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AUTHIGENIC FELDSPARS IN CARBONATE ROCKS OF THE WESTERN CARPATHIANS

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Abstract: Authigenic albites with frequent intergrowths of Roc Tourné and orthoclases are present in many horizons of Permian, Mesozoic and occasionally also in Paleocene limestones. They are formed in lithified rocks tens of millions of years after deposition, by the destruction of clay minerals and clastic feldspars. Solutions proceeding from evaporites have a favourable influence. The formation of authigenic feldspars in clasts of conglomerates was proved. Tracing the frequency of authigenic feldspars in thin sections of approximately equal outcropping rocks in different tectonic units gave the possibility to compare the degree to which they have been affected by heat and pressure (the pre-metamorphic stage and initial anchimetamorphosis).

Key words: Western Carpathians, anchimetamorphosis, diagenesis, carbonate rocks, authigenic feldspar.

Introduction

The aim of this article is to look at the number of occurrences of authigenic feldspars in the limestones and dolomites of the Western Carpathians, at the conditions of formation and period assignment in the process of diagenesis, and especially at the possibility of comparative studies of the degree of heat - pressure effects on tectonic units, including the weakest manifestations of anchimetamorphosis.

The first mention of authigenic feldspars in the Western Carpathians is given by Koutek (1931, p. 47), who found them in the upper part of the Middle Triassic marly limestones ("Campilian") of the Nízke Tatry Mts. Mišík (1963), Mandáková (1964), Turan & Vavro (1970) and Čurlík et al. (1984) published shorter articles devoted to authigenic feldspars in the Western Carpathians.

I found authigenic feldspars in limestones and dolomites of very many lithostratigraphic units from the Permian to Paleocene.

The criteria for distinguishing authigenic from clastic feldspars

We consider the following to be criteria for authigenic formation in carbonate rocks:
1 - Small calcite inclusions, usually in the middle of a grain, the margins are pure (Pl. IA); **2** - Euhedral shape (Pl. IB); **3** - Penetration into alochems, cutting organic remnants etc. (Pl. IC); **4** - A strong prevalence of feldspars over quartz; **5** - Intergrowths of Roc Tourné (Pl. ID - F, IIA - D). The growth of authigenic feldspars on a core of clastic feldspars in limestones (Pl. IIE) occurred only occasionally, in contrast to the frequent syntaxial growth of clastic quartz.

The conditions of formation of authigenic feldspars in carbonate rocks

A suitable source and suitable conditions are necessary for the formation of authigenic feldspars. The dissolution of clastic feldspars and destroyed clay minerals (dissolution of smectites) may be a suitable source. Increased temperature and pressure, causing increased dissolution and mobility of material, and a favourable chemical composition of the solutions, especially their derivation from evaporites, are suitable conditions. In our cases, we conclude that the occurrence of authigenic feldspars in dolomites of the Middle Triassic (Pl. ID, IIA, B), the Upper Triassic in the Keuper facies (Pl. IIF), as well as in the facies of the Opponitz beds (Pl. IIG, H), coarsed-grained limestones of the Permian underlying an anhydrite body (Pl. IE) and all other occurrences from the Permian, is associated with evaporites as a decisive actor. We also consider salty and sulphate pore water in the case of authigenic feldspars in the pebble of pelagic Carnian with *Gondolella noah*, with conodonts unaffected by heat - CAI-1 (Mišík et al. 1991b, p. 21 - Proč conglomerate). In other occurrences increased pressure and temperature are applied as the chief factor. Molenaar & de Jong (1987) deduced the temperature of formation of authigenic albites in Devonian limestones of Belgium at 90 °C to 120 °C.

The mineralogical composition of authigenic feldspars

In the greatest number of cases, authigenic albites were developed, while K-feldspars are rarer. A more detailed mineralogical study was not done. Turan & Vavro (1970) mention albites with a 3 - 12 % anorthite component and K-feldspars with i.l. - 1.518 and - 1.527 in Liassic Borinka limestones.

Authigenic orthoclases from the Muráň limestones (Barremian) had $-2V = 62°$ and 63°, weakly metamorphosed Liassic

limestones of the Tatricum at Donovaly 62° and twice 63° (Mišík 1963). Authigenic K-feldspars from dolomite with an admixture of anhydrite grains (the Carnian - Norian upper part of the Opponitz Formation) are optically unhomogeneous (Pl. IIG). It is possible to assess the initial microclinization of orthoclase from X-ray analysis (RNDr. E. Šamajová, CSc. prepared the X-ray analysis). Kastner (1971) designated all found K-feldspars as microclines.

According to Füchtbauer (1956) authigenic K-feldspars originates at the expense of clay minerals. He found a direct dependence between the quantity of orthoclase and the clayey admixture. He did not observe this dependence with authigenic albites, and he derived them from water containing Na.

Authigenic albites in Roc Tourné twins

It was described for the first time from Triassic dolomites at the locality of Roc Tourné in the French Alps. These characteristic quadripartite crystals are natural for authigenic low temperature feldspars (Füchtbauer 1950; Baskin 1956; Kossovskaja & Šutov 1957). More recently it is admitted that they may also originate from weak metamorphism (Exner & Erkan 1971). Kastner (1971) observes that the larger crystals at the locality of Roc Tourné itself are found in a rock in which fengite is also present. Authigenic "fourlings" are almost always formed by albite. According to Baskin (1956), microcline may also form them.

We found Roc Tourné twins many times in dolomites of the Triassic, from clasts originating from the exotic Pieniny and Neopieniny ridges:

1 - 1a/ dolomite pebble in the upper part of the central Carpathian Paleogene of Orava, locality Brezovica (Pl. ID - Mišík et al. 1968); 1b/ clast of dolomite in the Gregorian breccia of Paleogene age from near the klippen, at the locality Litmanová (Pl. IIA); 1c/ clast of dolomite from conglomerates of the upper Campanian-Maastrichtian from the Smolinské-7 borehole; boreholes in the area of Smolinské penetrate the westernmost occurrence of the Pieniny Klippen Belt in the basement of the Neogene Vienna Basin. In all three cases, an elevation on the inner margin of the Klippen Belt formed the exotic source. It is noteworthy that in hundreds of sections of dolomite of the Triassic of the Central Western Carpathians, and also from the Alpine nappes in the basement of the Slovak part of the Vienna Basin, no authigenic feldspars was found in Roc Tourné twins, and authigenic feldspars are quite rare in them generally (Pl. IIG, H) except Keuper-dolomite.

2 - "Fourlings" of the Roc Tourné type are found especially in anchimetamorphosed Permian of the Northern Gemericum: in albitolites (60 - 90 % albite, Fe - dolomite and Mg - siderite, illite etc. - Čurlík et al. 1984, their Pl. IV; Fig. 2).

3 - They are also abundant in the Permian Meliata Unit, but this is already clearly metamorphosed, for example from coarse-grained limestones underlying an anhydrite body (Pl. IE).

4 - Roc Tourné "fourlings" also occur in the anchimetamorphosed Borinka limestones of the Lias of the Malé Karpaty Mts. (Pl. IIC).

5 - In a pebble of Aptian limestone (Pl. IID) originating from Albian conglomerates of the Tatricum, also affected by weak metamorphism.

6 - They are also present in a pebble of anchimetamorphosed limestone (Pl. IF) in the Jablonica conglomerates of the Karpatian, probably originating from the Devonian Harmónia group of the Malé Karpaty Mts.

Authigenic feldspar as a criterium of the marine origin of limestones

Crowley (1939) already observed that authigenic feldspar is formed exclusively in limestones of marine origin, that their presence excludes a fresh water origin of the given carbonate rocks. Authigenic feldspar occurs relatively frequently in formations of the Carpathian Keuper (Norian), in fine grained carbonate breccias (Pl. IIF) and dolomites. The salinity of the sediments varies from limnic to hypersaline conditions. However their occurrence excludes occasional fresh water layers and is usually associated with features of a hypersaline environment.

Macroscopically visible authigenic feldspars

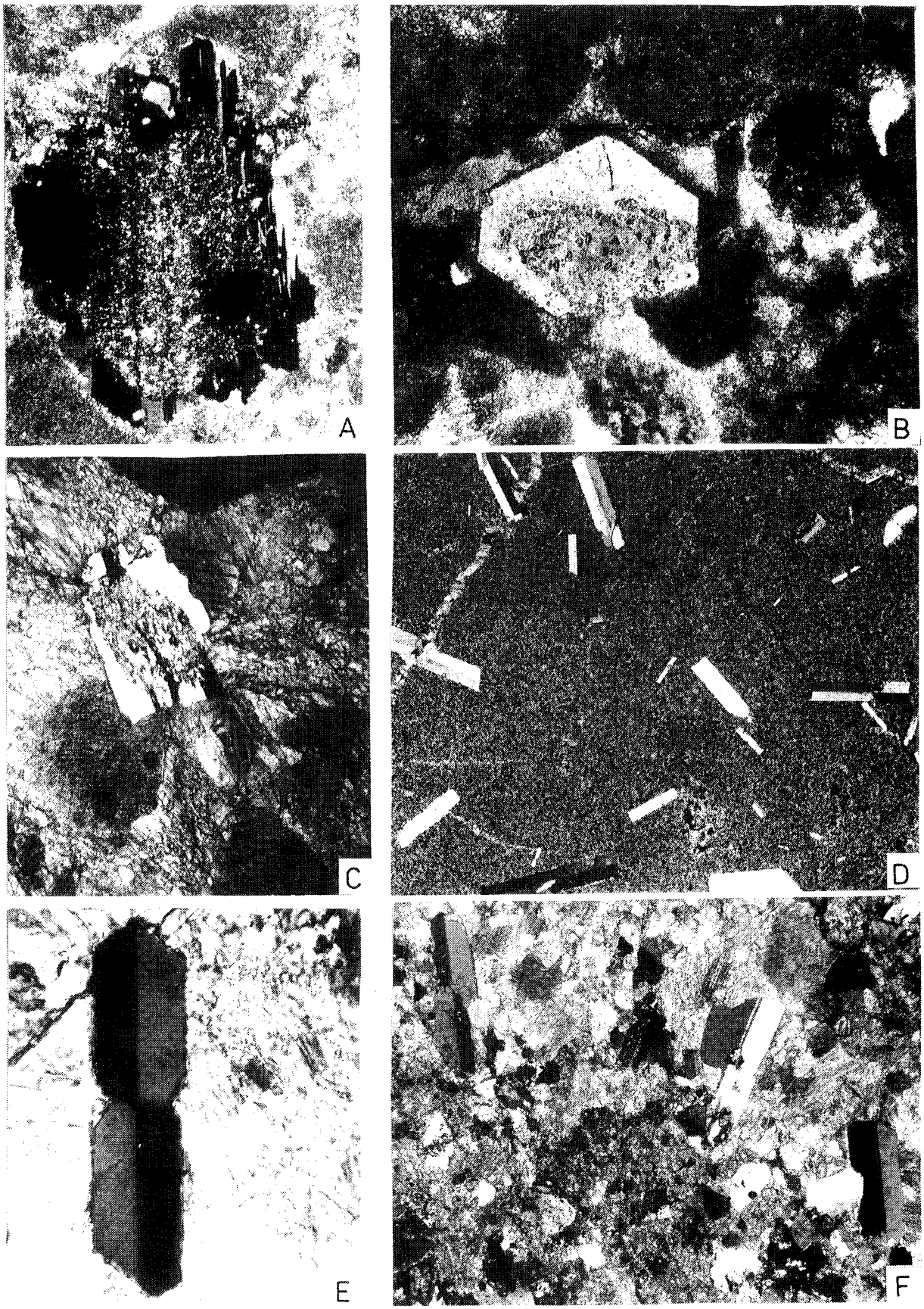
We found this in only one case - from a pebble of Triassic dolomite from conglomerates in the Biely Potok Formation (Priabonian - Lower Oligocene) of the Central Carpathian Paleogene of Orava, locality Brezovica (Pl. ID, Mišík et al. 1968). Columnar authigenic albites, including Roc Tourné twins are up to 3 mm long. Exner & Erkan (1971) describe albites, Roc Tourné twins and oligoclases from pebbles of Senonian conglomerate from the Gosau Formation of the Eastern Alps. The crystals with dark inclusions were up to 7 mm long, irregularly distributed in unmetamorphosed weakly marly limestone of unknown age.

The youngest limestones with authigenic feldspars

According to Kastner (1971 p. 1409), the youngest identified authigenic feldspars are generally found in Eocene limestones of the island of Rhodes. The youngest authigenic feldspars found by us in the Western Carpathians, are from Paleocene limestones with *Alveolina (Glomalveolina) primaeva* Reichel, which are found in contact with the Haligovka klippe, at an elevation point 844,3 north of Ježovka Hill (Pl. IIIA). According to the measurements of Doc. J. Turan it is albite with a very small proportion of the anorthite component (N_{max} = 1.534, N_{min} = 1.534, birefringence = 0.009).

The lack of authigenic feldspars in carbonate rocks from the last 30 million years shows us that authigenic feldspar originates in carbonate rocks tens of millions of years after their deposition, in the stage of epigenesis, usually in complexes, which were exposed to raised temperature and press-

PLATE I: A - Authigenic albite refilled in the centre with inclusions of calcite. Muráň limestone, Barremian, Krížna Nappe, Jatky, Belanské Tatry Mts. Enlarged 135×, crossed nicols. **B** - Authigenic orthoclase. As above, parallel nicols. **C** - Authigenic plagioclase truncating an echinoderm plate. Liassic limestone of the Tatric Donovaly Succession; Hanesy, Nízke Tatry Mts. Enlarged 43x, crossed nicols. **D** - Albite forming Roc Tourné twins in Triassic dolomite. Clast in conglomerates of the Biely Potok Beds, Upper Priabonian - Lower Oligocene; Brezovica, Orava. Enlarged 11×, crossed nicols. **E** - Roc Tourné twins in crystalline limestone from the basement of an anhydrite body in the Permian Meliata Unit; Rožňava, borehole G-1/2, 255 m. Enlarged 430×. **F** - As above. Weakly metamorphosed limestone, probably Devonian of the Harmónia Group. Pebble from the Karpatian Jablonica conglomerates; Hradište pod Vrátnom. Enlarged 95×, crossed nicols. *Photo.: L. Osvald.*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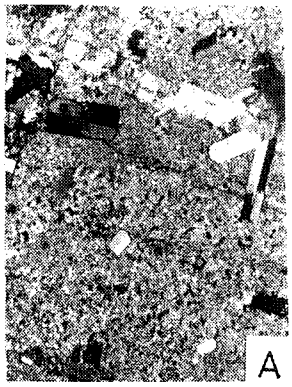
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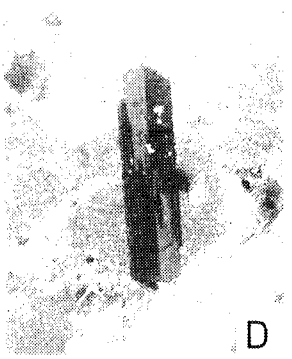
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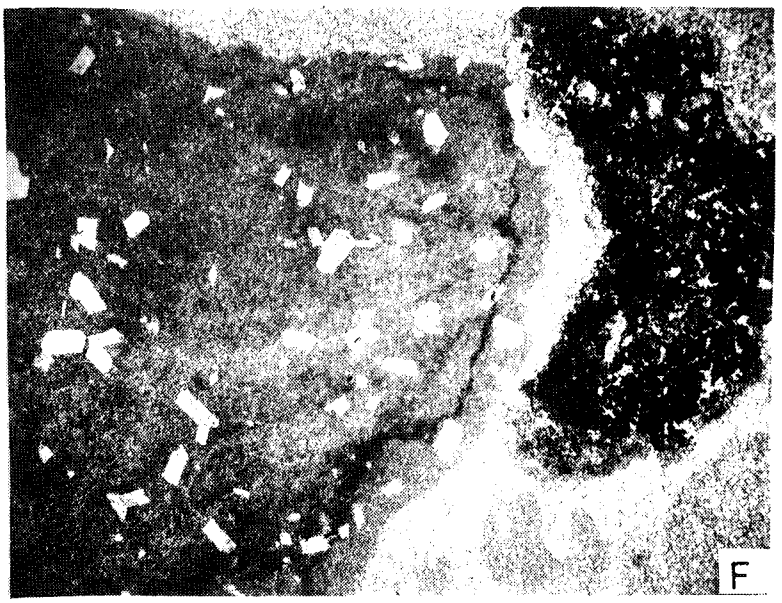
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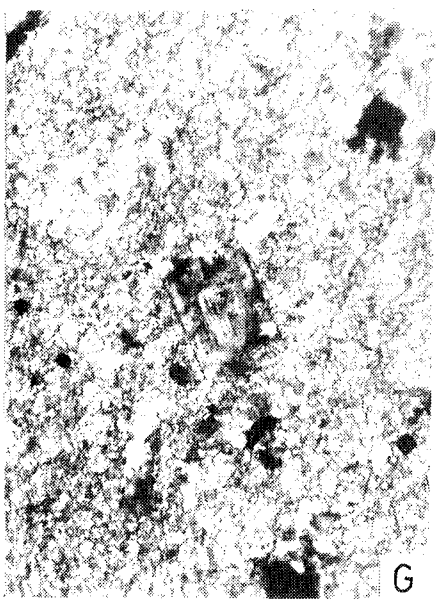
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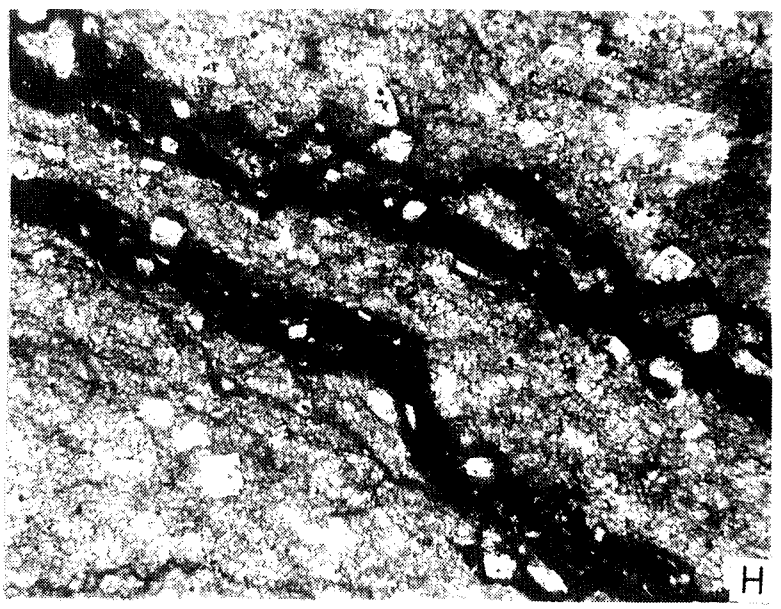
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Table 1: Frequency of the authigenic feldspars in the sections.

Jurassic limestones of the Klippen Belt (Czorsztyn Unit)	Jurassic limestones of the Central Western Carpathians (Veľká Fatra and Nízke Tatry)	
	Donovaly Unit	Krížna Unit
1% (4/290)	29% (4/14)	8% (14/196)
Pebbles of Jurassic and Lower Cretaceous limestones in Albian-Senonian conglomerates of the Klippen Belt	Pebbles of Jurassic and Lower Cretaceous limestones in Albian conglomerates of the Central Western Carpathians	
0.5% (3/541)	22.2% (52/234)	
Barremian-Aptian limestones only	Barremian-Aptian limestones only	
0.7% (1/152)	26% (14/53)	
Dogger-Berriasian limestones of the Manín Unit from Butkov	Dogger-Berriasian limestones of the Krížna Nappe of the Malé Karpaty Mts.	
authigenic feldspars	authigenic feldspars	
0% (0/81)	5% (5/102)	
authigenic quartz	authigenic quartz	
2% (2/81)	57% (59/102)	

ure. Their number significantly increases with the beginning of anchimetamorphism.

Age relations to other diagenetic processes ("timing")

a - Dating against later pressure. Authigenic feldspars older than pressure reshaping of the rock was found in Liassic limestones of the Donovaly Succession (Tatricum). The agregates of authigenic feldspars were broken by the later pressures (Pl. IIIB). Therefore the authigenic feldspars in this Liassic rock originated before the Upper Cretaceous.

b - The creation of authigenic feldspars in the clasts of conglomerates (breccias) and not in the mother rock. This may be reliably proved in a case where authigenic feldspars from the matrix continued to grow in clasts (Pl. IIIC). We have indirect information about their origin within clastic rocks from Albian conglomerates of the Tatricum (Ludrová conglomerate of the Central Carpathians - M. Mišík et al. 1981). Pebbles of such rocks and facies, which contain occasional authigenic feldspars in other units, have a large amount of it in this conglomerate. That reflects the anchimetamorphosis of conglomerates of the Tatricum of the Malé Karpaty Mts., which is also confirmed here by conodonts from pebbles of Triassic limestones with a colour alteration index up to 3 - 4.

c - Age relationship to dolomitization. So far it could only be studied occasionally. Authigenic plagioclases younger than dolomite rhombohedra were found in partly dolomitized limestone (Pl. IIID).

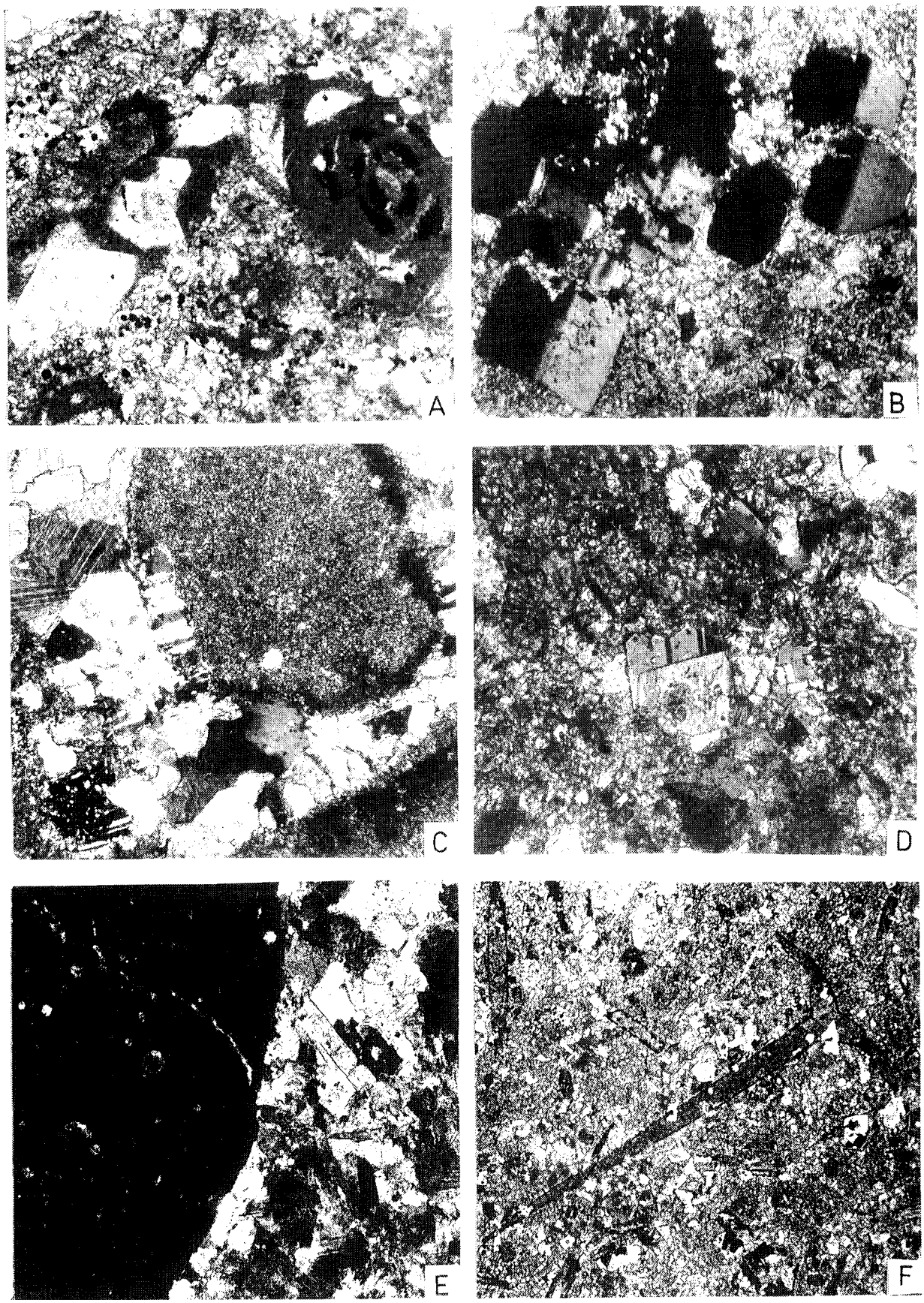
d - Dating against cracks. Calcite veins filling cracks are almost always younger than authigenic feldspar. So far we have observed authigenic feldspars in the calcite filling of a vein in only one case (Pl. IIIE).

Estimating temperature - pressure effects on units from the abundance of authigenic feldspar in limestones

Today there are various methods for comparing the intensity of diagenesis and the weakest stages of metamorphic effects, for example the reflectivity of vitrinite, CAI (index of colour changes of conodonts, palinomorphs, the crystallinity of illite, breakdown of smectites). If we limit the comparison of the temperature - pressure effects on two tectonic units to comparison of the same lithotypes (carbonate rocks of the same age and approximately the same composition), we can obtain supporting criteria with the help of the undemanding method of tracing authigenic feldspar.

Bausch and Poli (1976) already noted that the abundance of authigenic feldspars in limestones reflects the degree of tempera-

PLATE II: **A** - Authigenic albite in Roc Tourné twins in Triassic dolomite. Clast of Paleogene Gregorian breccia from the Klippen Belt; Litmanová. Enlarged 30×, crossed nicols. **B** - As above. Clast in fine-grained conglomerate of the Upper Campanian - Lower Maastrichtian. Basement of the Vienna Basin, borehole Smolinské-7, 1211 m. Enlarged 400×, crossed nicols. **C** - As above. Weakly metamorphosed Borinka limestone, Lias; Prepadlé, Malé Karpaty Mts. Enlarged 80×, crossed nicols. **D** - As above. Barremian - Aptian limestone. Pebble from Albian conglomerates of the Tatricum; Majdánske, Malé Karpaty Mts. Enlarged 80×, crossed nicols. **E** - Syntaxial overgrowth of authigenic feldspar with partial idiomorphic shape on a clastic core - a rounded grain of perthite. Crinoidal Lias limestone; klippe Lutý Potok, Orava. Enlarged 95×, crossed nicols. **F** - Authigenic feldspar in fine-grained carbonate breccia (Keuper), Norian of the Krížna Nappe; V. Lučivná, Malá Fatra Mts. Enlarged 43×. **G** - Authigenic K-feldspar, optically inhomogeneous, in dolomite with an admixture of anhydrite grains. Opponitz Formation (Carnian - Norian) Göller Nappe. Basement of the Vienna Basin, borehole Závod-91, 3730 m. Enlarged 185×, crossed nicols. **H** - Abundant idiomorphic K-feldspar. As above. Enlarged 95×. *Photo.: L. Osvald.*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ture - pressure effects on them to a significant degree. Authigenic albites are found in undissolved remnants in all profiles of the Upper Jurassic limestones of the Eastern Alps, while they are missing in the Upper Jurassic limestones of the adjacent platform. According to them, authigenic albite is an indicator of orogenesis (tectogenesis); its quantity and size reflected strong diagenesis to weak anchimetamorphism in the Alpine profiles.

Increased temperature increases solubility, and accelerates reactions. Increased pressure causes pressure dissolution, and significantly contributes to the mobilization of solutions. As a further development, we are trying to compare the degree of temperature-pressure effects on some Western Carpathian units from this point of view. Although the presence of evaporites (hypersaline facies) also has a favourable influence on the form of authigenic feldspar, we limit ourselves to formations in which these are not present: to the Jurassic and Cretaceous. In contrast to the previously mentioned authors, we did not trace insoluble residues, but only sets of thin sections from the given complexes, and recorded only the presence or absence of authigenic feldspar in a given thin section.

A striking difference in the frequency of authigenic feldspar is evident between the Jurassic of the core mountains (centralides) and the Klippen Belt (externides - Tab. 1). From the core mountains, authigenic feldspars were found in 8 % of 196 thin sections of Jurassic limestones of the Krížna Unit of the Veľká Fatra and Nízké Tatry Mts. (Mišík 1964). In the more affected Donovaly Succession of the Tatricum (weak anchimetamorphism) it was up to 29 %. The Jurassic of the Pieniny Klippen Belt was much less affected by temperature and pressure. Authigenic feldspars occurred in only 1 % from the 290 thin sections (4/290) of Middle Jurassic to Neocomian Czorsztyn Unit from the profiles of Vršatec, Kyjov, Babina, Krasin, Krivoklát and Bolešovská dolina Valley. In addition two cases of this were in the abnormal conditions of condensed sedimentation in hardground with Fe - Mn in Bolešovská dolina and Krivoklát.

We can note detailed differences between the Cretaceous conglomerates of the Klippen Belt in a broader sense and the Albian conglomerates of the Central Western Carpathians. Pebbles of Jurassic and Lower Cretaceous limestones from the "Upohlav" conglomerates of the Klippen and Peri-Klippen Belt (Mišík & Sýkora 1981) contained authigenic feldspar in 0.5 % of sections (3/541). In pebbles of the Jurassic and Lower Cretaceous from the Ludrová conglomerates of the Albian of the Tatricum and the Krížna Nappe (Mišík et al. 1981), there was authigenic feldspar in 22 % of section thin samples (52/234). If we limit ourselves to the Urgonian facies in a broader sense in the form of Barremian-Aptian limestones, we obtain 0.7 % (1/152) for conglomerates of the Klippen Belt, and 26 % (14/53) for conglomerates of the core mountains. The formation of authigenic feldspars and authigenic quartzes occurred to a decisive degree in Albian conglomerates. This was most marked in the Tatricum of the Nízke Tatry Mts., at the localities of Ludrová, where up to a third of thin sections contained authigenic feldspar.

From this point of view, we consider the Silica Unit to be the least affected by temperature and pressure effects. From 60 pebbles of shallow water Upper Jurassic limestones, derived from the Silica Unit (Mišík & Sýkora 1980), to conglomerates of the Senonian and Egerian, authigenic feldspar did not occur even once. I know a single case of authigenic feldspar from the Jurassic of this unit, from the Liassic Fleckenmergel facies of the Muránska Planina, where abundant small authigenic feldspars penetrate silicisponge spicules filled by calcite (Pl. 3F). Among 96 sections of Lower and Upper Jurassic limestones (Barmstein limestone) of the Čachtické Karpaty Mts., probably also belonging to the Silicicum, authigenic feldspar was not found even once, although terrigenous admixture as a possible source, was present in them.

Comparison may give a useful indication for the assignment of questionable units. The Manín Unit is considered to be either a part of the Krížna Nappe (Maheľ 1978 and others), or a unit deposited in a separate zone on the external margin of the Tatricum, which, from the Upper Cretaceous, had a common history with the Klippen and Peri-Klippen Belt. We see from the published detailed profiles of the Middle Jurassic to Berriasian Manín Unit from Butkov and the Krížna Nappe of the Malé Karpaty Mts. (Borza & Michalík 1984), that authigenic feldspars are completely absent in sections from the Manín Unit (0/81), but in the Krížna Unit they occurred in 5 % of sections (5/102). There is an even more marked difference in the presence of authigenic quartz - 2/81 in the Manín, and 59/102 in the Krížna Unit. It may be concluded from this that, as a result of the very weak temperature-pressure effect, the Manín Unit shows an affinity to the Klippen Belt.

The Haligovce Unit is also controversial. Birkenmajer (1977, p. 15; 1985, p. 104) places the Haligovce sedimentation zone in the neighbourhood of the Kysuce (Branisko) sedimentation zone, that is outside the so-called exotic ridge. Slovak geologists place it in sedimentational closeness to the Tatricum Vysoké Tatry Unit. The Haligovce Unit is notable for the presence of abundant authigenic feldspars, which are also still found in Paleocene limestones (Pl. IIIA), which are in contact with the Haligovce klippen. At the nearby locality of Lesnica, are pebbles of Rhaetian and Liassic limestones with abundant and quite large authigenic feldspars (Mišík et al. 1991a, p. 62). The degree of temperature - pressure effects shows that it belongs to the Paleogene of the Šambron zone, which was intensively affected by heat and pressure, in contrast to the neighbouring Klippen Belt. Authigenic quartz replacing nummulites and coralline algae in pebbles of the redeposited Paleogene also point to this (Mišík in Marschalko et al. 1976, Tab. XXXIX).

It is noteworthy that Grecula et al. (1981) expressed the view that the Šambron zone is not part of the Central Carpathian Paleogene, but forms a continuation of the Kričevo Unit. The observation we mentioned sheds a new light on the proof of post-Eocene metamorphism in the complex of the Iňačovce - Kričevo Unit, drilled into, below the Neogene of the Eastern Slovak Basin (Soták et al. 1993).

PLATE III: **A** - Authigenic feldspar (albite) in biodetritic limestone of the Paleocene, overlying the Haligovce klippe, elevation point 844.3 at Ježovka. Enlarged 120×. **B** - Authigenic feldspar in Lias limestone cracked during orogenic pressures in the Upper Cretaceous. Tatricum of the Donovaly Succession; Sliačany, Nízke Tatry Mts. Enlarged 210×, crossed nicols. **C** - Authigenic plagioclases formed in coarse grained carbonate sandstone (growing from the matrix into a clast), probably Albian, Tatricum of the Malé Karpaty. Pebble from the Karpatian Jablonica conglomerates; Prievaly. Enlarged 95×, crossed nicols. **D** - Authigenic plagioclase growing on a dolomite rhombohedron (the origin of the authigenic feldspar is later than the late diagenetic dolomitization of the Triassic limestone). Pebble from the Cretaceous "Upohlav" conglomerate of the Klape Unit; Nosice. Enlarged 136×. **E** - Authigenic albite in a calcite veinlet (filling a fissure) in radiolarian limestone (biomicrite) of the Manín Unit; Butkov klippe, Ladce, gallery LC-O-6, 65 m. Enlarged 23×, crossed nicols. **F** - Small crystals of authigenic albite penetrating the calcite filling of a silicisponge spicule. Liassic marly limestone of the Silicicum; Muránska Planina. Enlarged 43×. *Photo.: L. Osvald.*

Mesozoic limestones from pebbles of the Šambron conglomerates contain frequent authigenic feldspar, in contrast to pebbles of similar rocks in Paleogene conglomerates of the neighbouring Klippen Belt (Proč conglomerates, Mišík et al. 1991b, p. 62 - authigenic feldspar in 2 % of sections 7/328) and the Magura zone (Strihovce conglomerates, Mišík et al. 1991a, p. 51, without the presence of authigenic feldspar 0/157). However it is possible to assume that part of the authigenic feldspars in pebbles of the Šambron conglomerates originated already in the mother rocks, as dynamo-metamorphosed Mesozoic pebbles also occur in these conglomerates (Mišík in Marschalko et al. 1976).

The occurrence of appropriate phosphate rocks in the transgressive Albian, which are completely unknown in the Klippen Belt, also testifies to the sedimentary proximity of the Haligovce Unit to the Vysoké Tatry Unit.

Authigenic feldspar also appears to be suitable for comparing the degree of weak metamorphism of partial units of the Tatricum (and Penninicum?) of the Malé Karpaty Mts. The Borinka Unit is the richest in authigenic feldspar and the most intensively affected (Pl.IIC). Authigenic feldspars also occur in the Devín Unit (Turan & Vavro 1970). However they are rare in the Jurassic of the Kuchyňa Unit (Michalík et al. 1993) and absent in the Kadlubek Unit (Turan & Vavro 1970).

Authigenic feldspars are surprisingly rare in Triassic carbonate rocks of the Upper Eastern Alpine nappes, drilled into below the Neogene of the Slovak part of the Vienna Basin at depths of 4 - 5 km. However the Vienna Basin is a "cold" basin. Heat did not play the main role in the formation of the authigenic feldspars (Pl. IIG, H), but a favourable chemical composition of the solutions arising partly from evaporite formations.

Conclusions

Authigenic feldspars are formed in carbonate rocks tens of millions of years after their deposition. Their abundance is related to the temperature - pressure effects, to which the given formation was subjected. We attempted to compare the degree of effects by tracing the frequency of authigenic feldspars in groups of sections. Although the presence of hypersaline facies also favourably influences the formation of authigenic feldspars, we limited ourselves to the Jurassic and Lower Cretaceous, in which these are not present in the Western Carpathians.

The Czorsztyn Unit of the Pieniny Klippen Belt has a strikingly low frequency of authigenic feldspars in comparison with the Tatricum and the Krížna Nappe of the core mountains. The Tatricum, for example the Donovaly Succession is much more strongly affected than the Krížna Nappe. The Jurassic of the Silica Unit had the lowest level of affects of all.

There is also a very much lower representation of authigenic feldspars in limestone pebbles of the Jurassic and Lower Cretaceous in conglomerates of the Albian to Senonian of the Klippen and Peri-Klippen Belts, compared to Albian conglomerates of the Tatricum. A significant part of the feldspars in them was formed in the conglomerate itself during the Alpine anchimetamorphosis.

In the content of authigenic feldspars and quartzes, the Manín Unit, with a controversial position, shows a much greater affinity to the Klippen Belt, than to the Krížna Unit. The Haligovce Unit, placed by Birkenmajer (1977, 1985), in sedimentary proximity to the Kysuca zone, is connected to the Tatricum, according to its content of authigenic feldspars. A Paleocene limestone (block?), which is in contact with the Haligovce klippe, contains the youngest authigenic feldspars in the Western Carpathians. We consider that it belongs to the Šambron zone. This agrees with the view that the Šambron Unit significantly differs from the Central Carpathian Paleogene, and is connected with the Iňačovce - Kričevo zone (Grecula et al. 1981), in which post-Eocene metamorphism was shown (Soták et al. 1981). The temperature - pressure alteration of the Šambron zone may be considered as a periferal expression of this post-Eocene metamorphism.

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