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Neotectonic Deformations in Western Istria, Croatia

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Abstract

Studied neotectonic structure in West Istria has the orientation corresponding to the recent (NNE - SSW, almost N - S) direction of the global tangential stress in the area. The analyse suppose the existence of the trailing imbricated fan structure, what change the idea of gentle tectonic disturbance of this area and provides the knowledge of tectogenesis of the region.

1. INTRODUCTION

The majority of published papers dealing with the geological framework of the Istrian peninsula, from its very beginning up to today, have been mostly based upon the idea of gentle tectonic disturbance of the area. Elaborating on palaeogeographic and tectonic studies, ŠIKIĆ (1953), POLŠAK (1965), and POLŠAK & ŠIKIĆ (1969, 1973) considered the region of western Istria as a stable, gently anticlinal structure, so called West Istrian anticline. Undoubtedly proven as been the effect of the Upper Cretaceous tectonic movements, following the opinions of most of the investigators this region was not essentially affected by active deformation pertaining to younger periods. However, recent structural-tectonic investigations in Istria (MARINČIĆ & MATIČEC, 1989, 1991), as well as results shown on the Geological Map of Croatia 1:50.000 (work in progress) go far toward realising a complex structural fabrics, which is the scope of this paper.

The investigated area (shown on Fig. 1), encompasses a 4.5 km wide zone from the village of Galići (NE from Poreč), past to the village of Perušići, in the vicinity of the road Lovreč-Vižinada (approximately 8 km). The area is built up of Upper Jurassic and Lower Cretaceous carbonate rocks. Stratigraphic studies indicate a Tithonian-Valanginian age, while sedimentological ones define this rock complex as a continuous succession of carbonate sediments with a characteristic alternation of shallow marine platform facies (TIŠLJAR et al., 1983). The strike within investigated area coincides with the general strike of deposits which are gently inclined, mostly dipping toward the North or Northeast (0-30/8). The position of the zone, in the West Istrian anticline, is in the north-west part of its plunging crest. The orientation of the b axis of mentioned regional anticline is defined as 30/6 (MARINČIĆ & MATIČEC, 1991). A manifold recurrence of lithostratigraphic units, as shown on the geologic map (Fig. 2), is evident in the dip direction. Because of the fact that we are not dealing with folded deposits, but with a terrain built of equally gently inclined beds, mostly of the same strike orientation, the recurrance of lithostratigraphic units have to be treated as faulted structures, consequence of tectonic activity. Taking into account that the crest of the anticline represents the position of the strongest resistance toward new deformation such recurrence requires adequate structural-tectonic interpretation.

2. GEOLOGICAL BUILD-UP AND METHODOLOGY

Along the entire zone of the Tithonian-Valanginian deposits in West Istria a series of parallel arranged geological columns were recorded. The aim of the established methodological approach used during creation of the 1:50.000 Geological Map of Croatia was to recognize the genesis of the area in question, and to define more precisely the lateral and vertical facies alternation. Lithostratigraphic units which served as a base for the unit identification during the geological mapping, were distinguished following the biostratigraphic, sedimentological and structural-tectonic data synthesis (Fig. 2). Names of particular units are informal, because a regional correlation of this stratigraphic interval was not yet established. The following lithostratigraphic units were set up:

Zlatni Rat - the succession of dominant late diagenetic dolomite with intervals of non-dolomitized limestones. The limestones are dense, stylolitic mudstones, with rare occurrences of pelleted packstones to grainstones. The unit is of Tithonian age.

Fantazija - characterised by the frequent alternation of early-diagenetic and late-diagenetic dolomites (TIŠLJAR et al., 1983) of Berriasian age. The unit does not exceed 50 meters in thickness.

Materada - this unit is represented by the rhythmical succession of stylolitic mudstones with thin sublayers of pelletal and oncoidal packstones to grainstones. These are brittle, porous limestones with distinctive red

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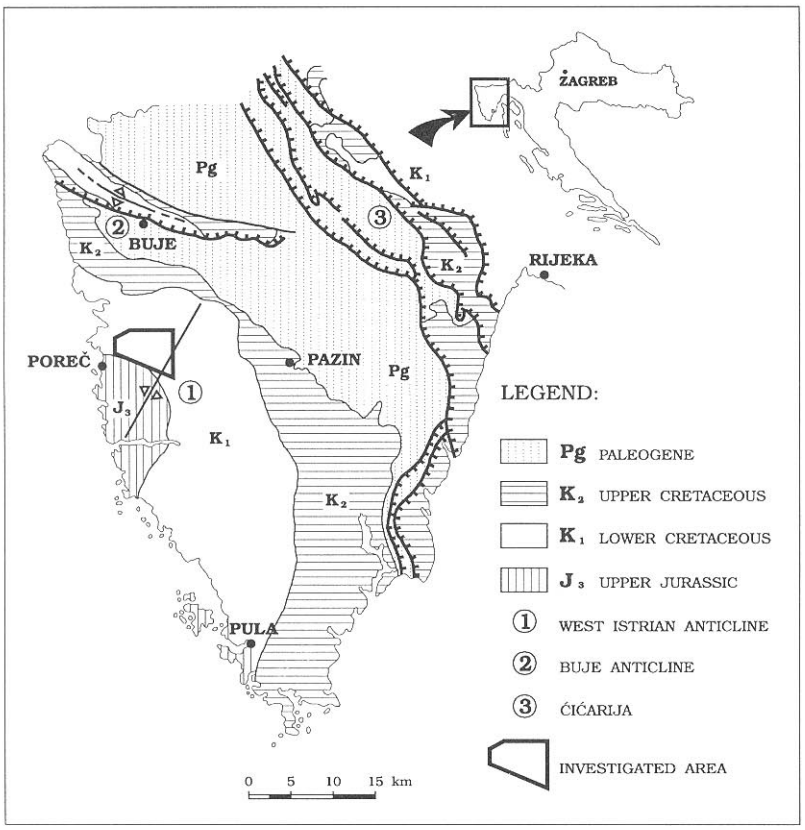

Fig. 1. Location map with the general geology of the Istrian peninsula.

coloured stylolites. Based on an aboundant microfossil assemblage Berriasian-Valanginian age was established.

The described lithostratigraphic units comprise a terrain represented on the geological map shown in Fig. 2. However, during the further geological investigations in the wider area numerous geological columns were measured throughout the Lower Cretaceous deposits. In these columns subtle facies changes are recorded, but there are no lithofacies units which would in any sense resemble the Fantazija Unit (characteristical alternation of late- and early-diagenetic dolomites). This leads to the conclusion that the development of the Fantazija lithostratigraphic unit required specific environmental conditions which created a unique, regional, and, in vertical sense unrepeated lithofacies.

Studied area is the carbonate terrain, almost completely flattened with uniquely dense vegetation cover. The deposits are gently inclined, intensively karstified, resulting with the lack of measurable data of brittle structures. Photogeological-geotechnical analysis does not offer expectable information. Because of aforementioned, only geological mapping, based on clearly defined lithostratigraphic succession of units yield the evidence of tectonic relationships.

3. KINEMATIC OF MOVEMENTS

An inappropriate approach in the analysis of structural-tectonic deformation will be to treat it without taking into account the concept of regional tectonic movements. Therefore analysis of particular structure should take into consideration the definition of kinematic type of the possible global deformation of the area. Structural elements which would indicate regional, extensional tectonic movements, ranging from the Lower Cretaceous up to the present were not established in the broader region of the mapped part of Istria. On the contrary, recently analized structures, being the consequence of polyphase tectonic deformations, reveal the constant presence of the contraction of the area. Intermediate phases, which are marked by decrease of the strength of regional stress (in fact a decrease of differential stress), could be explained as periods of "relaxation". Recognized extensional structures are the results of such "relaxations" but, from the regional point of view, they are more local, without any system character.

The importance of faults shown on Fig. 2, striking WNW-ESE, is regional: they extend beyond the frame of the displayed map and obviously influence the structural fabric of a broader area. A regularity in the fault appearance, as well as the effects of block movements, give them a systematic characteristics of a particular structure.

This structure had to be created in the active tectonic phase, not in the intermediate stage of the successive contraction of the area. Because of that, it is to be concluded that we are dealing with the structure which was developed by the means of contraction tectonics caused by the tangential stress having a direction, probably, perpendicular to the strike, i.e. NNE-SSW.

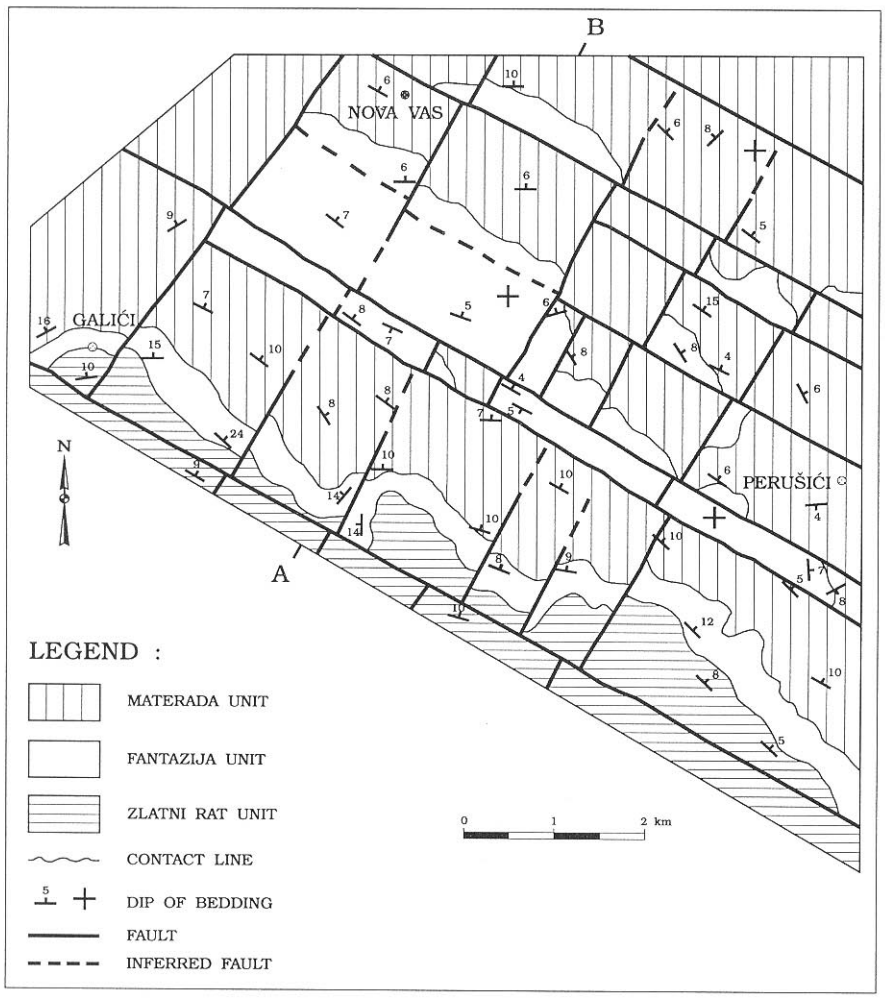

Fig. 2. Geological map. A-B - position of the cross-section presented in Fig. 3.

4. TYPE OF THE STRUCTURE

Two orientations of fault strike are perceivable on geological map shown on Fig. 2 - NNE-SSW and WNW-ESE. The first orientation represents vertical faults with the strike parallel to the axial plane of the West Istrian Anticline (MARINČIĆ & MATIČEC, 1991). These fault blocks, due to polyphase tectonics, were unequally and irregularly rised up causing unsystematic breaking of the structure.

Faults trending WNW-ESE are characterised by identical strike, vast extension, relatively steeply inclined fault planes at the surface, and uniform block movements in the sense of upthrown northern blocks. Common characteristics highlight their linkage and mutual dependence. As it is already mentioned, they are the effects of compressional tectonics. The fact that we are not dealing with the plicative structures makes difficult to comprehend that the faults can independently to each other disappear with the depth. It is to suppose that by bending with depth they are connected into the common separation plane. The fault plane bending has to be oriented toward the north (south vergence). In the opposite case lithostratigraphic units would be reduced at the surface, not successively repeated.

With respect to separation plane the assumption is that it is a type of detachement fault. But, gentle inclination of Mesozoic carbonate deposits in the basement suggest the possibility of the existence of decollement plane. Knowing the regional succession of Mesozoic deposits (in Istria only one deep well have been drilled, with poorly documented data) it is to suppose its position in the Middle or Upper (Carnian) Triassic.

However, gentle inclination and lithological characteristics of Lower Tithonian deposits, known as Kirmenjak Unit (VELIĆ & TIŠLJAR, 1988), do not exclude the possibility of the existence of another decollement plane, that can be involved in formation of the structure. Namely, characteristic of these deposits, representing a foot-wall of aforementioned Zlatni Rat unit (Fig. 3), is rhythmic sedimentation. Following the process of shallowing, in an upward direction, rhythmic units end by emersions. In the lower part of Kirmenjak succession these emersions are marly, having a thickness up to 20 cm, representing a favourable material for the formation of one or even several decollement planes.

Based upon the above characteristics of the described structure, a cross-section through the geological map on the Fig. 2 (A-B) was constructed (Fig. 3). From this cross-setion the structure has an image of reverse imbricated fan (Fig. 4).

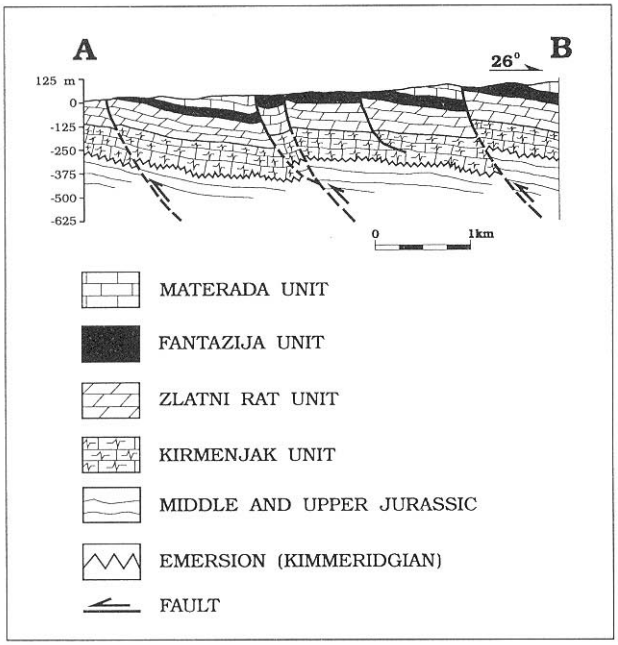

Fig. 3. Geological cross-section A-B.

5. SPATIAL IMPLICATION

The established structural type, as the consequence of certain kinematics, is likely to be recognized as an integral, peculiar structure, created by the reconstruction of the plunging part of the spacious anticline crest. However, from the regional viewpoint, we can identify, slightly to the north, a vast regional structure which, according to its characteristics, could represent the cause of formation or even be the part of the established fabric. Known in the literature as "the Buje Anticline" or "the Buje Karst" it stretches from the village of Savudrija, across Buje, Oprtalj and Buzet, following the WNW-ESE direction, toward the slopes of Mt. Ćićarija (Fig. 1). This structure, which is described in the Explanatory Notes of the Basic Geological Map 1:100.000, sheet Trieste (PLENIČAR et al., 1973), brings into contact, within its southern rim, an upthrowned sequence of Albian-Cenomanian limestones (VELIĆ & VLAHOVIĆ, 1994) and Eocene flysch deposits. The anticline is 5 km wide and its northern rim is also fault-bounded. This fault, which is a reverse one too, but with opposite vergence, represents a trailed backward structure. It brings into contact a reversed Cenomanian deposits and undisturbed hinterland of the Trieste flysch basin. The structure has the appearance of a frozen stage in the formation of a reverse, nappe-unit. An insufficient amount of regional stress or its amortization along the structures in the hinterland prevented its integral development.

The apparent extension of "the Buje Anticline" (45 km) gives it regional importance. Its forming had to be followed by deformation of wider area. If we sketch geological cross-section perpendicular to the extension of both structures, which is identical, it is possible on the fact of the same kinematic characteristics to connect them (Fig. 4). Such unique structure can be distinguished as a type of a trailed imbricated fan structure (RAMSY & HUBER, 1987).

6. TIME OF FORMATION

Taking into consideration that Eocene flysch deposits, which build up the hinterland and foreland of Buje anticline, are also the part of the structure (in bordering area), its formation could not be possible before the end of the Eocene. During the Oligocene and probably Miocene the Dinarides were forming, creating characteristic "Dinaric Strike" (NW-SE). Mt. Ćićarija (Fig. 1) represents the north-western part of it. If we compare the orientations of structures created during this period and the extension, orientation and strike of structures parallel to the Buje Anticline structure (WNW-ESE), a certain deviation is evident. There is neither apparent continuous transition nor clear tilting from the orientation of one strike direction to another. It is actually a confrontation of two different structural strikes. Opinions about the possible rotation of the Istrian block with respect to the Dinarides exist, but in that case, the

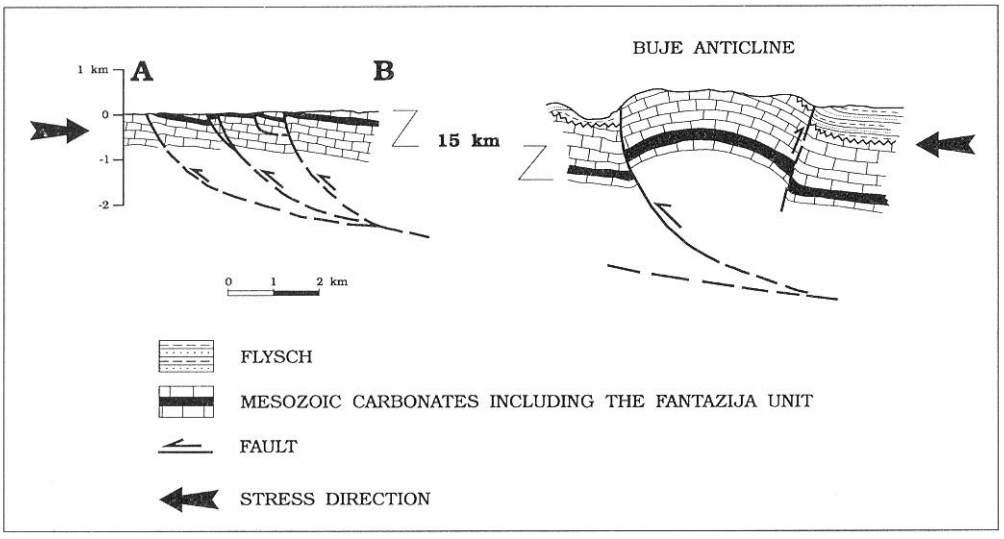

Fig. 4. Schematic cross-section of the basement and hinterland of studied structure. The supposed position of the Fantazija lithostratigraphic unit within the Buje anticline is based upon the surface data.

deviation of structural strike have to occure in the northeastern Italy too, which is not supported by existing data. Defined faults and nappe-like structures of the Dinaric strike in the region between Udine and Venice, kept their original orientation (CARULLI et al., 1990). This region together with Istria represents the integral area of the northern part of the Adriatic platform, so possibility of rotation is excluded.

As the arrangement of rock masses in the hinterland of the Buje Anticline (north) does not show any reason to be of the special resistance to the stress, what would cause tilting of Dinaric strike to the strike of Buje Anticline, it is to conclude that they are not syngenetic. The structures, whose b axes coincide in orientation with the b axis of the Buje Anticline, have to be younger. GRUNTHAL & STROMEYER (1986) gave the insight to the orientation of recent regional stress in Central Europe and neighbouring area. This survey clearly points out that described structures in western Istria are consequences of the youngest tectonics.

Therefore, the reverse structure of a trailed imbricated fan should be taken as one of the youngest structures in the Dinarides, formed in the last active phase of neotectonic movements.

7. CONCLUSION

The results of recent geological investigations in Istria confirm the opinions about the rather complicated structural fabric of the West Istrian anticline. Previously, it was considered as a region of gentle tectonic disturbance. Current reinterpretations of known structures and elaborations of, till now, undetected ones, make better and more complete comprehension of the tectogenesis of wider area.

In fact, the effects of active tectonic phases in the area of west Istria can be observed from Cretaceous time up to now. These structures can be classified and identified according to the orientation of their b axies. As the result of the global tangential stress, any change in direction of the least principal stress (new tectonic phase) had development of new structures and rearrangement of already existing ones as a consequence.

The formation of the Buje Anticline, which is in this paper treated as an effect of the youngest, neotectonic movements, was in its frontal part accompanied by a systematic faulting. This structure has been established as a trailed reverse imbricated fan structure. As a consequence of a recent global stress (NNE-SSW, almost N-S direction) it strikes WNW-ESE. The structure was detected by detailed geological maping of Fantazija lithostratigraphic unit (characteristic alternation of early and late-diagenetic dolomites). This unit has the significant lateral extension and, in vertical sense, is unique and unrepeatable. Thus, it represented a marker bed which enabled tracing of the structure. Characteristic carbonate terrain lacks the measurable structural elements. Therefore, the interpretation of the structure is based on the tectonic relationships revealed by geological mapping and known geology of the wider area.

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