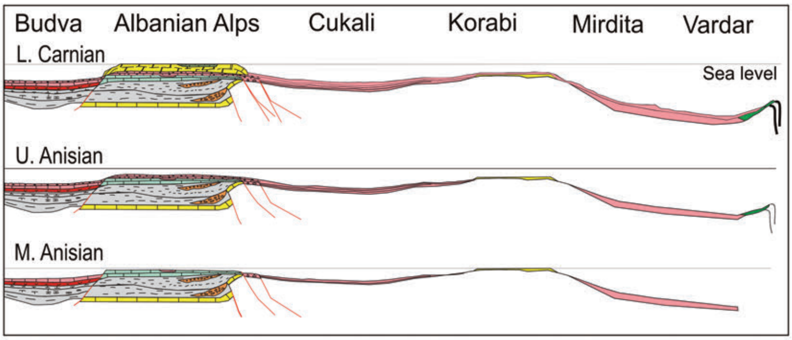

Fig. 3 – Palinspastic interpretation of the Adria margin evolution from Middle Triassic to earliest Carnian.

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