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The Origin and Importance of the Dolomite-Limestone Breccia Between the Lower and Upper Cretaceous Deposits of the Adriatic Carbonate Platform: An Example from Ćićarija Mt. (Istria, Croatia)

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Abstract

On the NE slopes of Ćićarija Mt. (N Istria) a 120-150 m thick complex composed of dolomite-limestone breccia crops out between the Lower and Upper Cretaceous deposits. This studied breccia sequence is of post-sedimentary, tectogenic-diagenetic origin. It was formed by polyphase tectonic fracture of the Upper Albian to Lower Cenomanian early- and late-diagenetic dolomite succession with relics of recrystallized limestone, which enabled very important subsequent diagenetic alteration. This included partial dissolution, dedolomitization, recrystallization and calcitization of the fine-grained, crushed dolomite matrix, and centripetal dissolution of dolomite fragments and their cementation by calcite and ferroan calcite cements, as well as the partial collapse of fragments from the roofs of dissolution cavities and limited late-diagenetic silicification (the silica surplus originating from layers of diagenetic quartz from underlying Upper Albian deposits). Such a complex pattern of different events resulted in the high variability of breccia characteristics over relatively small distances, especially near more intensively tectonized zones.

The contemporaneous stratigraphic level (Lower to Upper Cretaceous transition) in other parts of the Adriatic Carbonate Platform is also characterised by predominantly late-diagenetic dolomites with relics of limestones (including local occurrences of early-diagenetic dolomites) which are, in more tectonized areas, late-diagenetically altered into tectogenic-diagenetic breccias.

1. INTRODUCTION

During the exploratory geological works for the railway tunnel project through the Ćićarija Mt. belt (western Croatia - Fig. 1) special attention was paid to the problem of the complex of dolomite-limestone breccia on the NE flank of the mountain, regarding the position, shape, and origin of the sedimentary body.

Previously there were two opposing opinions concerning the occurrence and origin of the dolomite-limestone breccia.

According to the Explanatory notes of the Basic Geological Map, sheet Ilirska Bistrica (ŠIKIĆ & PLENIČAR, 1975) these deposits were formed by erosion of the carbonate rocks during tectonic uplift, and redeposition of the derived coarse-grained material into the basin. The brecciated appearance would therefore represent the consequence of irregular fragmentation of the carbonate rocks during weak synsedimentary movements, which were attributed to the "Austrian tectonic phase". Therefore, these breccia deposits were interpreted as intraformational, i.e. deposits which are positioned within the structure between Lower Cretaceous and Upper Cretaceous shallow-water platform limestones. The same level of brecciated rocks in the central Istria were referred to as "the horizon of the clastic-carbonate rocks", and interpreted in similar way by POLŠAK & ŠIKIĆ (1973).

According to the second, later opinion of some investigators presented in unpublished reports, these deposits would correspond to the so-called Jelar breccia, or Jelar beds, i.e. a post-Cretaceous tectogenic rock-fall breccia covering large areas of Velebit Mt. and some of the northern Adriatic islands. In this case the breccia deposits would represent irregular, lensoid bodies covering palaeodepressions in the more or less tectonized underlying Cretaceous deposits - therefore, they would not be concordantly inserted within the structure of the Ćićarija Mt., i.e. between the Lower and Upper Cretaceous carbonate deposits.

Explanation of the problem of structural position and origin of the dolomite-limestone breccia of the

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Fig. 1 Location map showing localities mentioned in the text, study area (black rectangle) and some other occurrences of a similar breccia (grey circles).

Ćićarija Mt. (VLAHOVIĆ et al., 1995) was a very important issue in the construction of the geological profile of the future tunnel, especially regarding their extremely variable, and more or less unfavourable engineering-geological properties (BIONDIĆ et al., 1995). Therefore, during the exploratory works detailed investigation of their superficial occurrence, relationship with neighbouring lithostratigraphical units, as well as a complex investigation of their sedimentological, petrographical, palaeontological and stratigraphic properties was performed. The results of these investigations and the completely new interpretation of their origin, as well as a brief regional overview of the transitional level between the Lower and Upper Cretaceous deposits, are the main topics of this paper.

2. THE OCCURRENCE, LITHOLOGICAL PROPERTIES AND STRATIGRAPHIC POSITION OF THE INVESTIGATED BRECCIA

2.1. Occurrence of the breccia deposits

In the study area breccia deposits occur in the undivided, approximately 1-1.5 km wide zone near the core of an anticline composed mostly of the Cretaceous deposits. A similar zone composed of dolomite-limestone breccia is also present in the NE limb of the anticline, in a contemporaneous stratigraphic position - between the Albian and Cenomanian shallow-water limestones (Fig. 2).

The field observations suggest that these deposits represent part of the structure, i.e. that they are concordant within the Upper Albian and Middle Cenomanian limestones. This, together with the need for obtaining as much data as possible concerning their engineering-technical properties at the level of the future tunnel, resulted in the location and drilling a 350 m deep well (ŽTĆ-2). The well was located within the area composed of Cenomanian limestones dipping at approximately 25° W, and in compliance with the prognosis profile penetrated the breccia deposits at depth between 50.5 to 215.4 m (Fig. 3). The well ended in the Upper Albian deposits (limestones and rarely late-diagenetic dolomites, including three layers of diagenetic quartz deposits equivalent to the contemporaneous deposits in Istria and island of Vis - GALOVIĆ, 1992).

Contacts between the breccia deposits and underlying Albian limestones, as well as the overlying Cenomanian deposits are very irregular, both in the well-core and on the surface. Generally, all varieties of gradual transitions from completely undisturbed limestones, over more or less intensely cataclastized and late-diage-

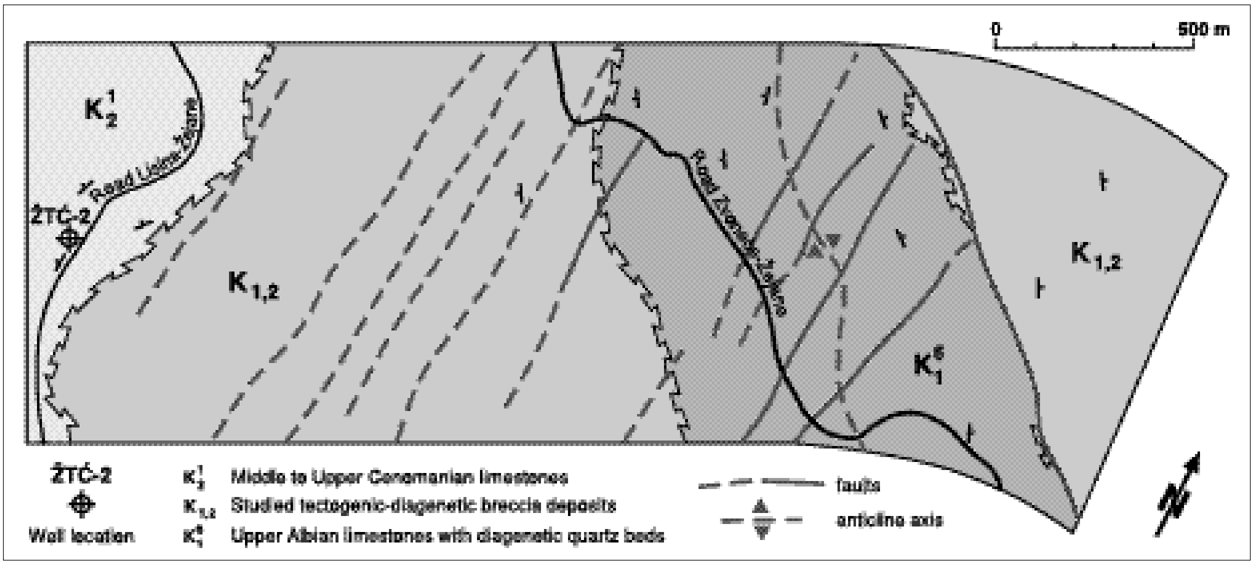

Fig. 2 Simplified geological map of the north-eastern slope of Ćićarija Mt. with the location of well ŽTĆ-2 (on the left).

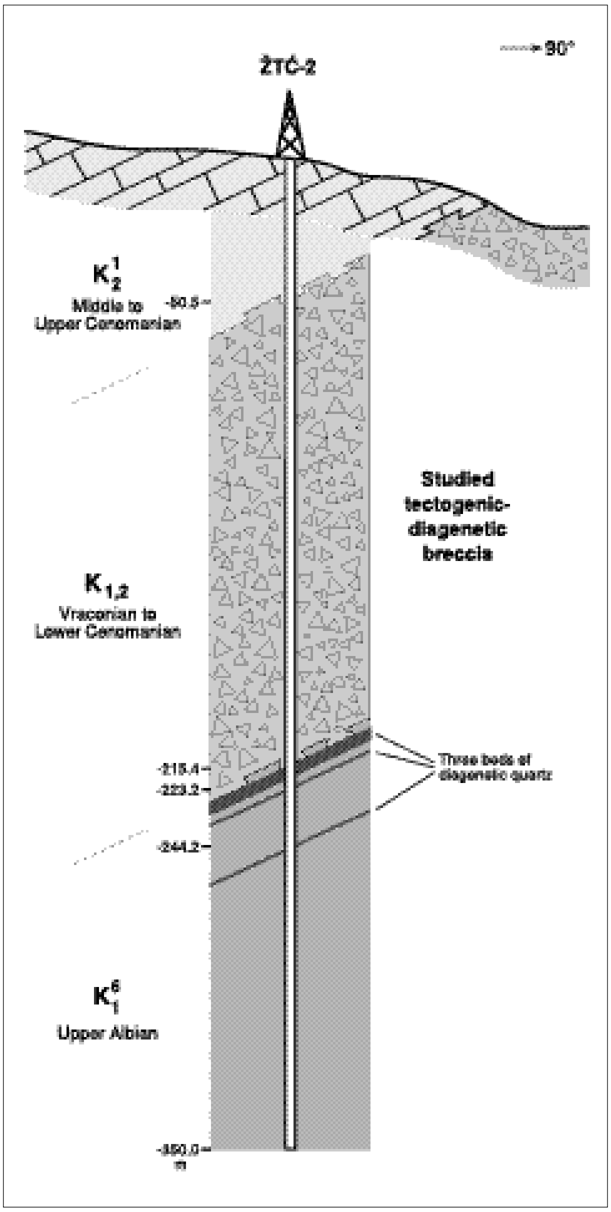

Fig. 3 Simplified well-log showing subsurface relations of the studied deposits.

netically dolomitized limestones, to the typical breccia can be observed in the transitional areas.

Within the breccia zone there are also frequent lateral changes, especially along the younger fault zones: in the areas further from the tectonic zones cutting the breccia unit, large, more or less well preserved dolomite blocks (in some places even with limestone relics) occur, while near the faults, rocks are completely fractured and brecciated.

2.2. Lithological properties

The breccia is predominantly composed of dolomite fragments, with variable amounts of limestone relics, authigenous quartz aggregates and mostly calcitic microspar to spar cement (Figs. 4 and 5). Dolomite fragments are characterised by variegated structural types: besides the most common homogenous crypto to microcrystalline texture some grains show alternation of dolomicritic and dolopelsparitic laminae with relics of cryptalgal lamination, indicating their origin from partially recrystallized early-diagenetic dolomites. Fragments exhibit different hues of a grey colour, a commonly obvious consequence of the varying intensity of diagenetic alteration, mostly by recrystallization and dedolomitization. Some fragments clearly exhibit their early-diagenetic dolomite origin, while others were formed by stronger or weaker recrystallization of fractured and crushed early-diagenetic dolomites or the complete late-diagenetic dolomitization of former limestones. Fragment size is very variable, the most common grains being 1-50 mm in diameter, but in some parts of the breccia zone there are dm-sized fragments,

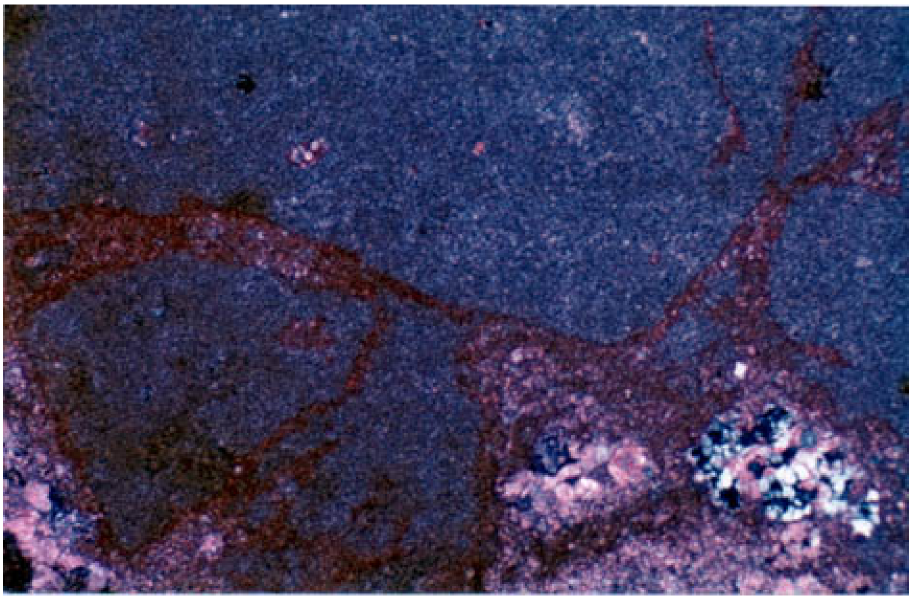

Fig. 4 Photomicrograph of diagenetic breccia composed of dolomicrite fragments and calcitized and partly silicified matrix. Note "rounding" of fragments due to corrosion of the dolomite fragments. ŽTĆ-2, 180.6 m; stained thin-section, polarised light, photo length = 3.3 mm.

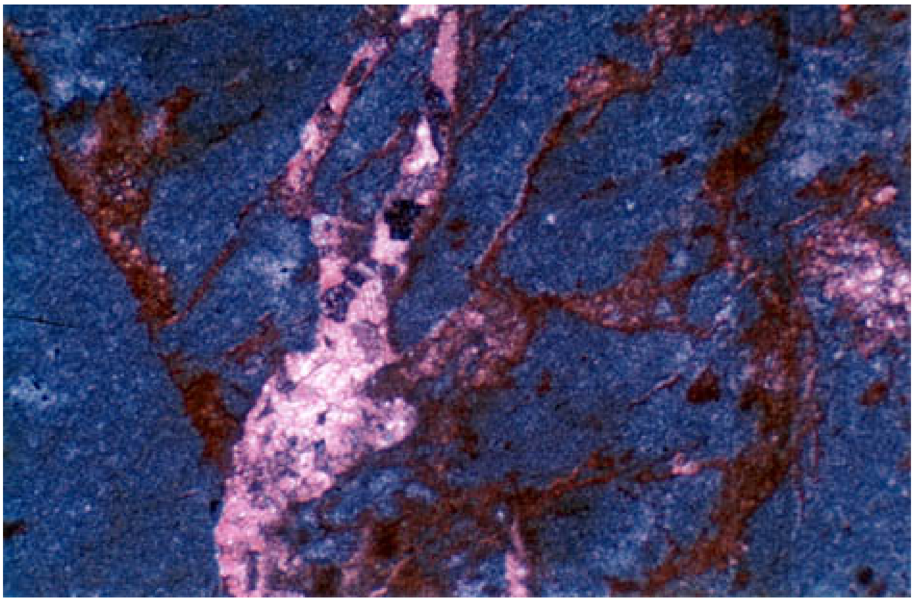

Fig. 5 Photomicrograph of diagenetic breccia with corroded dolomite fragments and completely calcitized fine-crystalline matrix and neocalcite mosaic cement. Most of the fragments are still characterised by relatively high fitting. ŽTĆ-2, 73.3 m; stained thin-section, polarised light, photo length = 3.3 mm.

and even blocks a few metres in size. The fragments are more or less isometric, mostly angular with more or less rounded corners. Infrequent rounded grains are obviously the result of corrosion and solution of the original rock by aggressive pore solutions and replacement of dolomite by calcite (i.e. dedolomitization), not of rounding during possible transport. Corrosional "rounding" of fragments is clearly visible in thin sections, especially by obvious centripetal calcitization, i.e. this process gradually prograded from tectonic fissures surrounding the fragments towards the interior of the grains (Fig. 4).

Fitting (FÜCHTBAUER & RICHTER, 1983), i.e. the compatibility of the contours of neighbouring grains, is variable, but relatively high: fragments are commonly divided only by tectonic fissures and joints (similar effects are also present in the underlying rocks - Fig. 6), which are more or less widened by corrosion (Fig. 5). In the more tectonized parts of the study area, characterised by more important dissolution and formation of dissolution pores and caverns, collapsed material within such open spaces is characterised by very low fitting. Fitting is also low in tectonic breccias formed along clearly marked tectonic lines. In some places, especially in the vicinity of more tectonized zones, intergranular contacts are frequently stylolitic, i.e. formed as a consequence of subsequent intense pressure solution (Fig. 7).

Quartz aggregates, which macroscopically appear as compact white clasts (Fig. 9B; these clasts were occasionally in former investigations even mistaken for white Cenomanian limestone clasts!), were formed by selective early-diagenetic silicification of the most unstable carbonate components (mostly dissolved and dedolomitized dolomite fragments, in some places also

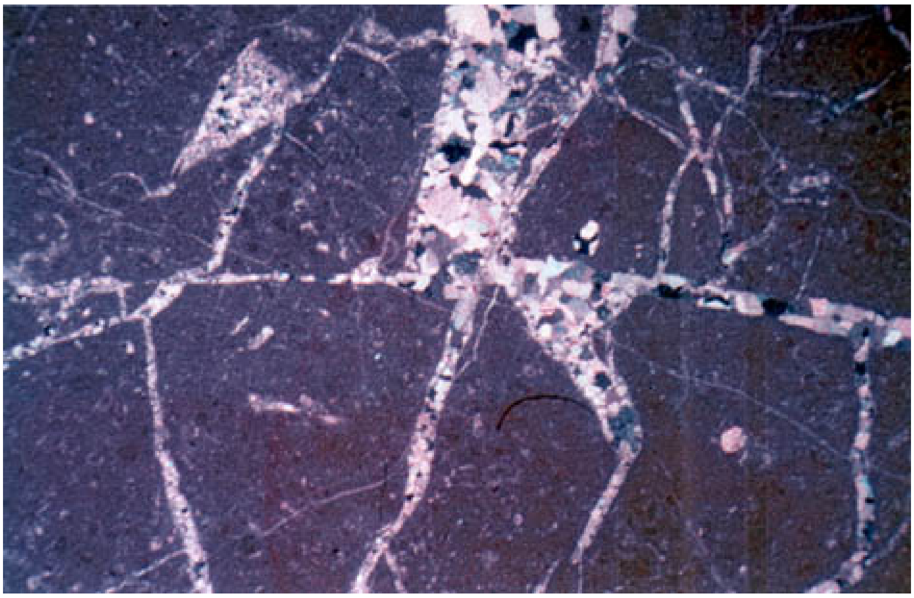

Fig. 6 Photomicrograph of tectonized Albian limestone showing fractures filled by coarse-crystalline calcite cement. Note high fitting. ŽTĆ-2, 285.4 m; stained thin-section, polarised light, photo length = 7.5 mm.

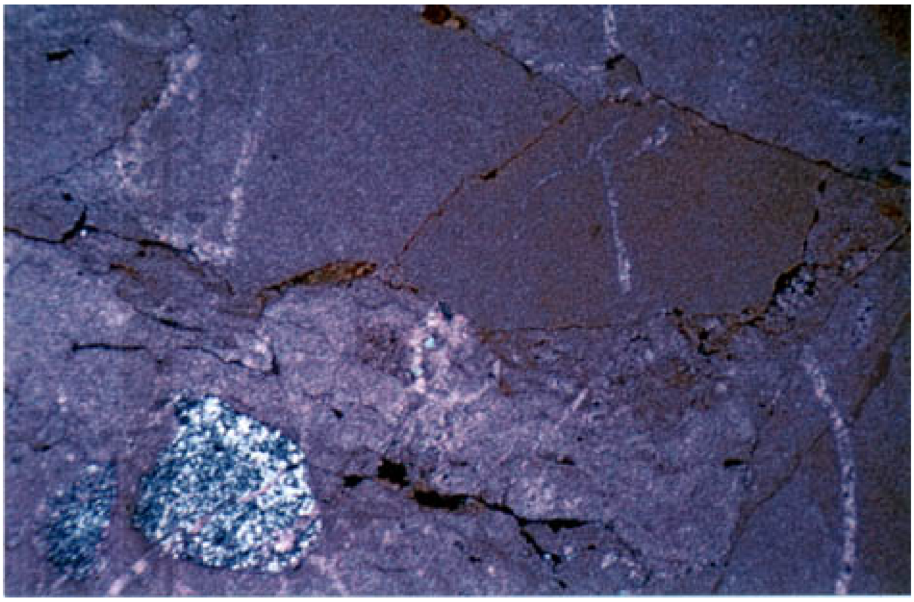

Fig. 7 Photomicrograph of stylolitization breccia characterised by stylolitic intergranular contacts formed as a consequence of intense pressure solution. Note intense late-diagenetic silicification of two small fragments of dolomicrites in the lower left, subsequently cut by calcite veins. ŽTĆ-2, 121.4 m; stained thin-section, polarised light, photo length = 7.5 mm.

calcitized fine-grained carbonate matrix). These quartz druses are mostly composed of hypidiomorphic crystals of variable size, which were during the most recent calcitization processes frequently disintegrated by neocalcite growth between quartz aggregates, resulting in formation of isolated quartz "grains" within a calcite mass. Quartz crystals frequently exhibit radial growth of the terminal surfaces in the form of rosettes (Fig. 8).

Subsequent calcitization of quartz aggregates is most obvious near numerous irregular tectonic fissures and fractures formed by the youngest tectonic movements (Neotectonic phase - post-Miocene). Calcitization is generally clearly centrifugal, resulting in complete calcitization of the inner parts of quartz rosettes.

Quartz aggregates were formed by *in situ* growth of quartz crystals during late diagenetic circulation of solutions enriched in silicic acid. The silica surplus probably originated from diagenetic quartz deposits found in the underlying Upper Albian deposits.

The cement and matrix of the dolomite-limestone breccia are mostly composed of microsparitic calcite. This matrix was formed by calcitization (i.e. dedolomitization) of finely crushed dolomicrite, which is present only in the form of small relics, while calcite cement filled the remaining voids. In some places gradual transitions from dolomicrite fragments and partially calcitized dolomicrite to cryptocrystalline calcite with rare dolomicrite relics are visible. Significant calcitization occurred in the most tectonically disintegrated areas, i.e. the intensity of calcitization is more or less positively correlatable with the intensity of tectonic disintegration. Both cement and matrix are partially recrystallized, and in some parts spelaeothems, formed by the circulation of solutions through corrosionally widened

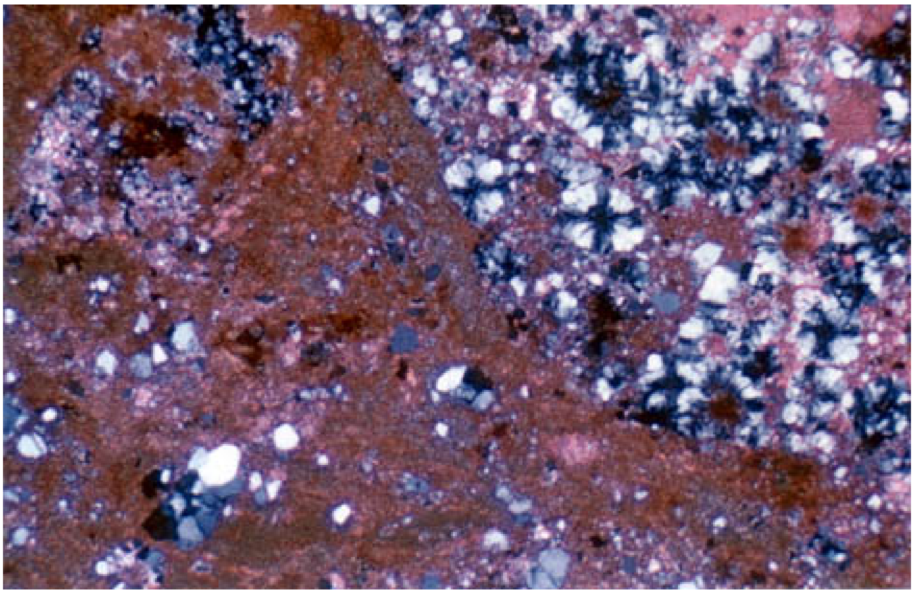

Fig. 8 Photomicrograph of partially silicified calcitized matrix (upper right) and a partly dedolomitized dolomicrite fragment (lower left) of diagenetic dolomite-limestone breccia. Note that quartz crystals frequently exhibit radial growth of the terminal surfaces in the form of rosettes. ŽTĆ-2, 51.25 m; stained thin-section, polarised light, photo length = 3.3 mm.

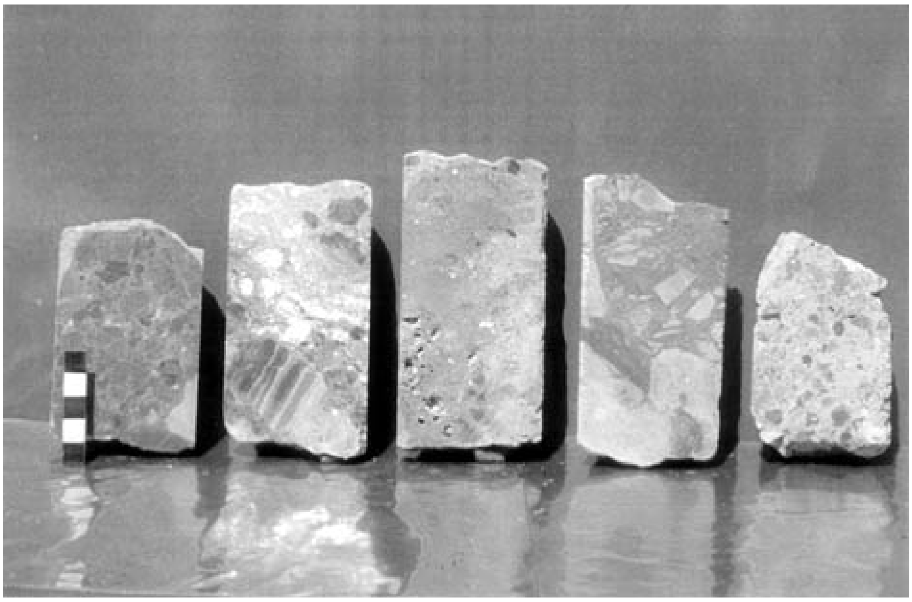

Fig. 9 Five typical examples of different varieties of the studied breccia from well ŽTĆ-2. A) Completely corroded dolomite fragments ("rounded" grains) surrounded by a large quantity of finely crushed recrystallized matrix; B) Large fragments of dolomite "floating" in dark calcitic matrix; C) matrix-rich breccia characterised by intense corrosion (isometric solution vugs formed by dedolomitization); D) breccia composed of completely silicified white fragments and laminated early-diagenetic dolomites; E) fractured dolomite with thin fillings of white calcite between dolomite fragments.

tectonical fractures, were observed. Younger tectonic fractures and some solution cavities are completely cemented by mosaic sparry calcite.

2.3. Stratigraphic position

No index fossils have been discovered in fragments or matrix of the dolomite-limestone breccia, which is not unusual as they are mostly composed of early- and late-diagenetic dolomites with late-diagenetic calcitized fractures. Only in infrequent undolomitized limestone relics have rare miliolids and ostracods been observed, but without any stratigraphic significance. Therefore, the stratigraphic position of the studied sequence can only be established on the basis of superpositional relationships. Both from surface data and information from drilling it is clear that the studied dolomite-limestone breccia is situated between Albian and Cenomanian carbonates.

The underlying deposits are mostly grey, dark grey-brownish to almost black, platy to thin-bedded (≤ 30 cm) mudstones, which are, in the upper part, frequently late-diagenetically dolomitized. On the basis of their fossil content (*Chama* sp., gastropods, nubecularids, and benthic foraminifera: *Praechrysalidina infracretacea* LUPERTO-SINNI, *Pseudonummoloculina heimi* (BONET) and other miliolids) and correlation with similar deposits of the neighbouring areas their Albian age is certain. However, the geological position of the studied deposits and three levels of diagenetic quartz deposits determined in the ŽTĆ-2 well (at 215.3-217.5, 223.1-223.2 and 244.1-244.3 m), which are regionally important for the latest Albian, indicate a probable Upper Albian age.

Overlying deposits are represented by brown - dark brown, rarely yellowish and grey-brownish, partly recrystallized mudstones to peloid-skeletal wackestones with infrequent rudist debris. Radiolitid and ostreid floatstones are relatively rare. In these deposits typical Middle to Upper Cenomanian fossils of the Adriatic Carbonate Platform have been observed: *Chrysalidina gradata* d'ORBIGNY, *Nummoloculina regularis* PHILIPPSON, *Pseudonummoloculina heimi*, *Pseudolituonella reicheli* MARIE, etc. Concerning the position of deposits directly overlying the breccia in the study area, the lack of *Broeckina* (*Pastrikella*) *balcanica* CHERCHI et al., a typical index species for the upper part of the Middle and Upper Cenomanian in the neighbouring area (VELIĆ & VLAHOVIĆ, 1994), indicates that a Middle Cenomanian age seems more probable.

On the basis of the aforementioned data, it may be concluded that the studied succession of dolomite-limestone breccia is probably of uppermost Albian (Vraconian) to Lower Cenomanian age. This determination completely complies with the stratigraphic position of the same or similar deposits (dolomite or dolomite-limestone breccia, recrystallized early and late-diagenetic dolomites, late-diagenetically dolomitized and recrystallized limestones) in other parts of the Adriatic Carbonate Platform in Croatia (e.g. eastern part of Istria, islands of Krk and Cres, Gorski Kotar area) and Slovenia (e.g. "massive to indistinctly bedded bituminous dolomitic breccia" of the Povir Formation in the area of the Trieste-Komen Plateau - JURKOVŠEK et al., 1996), and also in neighbouring Italy (TENTOR et al., 1994).

The complete thickness of the studied sequence of dolomite-limestone breccia of the Ćićarija Mt. could be approximated to 130-150 m, on the basis of surface and subsurface data, which is concordant with the estimated thickness of the corresponding level in other areas (e.g. Sis Formation on the island of Cres or Povir Formation of the Trieste-Komen Plateau - JURKOVŠEK et al., 1996). However, concerning the thickness of this complex it should be emphasised that both boundaries with the overlying and underlying lithostratigraphic units are gradual and irregular as the result of different amounts of tectonic disturbance and selectivity of diagenetic processes; therefore, the thickness of the breccia complex is laterally variable.

3. ORIGIN OF THE DOLOMITE-LIMESTONE BRECCIA

The origin of the studied rock complex is very complex and polygenetic, as in both the field and in thin-section several genetic types of breccia could be recognised, including different gradual transitions between them. This resulted in great variability of the observed lithofacies, i.e. almost each sample seems at least somewhat different form the others in its close vicinity (Fig. 9).

All breccia deposits are characterised by the important influence of late-diagenetic processes, which were enabled by intense tectonic disintegration, therefore the entire succession is defined as **tectogenic-diagenetic breccia**. However, within the breccia zone there are also spatially restricted occurrences representing relics of breccia deposits of specific origin, also caused more or less directly by recurring intense tectonic activity during post-Cretaceous tectonic phases (Tertiary tectonic phase and Neotectonic phase):

a) tectonic breccia;
b) stylolitization breccia;
c) collapse breccia.

Tectonic breccias were formed by tectonic disintegration of all rock types (Fig. 6), and only occur very close to important faults. Therefore, their surficial and subsurface extension is limited. **Stylolitization breccias** were formed by karstification of intensely stylolitized, and subsequently partially cemented dolomites and limestones (Fig. 7). Both these aforementioned breccia types can also be seen in the underlying and overlying deposits, as well as in other carbonate successions.

In the areas of very high dissolution, i.e. near the major zones of circulation, numerous cavities of variable size were formed, and collapse of material from their roofs caused formation of specific type of breccia - **collapse breccia**. This type is characterised by a mixture of different fragments originating from neighbouring beds (which were rotated during their accumulation, therefore resulting in much lower fitting), as well as variable proportions of fragments, finely-crushed matrix and cement filling remaining open spaces. Collapse breccias are much more common near major tectonic lines, but are usually also subsequently diagenetically altered.

Sometimes it is hard to define a borderline between the aforementioned types of breccia and the most complex, and by far the most comprehensive type described in this paper - **tectogenic-diagenetic breccia**. Within this breccia type elements of all the other types are encompassed in some places, but they are more or less overprinted by important polyphase diagenetic alterations. Therefore, in this paper the term **tectogenic-diagenetic breccia** is a **collective designation for rocks of brecciated appearance formed as a result of the diagenetic alteration of *in situ* rocks affected by intense tectonics**, although in some parts there are still visible traces of a specific major cause of brecciation (i.e. tectonic crushing, collapse of material from the cavity roof or stylolitization). It is important to notice that most of the rocks of this breccia type are characterised by *in situ* brecciation, i.e. the transport distance of fragments in the breccia is very short (e.g. in the case of collapse origin) or practically absent.

The original rock succession, before intense post-Cretaceous tectonic activity, represented the alternation of peritidal early-diagenetic dolomites and limestones. Fragments of the early-diagenetic dolomites are commonly characterised by relics of cryptalgal lamination, indicating their formation by early-diagenetic dolomitization in peritidal (supratidal) conditions. Interbedded shallow subtidal limestones were subsequently, during the late-diagenetic phase, gradually dolomitized into late-diagenetic dolomite characterised by a mosaic structure composed of hypidiomorphic dolomite crystals. Similar successions have been described from the Berriasian of Istria ("Fantazija dolomites" - VELIĆ & TIŠLJAR, 1988; TIŠLJAR et al., 1995) and the Upper Albian of Biokovo Mt. (TIŠLJAR & VELIĆ, 1991).

Underlying Upper Albian deposits and overlying Cenomanian deposits were composed of almost pure limestones. This is very important for the origin of the investigated breccia deposits, which resulted from polyphase processes and diagenetic changes which are here, as in other analogous cases, mainly induced by the presence of unit of specific lithology (in this case dolomites) surrounded by rocks of a different composition (in this case predominantly limestones, including infrequent layers of diagenetic quartz in the underlying succession).

During the Tertiary, the entire sequence of deposits in the study area was affected by quite intense post-sedimentary tectonics (this is the area characterised by the "collision" of Istria and its hinterland, resulting in the formation of the Ćićarija Mt. belt, as well as by intense Neotectonic deformation). However, concerning the fact that the dolomite rocks are much more prone to tectonic disintegration than limestones (HANDIN & HAGER, 1957), it is not unusual that the alternation of early-diagenetic and late-diagenetic dolomites was even more intensely fractured than the surrounding Albian and Cenomanian limestones. In zones near major faults they were even completely crushed, resulting in their greatly enhanced permeability.

Further diagenetic changes took place under conditions where limestone represented the stable and dolomite the unstable phase. Highly fractured and permeable dolomite rocks enabled circulation of chemically aggressive pore solutions causing partial dissolution and/or diagenetic changes of the rock fragments, since these solutions were oversaturated with respect to calcite and undersaturated in respect of dolomite. Such a chemical composition of pore waters, i.e. relatively high concentration of calcium hydrogencarbonate, resulted from the intense pressure solution of a thick sequence of Mesozoic deposits (predominantly limestones) during the phases of tectonic stress, as well as dissolution of the surficial part of deposits by meteoric waters enriched in CO_2.

Relatively aggressive pore solutions caused partial dissolution of dolomite rocks and important allochemical late-diagenetic processes, i.e. calcitization (dedolomitization) and late-diagenetic silicification, which were accelerated by the relatively large reactive surfaces of tectonically disintegrated dolomites, resulting in important changes of mineral and chemical composition of the original rocks.

Dissolution of dolomite rock along the tectonic fissures and joints caused formation of corrosional voids of varying size, significant widening of fissures and joints, as well as corrosion of surfaces and corners of dolomite fragments (therefore, in zones of intense circulation many "grains" are more or less rounded, which was formerly misinterpreted as a result of rounding of coarse-grained material during transport).

Recrystallization of the matrix and cementation of neomorphic calcite crystals in open spaces, fissures and fractures as a result of oversaturation of pore solutions in respect to calcium carbonate was a very important diagenetic process. This was followed by gradual replacement of dolomite by calcite, i.e. dedolomitization, which was especially important in the more intensely tectonized zones, resulting in further "rounding" of fragments. Calcitization was a polyphase process, as there are several generations of neocalcite of different composition (from calcite to ferroan calcite) caused by polyphase tectonics and variable chemical composition of pore solutions.

Another important allochemic diagenetic process, although of much lesser extent, was the late-diagenetic silicification of dolomites and dedolomites, and also neocalcite forming the matrix and cement. Solutions comprising SiO_2 diluted in the form of silicic acid gradually replaced carbonate minerals that were unstable under weakly acid pH conditions. Silicification resulted in the formation of microcrystalline, rarely even cryptocrystalline quartz aggregates, commonly within the contours of the dolomite fragments or within the calcitized matrix. Silicification was obviously a later process than the main calcitization phase, but it is evident that there was at least one subsequent phase of calcite crystallisation. The most probable source of the silica surplus was the underlying diagenetic quartz beds of Upper Albian age found in the ŽTĆ-2 well. These were formed by late-diagenetic silicification of lagoonal limestones caused by the aeolian input of volcanic ash. This is also why silicification is more intense in the lower part of the studied breccias.

4. DISCUSSION AND CONCLUSION

Carbonate breccias are deposits that are quite underestimated in the sedimentological literature. There are several reasons for this, but probably the most important one is their complexity caused by the very common presence of different genetic types at the same locality. Furthermore, breccias are often subsequently considerably modified either by tectonics or diagenetic processes, disabling the possibility of direct determination of their origin. This results in a common problem in the general perception of breccia: either their mystification (unfortunately, commonly resulting in their complete omission from discussions) or their extreme simplification (placing all types together and suggesting that their origin is already well-known), despite their importance for the appropriate determination of specific events in the geological history of many areas.

The transitional level between the Lower and Upper Cretaceous, i.e. Upper Albian and Lower Cenomanian deposits, is in most parts of the Adriatic Carbonate Platform characterised by intense dolomitization and recrystallization of limestone relics. At many locations it is obvious that the surplus of magnesium necessary for the massive late diagenetic dolomitization of limestones was provided by early-diagenetic dolomites, as a consequence of the formation of extensive tidal flats during relative sea-level fall. This is the reason why this level is one of those regionally recognised for profound dolomitization. However, dolomite-carbonate breccias are present only in some places, e.g. Ćićarija Mt., hinterland of Rijeka, parts of SE Istria, parts of Cres and Krk island, etc. Why are they absent in other areas?

The case of the Ćićarija Mt. dolomite-limestone breccia clearly indicates two substantial prerequisites for the formation of this type of breccia: (1) presence of rocks of specific lithology, different from neighbouring units, (2) their occurrence within zones of intense tectonic activity. Only the appropriate combination of both factors enabled the intense disintegration of rocks and significant influence of polyphase complex diagenetic processes. This is the main reason why the amount of tectogenic-diagenetic alterations is laterally extremely variable: even intense tectonic activity will result only in limited changes in successions composed of similar lithologies (since there will be no major allochemical diagenetic changes necessary for the formation of this kind of brecciated rocks) and vice versa: without tectonic disintegration even the successions of completely different lithology than neighbouring units will remain almost unchanged (since diagenetic processes will be much slower and of lesser extent).

On the basis of the occurrence of dolomite-limestone breccias of Ćićarija Mt., their composition and structural-textural characteristics, as well as the complex tectonic and diagenetic processes relevant to their formation the following main conclusions may be drawn:

1) these rocks are not sedimentary, intrabasinal breccias formed by synsedimentary tectonic phases between the Lower and Middle Cretaceous;
2) the investigated sequence of breccia deposits represent a continuous succession located within the structure of Ćićarija Mt. between the Upper Albian and Middle to Upper Cenomanian deposits, i.e. they are not equivalent to a tectogenous rock fall breccia of the Jelar type (Cenozoic breccia covering large areas of Velebit Mt. and some of the northern Adriatic islands - BAHUN, 1974);
3) the studied sequence represents rocks of specific properties and origin, formed by complex tectonic and diagenetic processes affecting a specific lithological succession different from neighbouring units - besides other specific breccia types recognised within the studied sequence, most of the rocks could be referred to as post-sedimentary tectogenic-diagenetic breccia formed *in situ*.

This kind of genetic interpretation is also partly or completely applicable for breccias from some other stratigraphic levels in the Adriatic Carbonate Platform realm, although these sequences are not so thick and outcrops of similar rocks are not so extensive. In these cases the interrelation of intense tectonics and specific lithologies is also obvious, as in the area of Mala Kapela Mt. where good examples of Neocomian tectogenic-diagenetic dolomite breccia can be found (Fig. 10). Very similar, although resulting from the completely opposite process (late-diagenetic dolomitization of calcite along tectonic fractures), breccias were described in the Malm deposits of the Velebit Mt. (TIŠLJAR, 1990).

The correct genetic interpretation of breccia deposits is extremely important for the sedimentological, tectonic and palaeogeographic interpretation of the wider region (TIŠLJAR, 2001). In the case of Ćićarija Mt. erroneous substitution of this type of breccia with synsedimentary ones, or their erroneous interpretation as younger, rock-fall breccias forming lens-shaped bodies only in near-surface zone, would be extremely critical. This is not purely a scientific question: in this case the interpretation of a large part of the geological profile for the planned tunnel through Ćićarija Mt. have to be based on the right conclusion, especially concerning possible serious problems during drilling of the studied complex.

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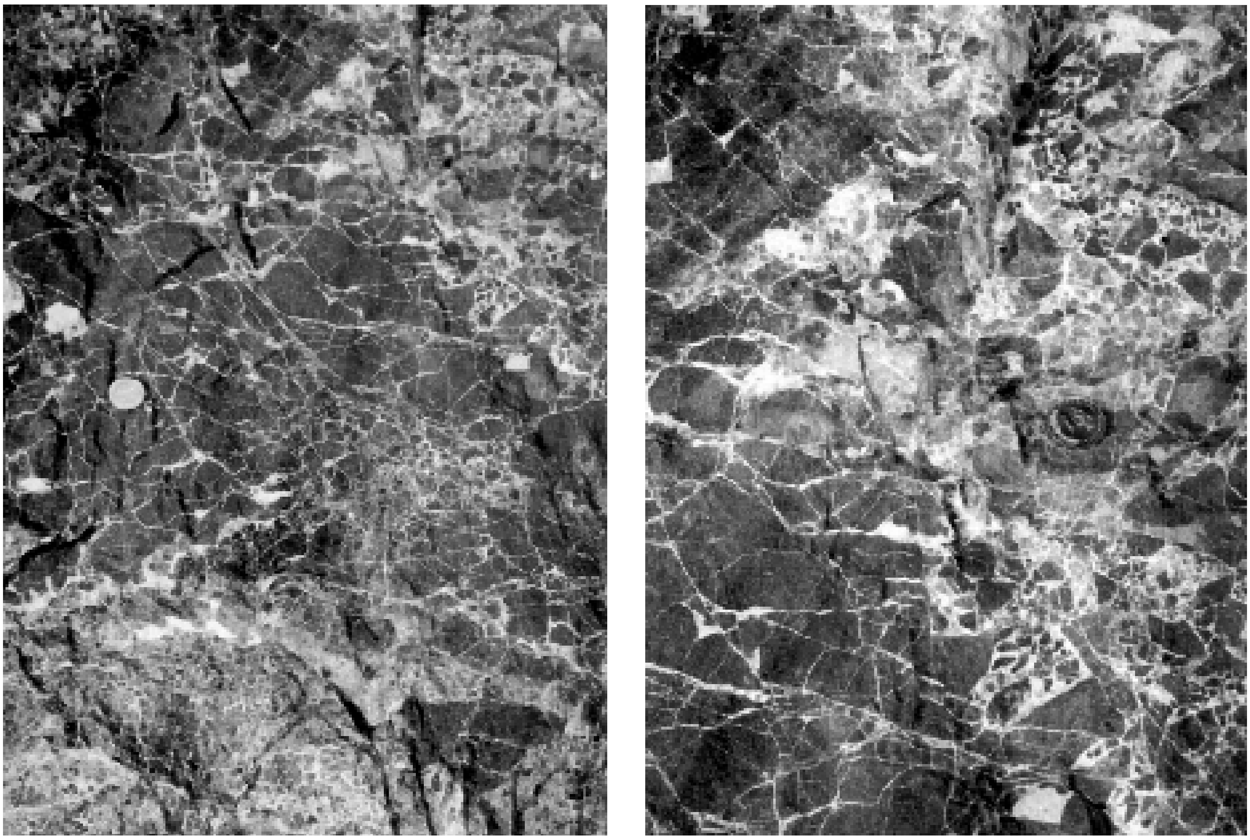

Fig. 10 Photograph of the outcrop of Neocomian tectogenic-diagenetic dolomite breccia on the Mala Kapela Mt. Coin is 27 mm in diameter. A) Tectogenic-diagenetic breccia characterised by different amounts of diagenetic alteration of the original dolomite rock. Tectonic fissures are filled with white calcite cement. The lower part of the photograph represents completely crushed dolomite with only small "rounded" relics of the original rock. B) Detail of the upper right part of Fig. 10A showing more intensely tectonized part of the outcrop, characterised by a large amount of white calcitized matrix and still relatively high fitting of dolomite fragments.

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