GEOL. CROAT. | 48/2 | 167 - 176 | 9 Figs. | ZAGREB 1995

New Data on Structural Relationships in the North Dalmatian Dinaride Area

Eduard **PRELOGOVIĆ**[1], Bruno **ALJINOVIĆ**[2] and Stjepan **BAHUN**[3]

Key words: Gravity maps, Seismic profiles, Structural relationships, Seismically active zones, Tectonic movements, Dinarides

Abstract

Subsurface structural relationships are presented based on gravity data and seismic reflection profiles. Reflection marker horizons and the relative positions of different rock masses and structural units have been established, and are compared with surface observations. Active zones, marked by pronounced reflection boundaries in seismic profiles, have been established, the deepest of which are connected with the Dugi Otok fault zone. Below this interface, rock masses of the Adriatic platform underthrust the Dinarides. The active underthrusting plane reaches a depth of about 17 km. In the northern part of the area under consideration, contours of upthrown rock masses at depths of 5 to 11 km have been established. The area of numerous reverse faults is particularly active, and is defined on the surface by the Obrovac-Drniš-Klis fault. Reconstruction of tectonic movements indicates that rotation of structures and dextral strike slips have occurred, particularly along this fault zone.

1. INTRODUCTION

This paper presents the results of a study of subsurface geological structures in the area of the eastern part of Ravni Kotari, the southern area of Mt. Velebit and, partly, its hinterland (Fig. 1). This research began with the detailed surface geological mapping of evaporites and associated rocks (ŠUŠNJARA et al., 1992). Study of the collected data provided new insights into the structural characteristics, possible correlation of surface and subsurface structures, their movements, and active zones. Additional significance is provided by the fact that the relationships studied refer to the "interface" zone of two different structural units, which according to HERAK (1986, 1991), have been defined as the Adriaticum and the Dinaricum, respectively.

Initially, surface data scattered in numerous papers were reviewed and collated. The following sheets and accompanying explanatory notes of the Basic Geological Map of Yugoslavia, scale 1:100.000 were particularly important: Knin (GRIMANI et al., 1972, 1975), Drniš (IVANOVIĆ et al., 1977, 1978), Obrovac (IVANOVIĆ et al., 1973, 1976) and Šibenik (MAMUŽIĆ, 1971, 1975). Other published papers with detailed geologic maps and/or structural-tectonic or seismotectonic presentations include ALJINOVIĆ et al. (1990), BAHUN (1974), CHOROWICZ (1977), FRITZ (1977), FRITZ et al. (1978), HERAK (1973), MARINČIĆ & MATIČEC (1990), OLUJIĆ et al. (1971), PRELOGOVIĆ et al. (1979) and ŠIKIĆ (1976). However, examination of the available geologic maps suggested that, in order to better differentiate the structural and neotectonic relationships, additional data or some new classifications were required. Therefore, particular attention was paid to the elaboration of geomorphological features, data concerning the neotectonic activity, possible origin and destruction of structures, and recent seismotectonic relationships.

Basic insights into the possible subsurface structural relationships resulted mainly from regional geological interpretation, included in papers in which surface and subsurface data (and their comparison), tectonic movements, and individual geophysical maps and seismic boundaries are presented, e.g.: ALJINOVIĆ (1984), ALJINOVIĆ et al. (1984, 1987), ANDERSON & JACKSON (1987), BIJU-DUVAL & MONTADERT (1977), HERAK (1986, 1991), HORVÁTH & CHANNELL (1977), LABAŠ (1987), MILJUSH (1973) and ZAGORAC (1975). The area studied represents a small segment of a large area. Therefore, seismic and geoelectric profiles, boreholes, and gravity and geomagnetic maps were of primary importance. The most important observations concern the structural relationships which, including the available data, range from the surface down to depths of about 15-20 km.

2. GEOPHYSICAL DATA, SURFACE AND SUBSURFACE STRUCTURES

Previous research suggests that both the Adriaticum and Dinaricum structural units are characterized by reverse and overthrust structures. The studied part of the Adriaticum shows Cretaceous and Tertiary sediments on the surface, structured into NW-SE to W-E striking symmetrical, asymmetrical, and overturned folds. Rows

---

[1] Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb, Pierottijeva 6, HR-10000 Zagreb, Croatia.

[2] Geofizika, Savska cesta 64, HR-10000 Zagreb, Croatia.

[3] Faculty of Science, University of Zagreb, Kralja Zvonimira 8, HR-10000 Zagreb, Croatia.

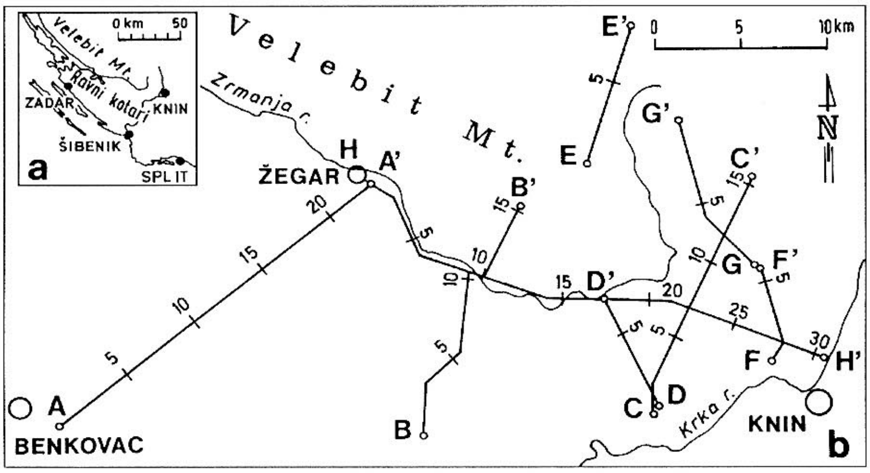

Fig. 1. Location Map. Legend: 1) traces of seismic reflective profiles; length in km.

of folds are usually separated by reverse faults. In the area bordering the Dinaricum unit, tectogenetic sedimentary complexes of the Late Palaeogene Jelar and Promina deposits are found. The Dinaricum unit is composed of Permian - Lower Triassic clastics, evaporites and eruptives in karst poljes and valleys (in the vicinity of Knin, Drniš and Vrlika), while the Triassic - Jurassic - Cretaceous (dominantly carbonate complex) is overthrusted onto the Adriaticum unit (in the area of Knin, Mt. Svilaja and Mt. Dinara). On the surface these relationships are expressed by reverse faults and overthrusts demarcating tectonic windows and klippen. Within both units, most commonly in the karst poljes, evaporites (Fig. 3e), Permian-Triassic clastics and igneous rocks crop out (ALJINOVIĆ et al., 1990; GRIMANI et al., 1972; HERAK, 1991; IVANOVIĆ et al., 1977).

Initially, in order to reveal the geological structures, gravity maps were correlated with seismic reflection profiling data. Measured gravity data are available for the entire study area and have regional significance. From the basic map of Bouguer anomalies, maps of corresponding residual and regional anomalies with several different radii were derived, and this was complemented by a second derivation map and upward and downward continuation maps (MORELLI, 1968). The

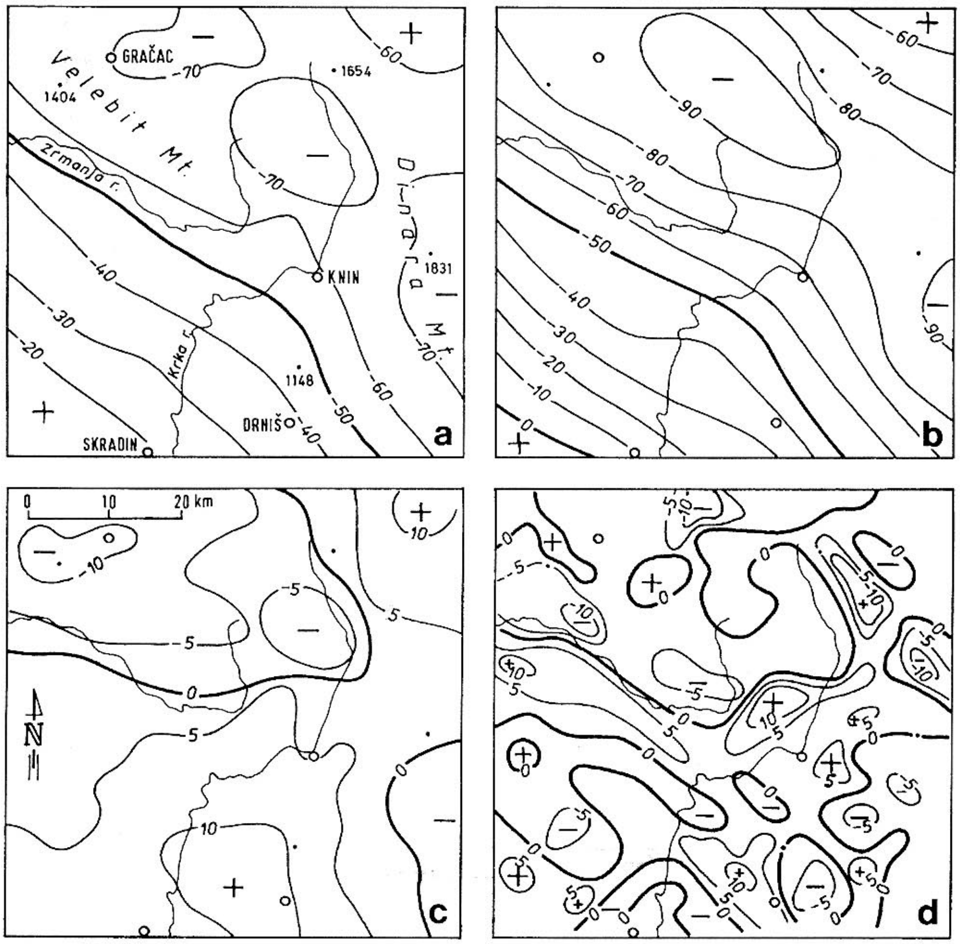

Fig. 2 Gravity maps. Legend: a) Bouguer anomalies; b) map of continuation with observative level H=8 km; c) residual between regression surface of the second order and Bouguer anomaly data; d) second derivation map; e) correlation map of geological-geophysical data (shallow positive residual anomaly contours according to residual anomaly map for R=4 km (2), that diverge from the direction of strike of structure; f) residual anomaly map; 1) isoanomalies (in mgal); 2) shallow (down to 4 km) positive anomaly contours; 3) possible location of evaporites at depth according to residual gravity maps with different radii; 4) areas with surface evaporite occurrences; 5) main fault traces; 6) zone of reverse faults with pronounced strike slips.

maps were useful because of the presence of thick carbonate deposits, clastics and evaporites and marked reverse structural relations. From a comparison of a number of maps, additional informations on the spatial distribution of different rock masses, their morphology and strike orientation were obtained. This augmented the interpretation of structural analysis in the sense of recognition of reverse structural relations, fault zones and the displacement of structures.

The Bouguer anomaly map (Fig. 2a) depicts the areal distribution of gravity anomalies. The position of anomalies is relatively shallower in the southwestern part of the study area, and they dip toward the NE, reaching maximum depths in the broad minimum zone, situated below the highest mountain ranges of the Dinaricum. In the continuation maps (Fig. 2b) the minimum zone is particularly well expressed, with a marked strike displacement in the area of Mt. Dinara, while Fig. 2c allows better observation of additional structural characteristics. The separation of two minima is visible: one, striking E-W, in the Mt. Velebit area, and another one, striking NW-SE, in the Mt. Dinara area, while high gradient values in between suggest the existence of fault zones.

The second derivation map displays the vertical gradients of the Bouguer anomaly values (Fig. 2d). The isoanomaly contours show a series of prolonged anomalies with low intensity mostly aligned in a NW-SE direction. The south-southeastern part of the study area is characterised by predominance of the minima, indicating downthrown causal rock masses. In the immediate hinterland of Mt. Velebit a series of maxima (residual anomalies in Fig. 3f) indicate an upthrown structure at relatively shallower depths. Comparison of different residual maps (Figs. 2c and 3f) with those of predominantly regional significance (Figs. 2a and b), suggests the presence of causal masses at shallower depths, with different strike orientations, situated above the more deeply downthrown, underthrusted, basement rock masses (Fig. 2a, b). The outstanding maxima, particularly those in the vicinity of Knin (Fig. 3f), around Drniš and possibly along the Zrmanja river, are probably caused by the presence of comparatively large evaporite bodies. This refers, first of all, to the anomaly contours at depths down to 4 km (Fig. 3e represents a correlation map between surface evaporite occurences and their probable manifestations on the residual map for R=4 km). These anomalies cannot obviously be caused by geological structures of a different orientation, because they can be directly correlated with surface evaporite occurrences. In Fig. 3e we have also added the probable anomaly contours of comparatively larger subsurface evaporite bodies indicated as higher and larger residual anomalies on maps with higher radii, surface evaporite zones, and individual faults.

The residual anomaly map (Fig. 3f), in general, reflects the appearance of different rock masses at shallower depths. Isoanomaly contours striking NW-SE, that follow the rows of surface structures (GRIMANI et al., 1972; IVANOVIĆ et al., 1973), are very visible (compare with Fig. 8). Positive anomalies in the area of Mt. Velebit and its hinterland also stand out because of the influence of an upthrown structure. An obvious negative anomaly north of Knin may be due to the sinking of a rock mass below the Plavno overthrust (5 in Fig. 8). Two conclusions can be drawn:

- the anomaly axes generally strike in a NW-SE direction, which points to the same basic structural relationships as shown, for instance, in the Bouguer anomaly map;
- contours of positive and negative isoanomaly values are caused by the structural positions of individual rock masses at comparatively shallower depths and they are comparable with surface structural relationships.

Seismic reflection profiles (source: Vibroseis; acquisition and processing: 2400 folding and migration) contribute significantly to the knowledge of subsurface structures. Eight seismic profiles have been recorded, their positions on the surface being shown in Fig. 1b. Penetration depth reaches 20 km. Reflector boundaries are classified according to quality, the best of which are those boundaries between contrasting lithologies. Limestones, dolomites, and evaporites have similar values of acoustic impedance, they therefore have very weak

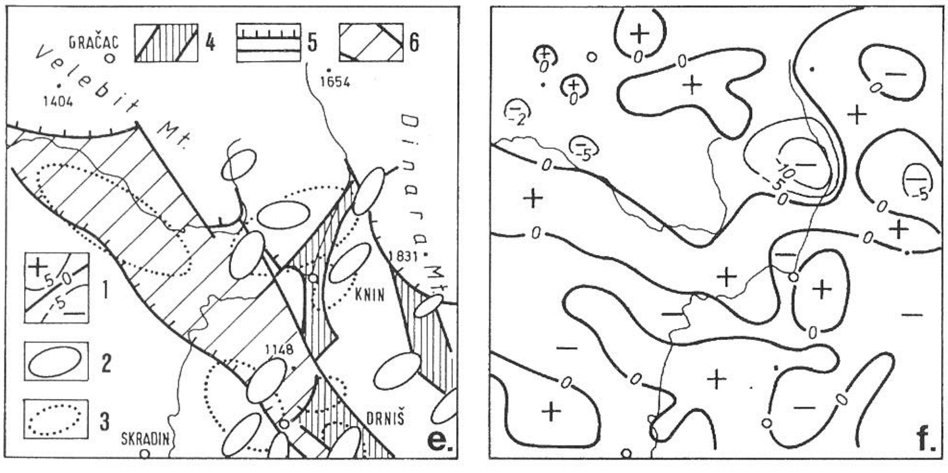

Fig. 3 Gravity maps. For legend see Fig. 2.

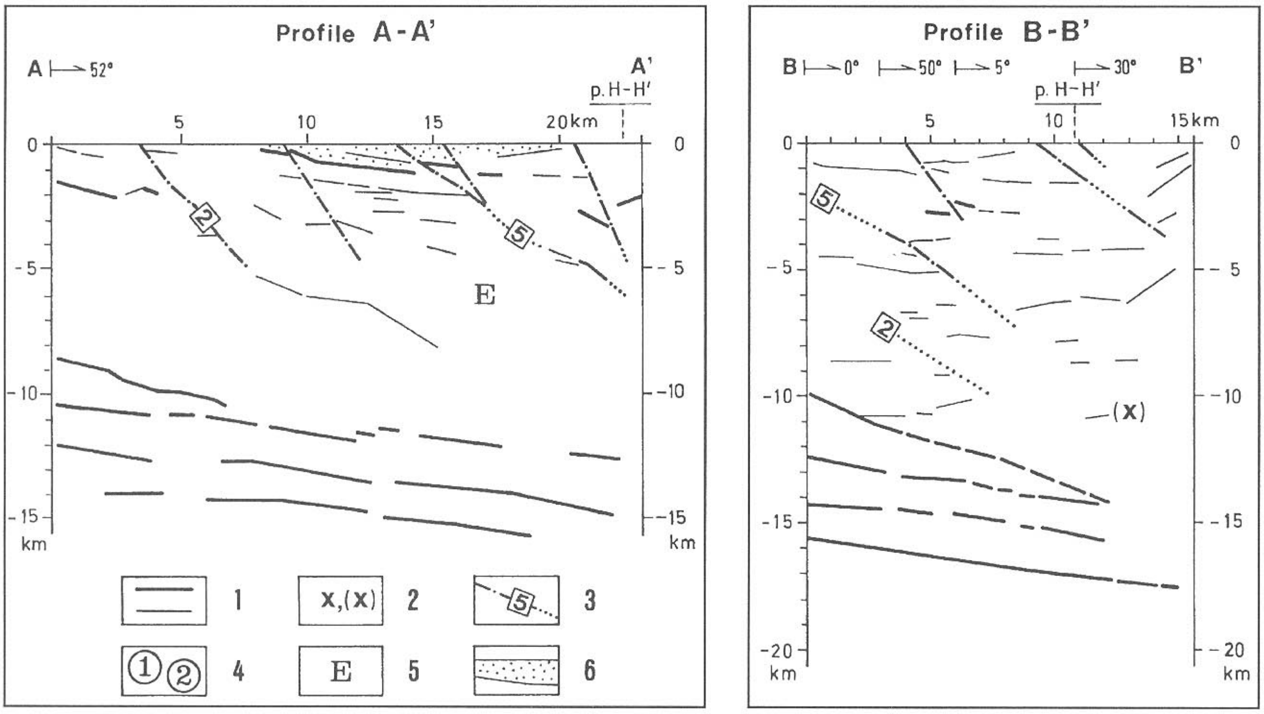

Fig. 4 Seismic reflection profiles (source: vibroseis, acquisition: 2400 folding, processing: migration). Legend: 1) reflective boundaries (interfaces) on seismic profiles of (a) recognisable very good and (b) good quality; 2) pronounced marker horizon; 3) faults (2 - Novigrad-Skradin-Brštanovo fault; 5 - Obrovac-Drniš-Klis fault); 4) Plavno overthrust; 5) probable position of comparatively larger evaporite masses; 6) surface occurrences of clastics.

interfaces. Also, within large rock masses of homogenous composition, contrasting reflections are lacking.

Figures 4, 5 and 6 represent the seismic boundaries along the recorded reflective profiles and faults down to the depth controlled by the reliability of data. In Fig. 8 the seismically determined faults are compared to their surface traces. Markings indicating the likely positions of comparatively larger evaporite masses, that may influence the structural relationships, are also added. This has been most frequently done in areas where reflections are lacking, and is also based on gravity data, to indicate the possible positions of causal anomaly masses.

From the net of seismic profiles, recorded over a much larger area than discussed here, a well pronounced reflection boundary at comparatively greater

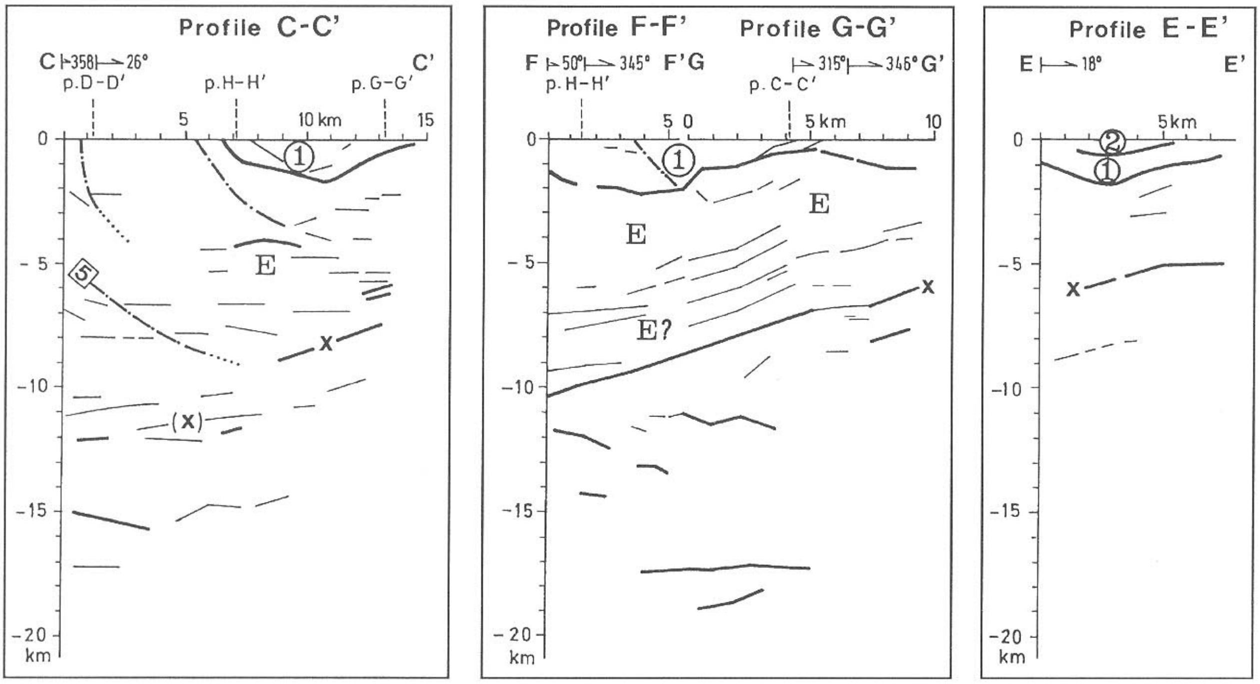

Fig. 5 Seismic reflection profiles (source: vibroseis, acquisition: 2400 folding, processing: migration). For legend see Fig. 4.

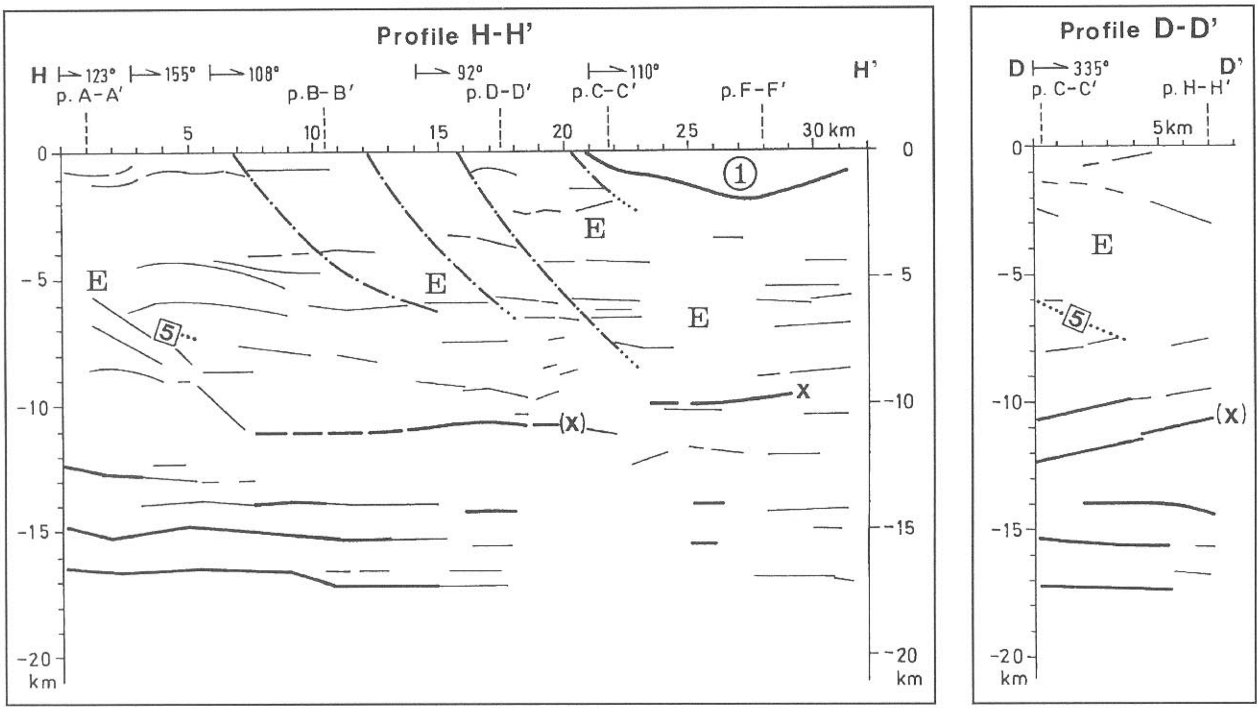

Fig. 6 Seismic reflection profiles (source: vibroseis, acquisition: 2400 folding, processing: migration). For legend see Fig. 4.

depths has been identified (ALJINOVIĆ, 1984). The intensity of reflections indicates a marked lithological boundary. This information has been obtained from refractive data because of the absence of seismic reflections below. In the part of the Ravni Kotari area from the present study area, the seismic horizons that mark the above mentioned boundaries are evident on the profiles. Along the profiles A-A', B-B' (Fig. 4), D-D', and H-H' (Fig. 6), there are three such boundaries, up to 2500 m apart. Three important facts should be noted. The reflective horizons appear near the shore, becoming deeper toward the northeast, and they show no significant spatial deformations. The deepest reflector is the most pronounced one. We suppose that the quality of all three reflections - corresponding surely to obvious lithologic boundaries - can be maintained during time only by the continuous shearing of two radically different media against each other. Were it not the case, structural changes would have led to the deformation, and even disruption, of the reflective boundaries. If this is true, then all the three determined reflections represent faults.

Detailed study of profiles and their comparison with the surface reveals more well-defined reflections that correspond to faults. Particularly observable are the boundaries of two overthrust sheets, that are cut by the profiles almost at their front. These are: (1) the Plavno overthrust (1 in Figs. 5 and 6, profiles C-C', E-E', F-F', G-G' and H-H') and (2) the South Velebit overthrust (Fig. 5, profile E-E'). Moreover, along the Zrmanja River, the South Velebit structure is overthrusted onto the Plavno structure (Fig. 5, profile E-E'). Elsewhere, additional faults are indicated by reflections in the following profiles: A-A' (Fig. 4, parts of fault 2 and fault 5, 5-9 km deep and the well pronounced reflective horizon on the left side of the profile A-A' at 8-10 km); F-F' and G-G' (Fig. 5, in the shallowest parts below or within the Plavno overthrust unit); D-D' (Fig. 6, inversely inclined reflections at 1-3 km); H-H' (Fig. 6, reflections on the left side of the profile at 5-11 km and the oblique series of reflections between the intersections with the A-A' and D-D' profiles at 5-9.5 km). In the majority of cases the faults can be inferred from the stepwise displacement of individual reflective boundaries.

Furthermore, the data represented in these profiles shows that particular reflections can be traced over comparatively long intervals of the same (or almost the same) dip, first dipping gently toward the north-northeast (profile A-A', Fig. 4) and then, mostly at the depth below 10 km, more steeply in the reverse direction (profiles B-B' in Fig. 4 and profiles C-C', F-F', and G-G' in Fig. 5). Local antiforms can be observed, for instance, in the following profiles: B-B' (Fig. 4, in connection with the faults numbered 2 and 5 at 6-10 km); C-C' (Fig. 5, in connection with the Obrovac-Drniš-Klis fault at 5-9 km deep); H-H' (Fig. 6, at a depth of about 5 km, on the left side of the profile). The more strongly inclined reflections usually occur in the footwall, i.e. the underthrust block of the reverse faults. Positions of larger throws are correlative with manifestations on the gravity maps, (e.g. in the profile C-C' Fig. 5, at a depth of 8 to 10 km, compared with the position of a high gradient change of 10 mgls near Knin in Fig. 2d). Structurally the basic deformations with which the described phenomena are associated are the most important. In this sense, the reflective boundary marked by "x" is the most indicative. It is situated

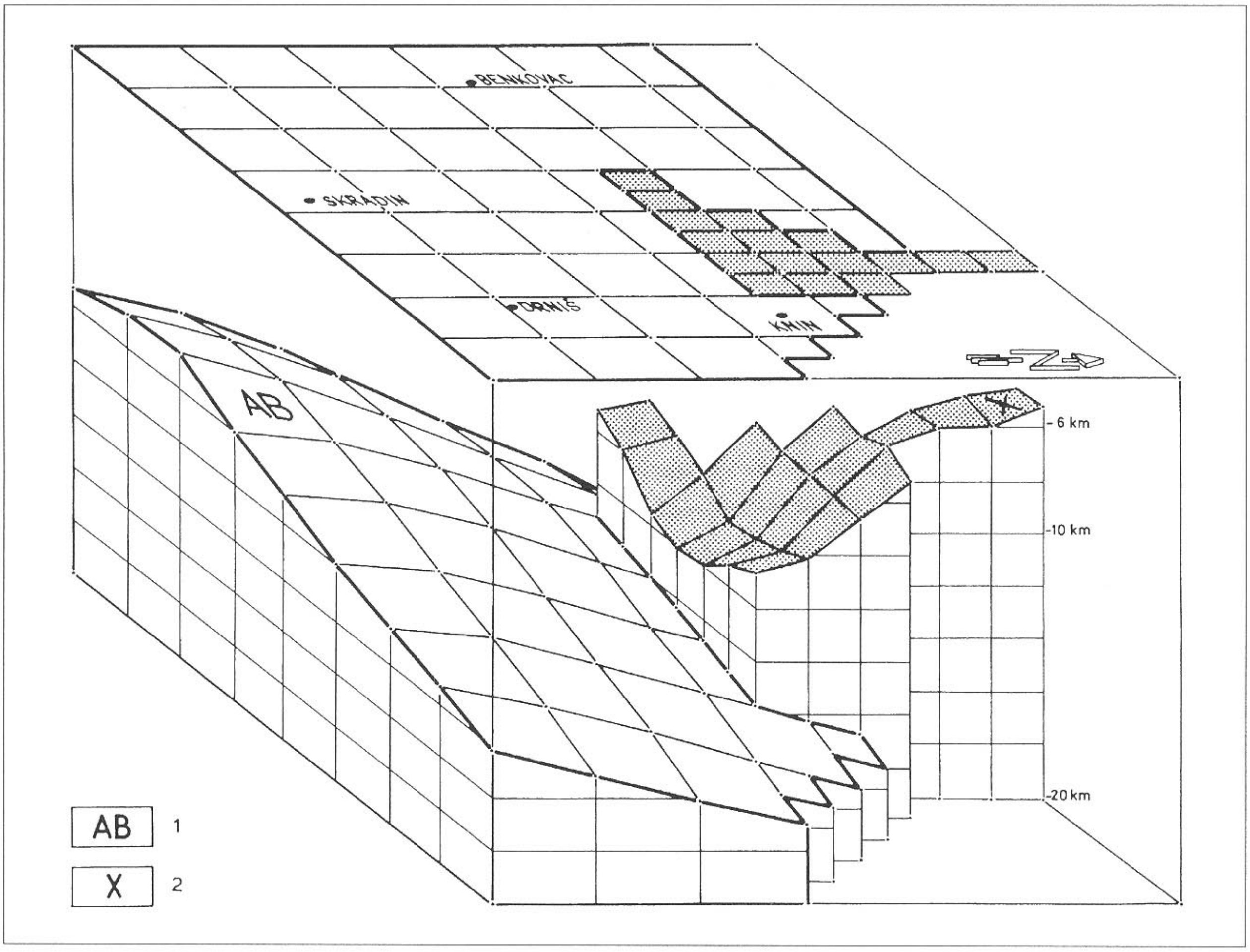

Fig. 7 Spatial position of the most important structural active zones - reflective boundaries in seismic profiles. Legend: 1) deepest seismic reflector; 2) reflection marker horizon "x".

above the deepest triple reflection mentioned above, probably within Palaeozoic rocks, and is best observed in the profiles C-C', E-E', F-F', and G-G' (Fig. 5). It steeply rises upwards toward the north-northeast at an angle of over 20°. The slope plane itself does not seem to be disturbed. At the end of the E-E' profile it reaches a depth of 5 km (Fig. 5). In the profiles C-C' (Fig. 5), D-D' and H-H' (Fig. 6), at depths below 10 km, another reflection boundary apears. It is marked ("x"), because of its similar quality to "x". However, it is not clear whether this is the same reflection marker boundary.

At greater depths (down to 17 and 19 km in the profiles D-D', F-F', and G-G'), undertrusting of rock masses below the shallower structures can be seen. Such large-scale structural relations are best visible by the spatial presentation of the interrelationships of the main reflection boundaries: the deepest discernible reflection (AB) and the "x" marker horizon (Fig. 7). By its inclination and position, the deepest reflector indicates the possible lower underthrusting boundary. The "x" marker horizon represents a boundary of a comparatively larger upthrown rock mass, that by its reverse displacements influences the formation of structures and their relationships at shallower depths.

The presentation of subsurface structural relationships would be incomplete without correlation with the surface. Here the spatial positions of the main rock masses are most important, as well as the largest faults or fault zones which are reflected on the surface and delimit the individual structures. Therefore it was necessary to undertake further elaboration of faults, primarily by means of satellite images, and include some new mapping data and seismic characteristics (e.g., FRITZ, 1977; KAPELJ, 1989; HERAK et al., 1988; HERAK, Ma. & HERAK, D., 1990; PRELOGOVIĆ et al., 1979; ŠUŠNJARA et al., 1992). The main objective was to highlight the main characteristics of the structures and gather information on their displacements.

On the surface, a zone consisting of several parallel faults striking NNW-SSE to NW-SE, is most obvious (Fig. 8). It is delimited to the south by the fault striking NNW-SSE in the direction Obrovac-Drniš-Klis. These are reverse faults, the largest among them being evidenced in the previous profiles. Along their traces, dextral strike slips of individual structures and blocks may be discerned (Fig. 8). These horizontal displacements are also visible from the changing strike directions, particularly in flysch deposits (GRIMANI et al., 1975; IVANOVIĆ et al., 1973, 1977). The entire zone is situated in a favourable position with regard to the activity of the youngest regional stress (maximum horizontal stress according to ANDERSON & JACKSON, 1987,

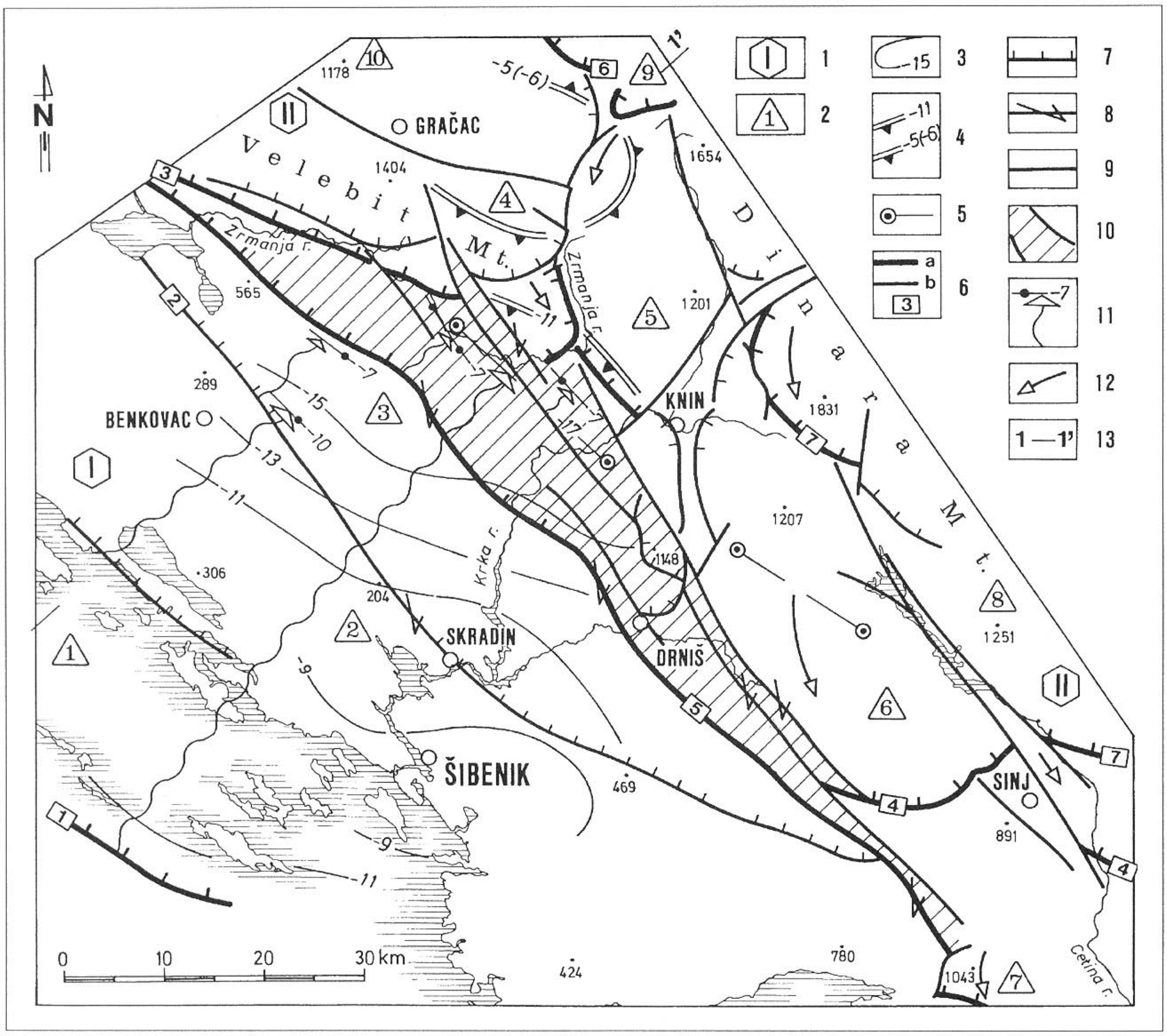

Fig. 8 Structural map. Legend: 1) regional structural units: Adriaticum (I); Dinaricum (II); 2) comparatively larger overthrust structures or rows of minor structures which form overthrust units: Dugi Otok-Žirje unit (1), Benkovac-Skradin-Kozjak unit (2), Novigrad-Djevrske-Unešić unit (3), Velebit unit (4), Plavno unit (5), Svilaja unit (6), Mosor unit (7), Dinara unit (8), Gologlav-Ilica unit (9), Bruvno-Popina unit (10); 3) isobaths (in km) of the possible basal surface of the sedimentary complex; 4) contours of upthrown rock masses at the depths of 11 km and 5-6 km, respectively, according to the position of the seismic reflection marker horizon "x" and indications from gravity residuals maps; 5) limit of reliable separation of the deepest reflection in seismic profiles; 6) faults on surface: a, faults delimiting regional structural units or larger overthrust structures - Dugi Otok fault (1), Novigrad-Skradin-Brštanovo fault (2), Velebit fault (3), Muć fault (4), Obrovac-Drniš-Klis fault (5), Mazin-Dabašnica fault (6), Dinara-Kamešnica fault (7); 7) reverse faults; 8) segments of reverse faults with pronounced strike slips; 9) faults of undefined character; 10) zone of reverse faults with pronounced strike slips; 11) supposed surface projections of the same faults in the depth indicated by correspondent values; 12) direction of surface displacement of structures; 13) position of structural profile.

has an approximate orientation of 350°-170°) thus making possible the horizontal displacements. This makes clear its importance in the displacements of individual structures. In the same sense, other, smaller zones should be mentioned, e.g. the one in the vicinity of Sinj (Fig. 8). Right-lateral vectors occur along the reverse, NNW-SSE to NW-SE striking, faults (MARINČIĆ & MATIČEC, 1990), due to interrelationships between the positions of structures and orientation of stress. In addition, there is also rotation of structures. True reverse relations are established only at the very front of the overthrust structures, e.g. in Mt. Svilaja and Mt. Velebit, where the faults change their direction of strike into the WNW-ESE to W-E directions. In the study area, larger gravity gradients are observable (e.g., Fig. 2d). This is an indication of the sinking of individual rock masses because of reverse relations (particularly observable in the profile 1-1' in Fig. 9).

In the formation of structures, the position of a separate, upthrown rock mass in the area of Mt. Velebit and its hinterland (Fig. 8), obviously plays an important role. This mass caused the displacement of the Mt. Svilaja (6) and Mt. Dinara (5) structures within which comparatively shallower upthrown rock masses can be detected. However, accompanying gravity anomalies (Figs. 2d and 3f) have weaker intensity. We should also mention the concordance of the direction of strike of the zone of reverse faults with pronounced dextral

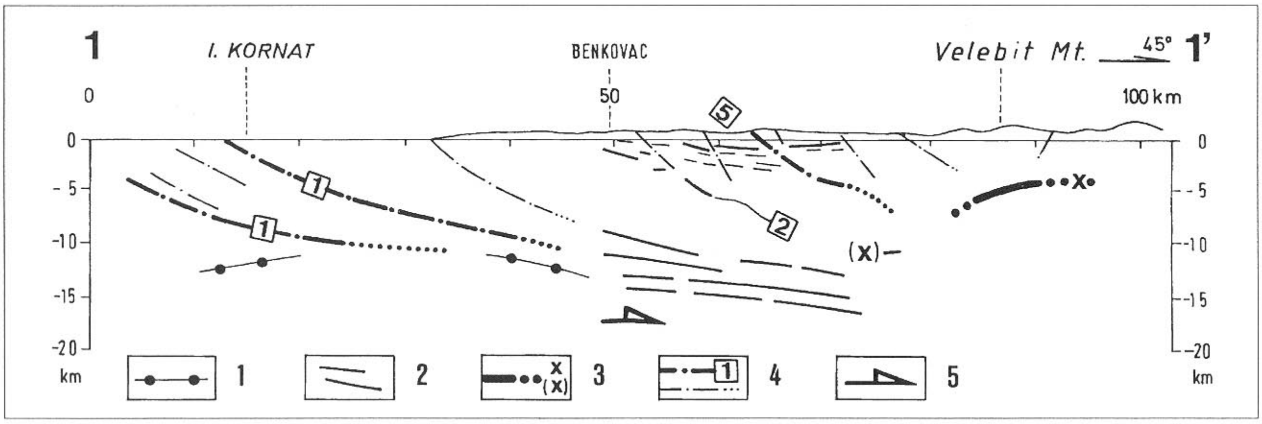

Fig. 9 Structural profile. Legend: 1) possible basal boundary of the sedimentary complex; 2) other reflection boundaries in seismic profiles; 3) pronounced marker reflection horizons "x" and ("x"); 4) faults: Dugi Otok fault zone (1), Novigrad-Skradin-Bršlanovo fault (2), Obrovac-Drniš-Klis fault (5); 5) underthrusting direction of deep subsurface rock masses.

strike-slip of structures and the contours of the subsurface rock masses. This emphasizes the position of the above mentioned fault zone as an important boundary in the structural sense.

3. CONCLUSIONS

The elaboration of subsurface and surface structural data has revealed structural relationships between rock masses which are presented with their most important characteristics in Figs. 7, 8 and 9. Most outstanding are the deep reflections revealed in seismic profiles (e.g. profile 1-1' in Fig. 9). The only acceptable explanation of their occurrence is their connection with the Dugi Otok fault zone (1 in Fig. 8), in which case it is clear that the deepest seismic reflector corresponds, in its largest part, to the footwall of the sedimentary complex. In this area, the interface represents a boundary below which the rock masses of the Adriatic platform underthrust other units of the Dinarides (Fig. 9). The subduction surface is gently inclined, reaching a depth of approximately 17 km in the surroundings of Knin.

Another important contribution to the explanation of structural relationships is furnished by the well pronounced reflective marker horizon labelled "x". It represents the upper boundary of a comparatively large upthrown rock mass. Its reverse displacements are indicated from information on the underthrusting movements of the rock masses lying below the "x" marker horizon (e.g., Fig. 5, profiles F-F' and G-G'). The spatial position of the hanging wall of the upthrown rock mass (above the marker horizon "x") and of the deepest active underthrust boundary (AB) is shown in Fig. 7. Observation of the seismic profiles C-C' (Fig. 5) and H-H' (Fig. 6), gives the impression that the reflection marker horizon "x" passes, due to reverse relationships, into the ("x") at the depths below 10 km. However, an alternative explanation is also possible. The marker horizon "x" is a clear reflective boundary, which, moreover, on the profiles E-E', F-F', and G-G' (Fig. 5) appears uninterrupted. It is clearly an active displacement boundary between two lithologically different media. In addition, the dip of the marker horizon "x" is characteristic. During reverse movements, it may represent a gliding surface which allows for gravitational displacement of the rock masses situated above it. These reverse movements might have caused the formation of a zone of reverse faults, particularly along the front of the separated upthrown rock mass. The boundary fault of that zone, striking in the direction Obrovac-Drniš-Klis (5 in Fig. 8), could pass, according to its position established in the profiles 1-1' (Fig. 9), C-C' (Fig. 5), and H-H', into the marker horizon "x".

Based on the profile 1-1' (Fig. 9), the main characteristics and relationships of the regional structural units can be postulated. Particular seismic reflections can be traced over comparatively long distances without significant disturbances, particularly within the Adriatic unit. More significant rock masses that resist the movements of the Adriatic platform are situated only in the area of the Dinaricum unit. In the subsurface, two active zones are well pronounced. The first is the very well pronounced zone marked by deep seismic reflections. It is connected with the Dugi Otok fault (1) and is about 5 kms wide. The second active zone is marked by the reflection marker horizon "x". It outlines the contours of the upthrown rock mass at depths of 5-11km in the Dinaricum unit (in the profile 1-1'; Fig. 9 in the area of Mt. Velebit and its hinterland, and according to maps - Figs. 2d and 3f - in the Mt. Svilaja and Mt. Dinara area). As a result of reverse movements this rock mass probably directly influences the relationships of the overlying structures. The most active area is marked by a series of reverse faults that penetrate to the surface and where the horizontal displacements (strike slips) are evident. In Fig. 8, the zone itself is particularly well defined, firstly because of pronounced displacements of individual structures, and secondly because it represents the boundary between two regional structural units.

4. REFERENCES

ALJINOVIĆ, B. (1984): Najdublji seizmički horizonti NE Jadrana.- Unpublished Ph.D. Thesis, University of Zagreb, 264p.

ALJINOVIĆ, B., BLAŠKOVIĆ, I., CVIJANOVIĆ, D., PRELOGOVIĆ, E., SKOKO, D. & BRDAREVIĆ, N. (1984): Correlation of Geophysical, Geological and Seizmological Data in the Coastal Part of Yugoslavia.- Bolletino di Oceanologia Teoretica ed Applicata, II/2, 77-90, Trieste.

ALJINOVIĆ, B., PRELOGOVIĆ, E. & SKOKO, D. (1987): Novi podaci o dubinskoj geološkoj građi i seizmotektonski aktivnim zonama u Jugoslaviji.- Geol. vjesnik, 40, 255-263.

ALJINOVIĆ, B., PRELOGOVIĆ, E. & SKOKO, D. (1990): Tectonic Processes on the Contact of the Adriatic Platform and the Dinarides in the Area of the Northern Dalmatia.- Proc. of the Inter. Conf. on Mechanics of Jointed and Faulted Rock, Inst. of Mech/Tech. Univ. of Vienna, 179-182, A.A. Balkema, Rotterdam/Brookfield.

ANDERSON, H. & JACKSON, J. (1987): Active tectonics of the Adriatic Region.- Geophys. J.R. Astr. Soc., 91, 937-983.

BAHUN, S. (1974): Tektogeneza Velebita i postanak Jelar-naslaga.- Geol. vjesnik, 27, 35-51.

BIJU-DUVAL, B. & MONTADERT, L. (1977): Geological evolution from the Tethys to the Mediterranean from the Mesozoic to the Present.- Inter. Symp of the Structural Hist. of the Mediteran. Basins, Split 25-29 Oct. 1976, Technip, 13-18, Paris.

CHOROWICZ, J. (1977): Étude géologique des Dinarides le long de la structure transversale Split - Karlovac (Yougoslavie).- Sociéte géol. du Nord, 1, 11-330, Villenueve d'Asq.

FRITZ, F. (1977): Litostratigrafska i tektonska osnova hidrogeoloških odnosa Ravnih Kotara i Bukovice.- Unpublished Ph.D. Thesis, University of Zagreb, 148p.

FRITZ, F., BAHUN, S. & PAVIČIĆ, A. (1978): Tektonski okvir karbonatnih klastita u području Zrmanje uzvodno od Obrovca.- Krš Jugoslavije, 9/6, 273-282, Zagreb.

GRIMANI, I., JURIŠA, M., ŠIKIĆ, K. & ŠIMUNIĆ, A. (1975): Osnovna geološka karta SFRJ, tumač za list Knin, L 33-141.- Inst. geol. istraž., Zagreb, 1966, Sav. geol. zavod, Beograd, 61p.

GRIMANI, I., ŠIKIĆ, K. & ŠIMUNIĆ, A. (1972): Osnovna geološka karta SFRJ, 1:100.000, list Knin, L 33-141.- Inst. geol. istraž., 1962 - 1966, Sav. geol. zavod, Beograd.

HERAK, D., HERAK, Ma. & CABOR, S. (1988): Neka obilježja seizmičnosti i katalog potresa šireg područja Dinare za razdoblje 1979 - 1987.- Acta seism. Iugoslavica, 14, 27-59, Beograd.

HERAK, Ma. & HERAK, D. (1990): Anomalous Seismicity of the Knin Area prior to the M=5.5 Earthquake of 1986.-Elsevier Sci. Publ. B.V., 323-329, Amsterdam.

HERAK, M. (1973): Some Tectonical Problems of the Evaporitic Area in the Dinarides of Croatia.- Geol. vjesnik, 26, 29-40.

HERAK, M. (1986): A New Concept of Geotectonics of the Dinarides.- Acta. geologica, 16/1, 1-42, Zagreb.

HERAK, M. (1991): Dinaridi, mobilistički osvrt na genezu i strukturu.- Acta geologica, 21/2, 35-117, Zagreb.

HORVÁTH, F. & CHANNELL, J.E.T. (1977): Further evidence relevant to the African/Adriatic promontory as a palaeogeographic premise for Alpine orogeny.- Inter. Symp of the Structural Hist. of the Mediterran. Basins, Split 25-29 Oct. 1976, Technip, 133-142, Paris.

IVANOVIĆ, A., SAKAČ, K., MARKOVIĆ, S., SOKAČ, B., ŠUŠNJAR, M., NIKLER, L. & ŠUŠNJARA, A. (1973): Osnovna geološka karta SFRJ, 1:100.000, list Obrovac, L 33-140.- Inst. geol. istraž., Zagreb, 1962 - 1967, Sav. geol. zavod, Beograd.

IVANOVIĆ, A., SAKAČ, K., MARKOVIĆ, S., SOKAČ, B., ŠUŠNJAR, M., NIKLER, L. & ŠUŠNJARA, A. (1976): Osnovna geološka karta SFRJ, tumač za list Obrovac, L 33-140.- Inst. geol. istraž., Zagreb, 1967, Sav. geol. zavod, Beograd.

IVANOVIĆ, A., SIKIRICA, V., MARKOVIĆ, S. & SAKAČ, K. (1977): Osnovna geološka karta SFRJ, 1:100.000, list Drniš, K 33-9.- Inst. geol. istraž., Zagreb, 1967 - 1972, Sav. geol. zavod, Beograd.

IVANOVIĆ, A., SIKIRICA, V. & SAKAČ, K. (1978): Osnovna geološka karta SFRJ, tumač za list Drniš, K 33-9.- Inst. geol. istraž., Zagreb, 1972, Sav. geol. zavod, Beograd.

KAPELJ, J. (1989): Neotektonski odnosi u području gornjeg toka rijeka Krke i Zrmanje.- Unpublished M.Sc. Thesis, University of Zagreb, 71p.

LABAŠ, V. (1987): Neke specifičnosti građe podzemlja dijela centralne zone dinaridskog gravimetrijskog minimuma.- Nafta, 38/10, 547-554, Zagreb.

MAMUŽIĆ, P. (1971): Osnovna geološka karta SFRJ, 1:100.000, list Šibenik, K 33-8.- Inst. geol. istraž., Zagreb, 1962 - 1965, Sav. geol. zavod, Beograd.

MAMUŽIĆ, P. (1975): Osnovna geološka karta SFRJ, 1:100.000, tumač za list Šibenik, K 33-8.- Inst. geol. istraž., Zagreb, 1966, Sav. geol. zavod, Beograd.

MARINČIĆ, S. & MATIČEC, D. (1990): Kinematika neotektonskih deformacija na području srednjeg toka rijeke Neretve.- Geol. vjesnik, 43, 53-58.

MILJUSH, P. (1973): Geologic - Tectonic Structure and Evolution of Outer Dinarides and Adriatic Area.- Bull. Am. Assoc. Petrol. Geol., 57/5, 913-929.

MORELLI, C. (1968): Gravimetrià.- Del Bianco, Udine, 575p.

OLUJIĆ, M., HAČEK, M. & HANICH, M. (1971): Fotogeološko - terenska interpretacija šireg područja Bukovice (sjeverna Dalmacija).- Geol. vjesnik, 24, 57-63.

PRELOGOVIĆ, E., FRITZ, F., CVIJANOVIĆ, D. & MILOŠEVIĆ, A. (1979): Seizmotektonska aktivnost u području doline Zrmanje.- Geol. vjesnik, 31, 123-136.

ŠIKIĆ, D. (1976): Duboki rasjed i sekundarne strukture zapadnog dijela Dinarida.- Geol. vjesnik, 29, 181-190.

ŠUŠNJARA, A., SAKAČ, K., JELEN, B. & GABRIĆ, A. (1992): Upper Permian Evaporites and Associated Rocks of Dalmatia and Borderline Area of Lika and Bosnia.- Geol. Croatica, 45, 95-114.

ZAGORAC, Ž. (1975): Neki rezultati magnetometrije u sklopu kompleksne geofizičke interpretacije područja Dinarida.- Nafta, 2, 64-71, Zagreb.

Manuscript received October 11, 1993.
Revised manuscript accepted November 10, 1995.