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AUTHIGENIC QUARTZ AND AUTHIGENIC FELDSPARS IN MESOZOIC LIMESTONES OF WEST CARPATHIANS

(Pl. IX—XI)

Abstract. New sedimentological investigations show, that the authigenic quartz represents a current constituent of the Carpathian limestones. It was found in the limestones of the Lower, Middle Triassic, Keuper, Rhaet, Lias and Tithonian-Aptian. As very frequent appears also the authigenic feldspars — albite and orthoclase and rarely oligoclase.

Authigenic quartz and feldspars in carbonate rocks of West Carpathians were not yet studied. Therefore, I wish in this contribution to give a principal information to their occurrences and to discuss some questions with which the geologists all over the world intensively deal.

The authigenic quartz represents a current constituent of the Carpathian limestones; we may say, that limestones without authigenic quartz are very rare. Up to present by orientation analysis I have found the authigenic idiomorphic quartz in these stratigraphical units: Lower and Middle Triassic, Keuper, Rhaet, Lias and Tithonian-Aptian. From the Muráň limestone of the Hight Tatra it was recorded by K. Borza (1957). In almost all cases these limestones are in a shallow-water facies (littoral and shallow neritic). In that of more deep-water character SiO_2 is mostly in the form of chalcedony dispersed in rock or concentrated in cherty concretions. Although they content aggregates of well separated quartz grains, from their occurrences is almost always clear, that they originated by dehydration of chalcedony, while the authigenic quartz of formerly mentioned shallow-water limestones originated mainly without a chalcedony stage. These differences are probably due to those in structures of rocks and sources. In the case of the shallow-water limestones the source of migratory SiO_2 is in the clastic admixture of quartz. Migration of the last is facilitated by heterogenous structures and absence of clayey substance. In the deep-water limestones the source of SiO_2 is represented mainly by Radiolarias and Sponge spiculae and material is of opal-chalcedony character; for these limestones is characteristic certain clayey-marly admixture and homogenous structures.

The idea about an extensive migration of SiO_2 in non marly shallow-water limestones is in accordance with experimental curves of solubility of SiO_2 (Okamoto-Okuro-Goto, 1957, N. M. Strachov, 1960, p. 278). Solutions migrating within the limestones have apparently the alkaline character. Due to this alkalinity (mainly when pH is 10) increases solubility of SiO_2 in contrast to $CaCO_3$; also in neutral environment solubility of SiO_2 under condi-

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tion of diagenesis increases with temperature in contrast to decrease of solubility of $CaCO_3$. The authigenic quartz originates by segregation probably already in consequence of small, resp. local decrease of pH. Slowness of these processes, which is a cause of unsaturation of waters in sedimentary basins by SiO_2, does not represent an obstacle of diagenetic processes.

I have studied the presence of the authigenic quartz in some hundreds of slides from numerous types of the Liassic limestones of Veľká Fatra. They occur currently in oolitic and fine lumachellous limestones (almost 75—90 per cent of studied samples of this type) and very frequent are idiomorphic grains. In relatively deeper facies: spotted marly limestones („Fleckenmergel") and Adnet limestones they occur only in 15, resp. 35 per cent of examined slides. They are never idiomorphic. Probably it is due to retarding influence of clayey (marly) admixture.

In the core mountains of Carpathians we may distinguish mantle series and these units: Križná and Choč ones, which lay usually in overthrust position on the mantle series. These mantle series in the majority of mountains are frequently dynamically affected, which emphasized their connection with crystalline core, with „substratum construction". If we compare the stratigraphical and lithological units, it is clear, that the absolute amount of the authigenic quartz and feldspars, as well as maximum size of crystals, is apparently larger in dynamically affected series than for instance in the Križná unit. The dynamic affects represent a catalyzer of the origin of authigenic minerals and mobility of solutions. There are interrelations between intensity of dynamometamorphosis or progressive epimetamorphosis and amount of authigenic minerals (compare for instance with M. Topkaya, 1950, p. 86—88). These interrelations are not rectilinear due to other factors, as well as textures and original material of rocks.

In conclusion, an amount and character of authigenic minerals are in close connection with:

1. presence of matrix minerals with possibility of their transmission into solutions (geochemical conditions of environment),
2. structural-textural features, degree of permeability for solutions, degree of homogenity, porosity, presence of materials retarding migration,
3. factor of duration and intensity of processes (geological age, diagenesis under various geotectonic conditions, dynamometamorphosis, beginning epimetamorphosis and others).

Further I shall briefly describe the modes of occurrences of the authigenic quartz in the Carpathian limestones.

1. Idiomorphic crystals.

a) The most current are grains of quartz in the form of small hemiidiomorphic crystals with size less than 0,1 mm, occurring in grey cryptocrystalline calcitic aggregates, such as are for instance muddy matrix, pseudooolites and cyanophytic nodes (Pl. IX, Fig. 1). In general, they are missing in portions composed of clearly grained calcite (cement of calcarenites and oolites with well preserved structure).

b) To some degree less frequent are bigger, well developed crystals of quartz reaching 0,3—0,5 mm in length. In some slides there were very frequent strongly elongated to needle-shaped individuals, or almost izodiametrical ones. Different habitus was probably caused by differences in concentration of solutions. From less concentrated solutions originate more elongated crystals (J. K o n t a, 1954).

In dynamically affected limestones originate frequently aggregates of crystals. Calcitic inclusions overfill mainly the central portions of grains. Scarcely we may see their arrangement into growth lines (see for instance J. P e t r á n e k, E. Š t e n g l o v á, 1953, K. Ł y d k a, 1956). This phenomenon is very frequent and distinct in anhydritic rocks of the Werfenian of Spišsko-Gemerské rudohorie, deposit of Biela Voda (M. M i š í k, 1962, Pl. 17) with distinct rhythmicity of growth of the authigenic quartz.

c) Optically identical growth up to the sandy grains in limestones. This phenomenon is very rare. We may see it for instance in the Lower Lias in the Gresten facies. More frequently we may see growth up of the quartz clastic grains from the core of oolite to the detriment of concentrical covers. Such processes were described by L. C. H e n b e s t, 1945.

Figured example of our Rhaetian oolitic limestones (Pl. IX, Fig. 3), shows that growth of crystals took place (passed) for a long time. For a short time it was stopped by an origin of microstylolith (the straight contact line on the plain of crystal) and in the upper portion continued its growth also after an origin of the stylolith, till it was retarded by its impermeabile membrane. As further relative time datum may serve phenomenon that authigenic quartz in general does not occur in calcitic veinlets of mesozoic limestones, the fracturing of which is due to an effect of the alpine orogenesis. Up to present the only exclusions are veinlets in the Pajštún Liassic limestones containing the quartz crystal to 2 cm in lenght, without clear genesis. Authigenic idiomorphic quartz sometimes overlap the outer margin of oolites. However, an arrangement of inclusions shows the relict concentrical structure („ghostlike residue of oolitic texture", A. C a r o z z i, 1960, p. 257).

2. Selective metasomatism of oolites. In the Liassic oolitic limestones of the mantle series of Small Tatra near Donovaly I found a special mode of silicification of calcitic oolites. The authigenic quartz selectively displaced laminae of oolites in the form of 1—3 optical individuals (Pl. X, Fig. 1). We may see that the quartz penetrated into oolites along radial cracks. Oolites have usually calcitic cores unaffected by silicification, as well as matrix between oolites. In less frequent cases this phenomenon is connected with growth up of core, which has then identical orientation with some of crystals of the authigenic quartz from lamina. As far as I know, this form of complete silicification of oolites up to present was not described (to some degree similar case was described by V. N. C h o l o d o v, 1960). In other described cases displacing mineral was chalcedony (P. W. C h o q u e t t e, 1955, L. V a l e n s i, 1954, A. K. W e l l s, 1947, all see in A. C a r o z z i, 1960; P. D. K r y n i n e and coll., 1941, P. J. P e t t i j o h n, 1949, p. 328, F. F e d j u k, 1956 and K. Ł y d k a, 1956b).

3. Displacement of organic remains. Organic remains are well known as retainer of migrating solutions of SiO_2 (for instance by chalcedony silicified Echinids and other macrofossils from the Rügen chalk or cases described by W. W e t z e l, 1957). For Carpathian limestones the concentration of SiO_2 solutions into fragments of organisms is very typical. Frequently the solutions selectively metasomate the fragments of certain animal groups (for instance Brachiopods) and do not metasomate other organic remains. Even in one type of shell certain lamelles are being selectively displaced by SiO_2, for instance

nacreous lamelles in Lamellibranchiats. We may here quite clearly distinguish displacement by colloidal solutions (chalcedony with imperceptible amount of quartz originated clearly by dehydration processes) and by true solutions from which crystallized the authigenic quartz without the chalcedony stage. We shall not deal here with the first case, which is among others connected with a wider question of the origin of cherty concretions, as well as in the mentioned part; we shall deal only with the second case. Very frequent is mainly displacement of Foraminifera by the authigenic quartz. Shells of the species of the genera Nodosaria, and Lenticulina are sometimes very completely pseudometamorphosed by the only one optical individual, while the filling of chambers and surrounding mass is unaffected by silicification. In one of slides from the Middle Triassic limestone with plain of 16 cm^2 were for instance displaced all 8 shells of Foraminifera, while in surrounding rock were no traces of SiO_2. The shells of Foraminifera serve here as obstacles and „retainers" of siliceous solutions. Similar case we may see sometimes on the shells of Ostracoda and Lamellibranchiata of Posidonia type with thin shells.

Authigenic feldspars. The first brief note on the West Carpathian feldspars we may find in the paper of J. Koutek (1931, p. 47), who found the authigenic albite in the Upper Werfenian limestones of Small Tatra. By orientation analyses I found the authigenic feldspars in the rocks of Werfenian, Keuper, Lias and Lower Cretaceous (the Muráň limestone of Hight Tatra); we may suppose that the systematical study will show them as very frequent. Up to present were identified albite and orthoclase as very frequent and oligoclase as rare. The growth up to the clastic cores I did not observe. Except for the Werfenian in all cases the limestones carry no traces of dolimitization. From 200 slides of Liassic limestones of Hight Tatra the authigenic feldspars were in 8 per cent of slides.

Authigenic character of feldspars I might proved by almost all known criteria:

1. small inclusions of calcite, especially frequent in central portions of grains (Pl. XI, Fig. 1, 2),
2. idiomorphic shape,
3. destruction of older structural elements (incision of pseudooolites, oolites and crinoidal internodes), (Pl. XI, Fig. 2),
4. presence of feldspar aggregates,
5. quantitative prevailing of feldspars over quartz in some rocks,
6. compound crystall by Roc-Tourné rule (Pl. XI, Fig. 3), up to present known only from the authigenic feldspars of the sedimentary rocks (H. Füchtbauer, 1950, J. Baskin, 1956, A. G. Kossovskaja—V. D. Šutov, 1957, J. Emberger, 1960). Criteria, based upon chemical purity of the authigenic feldspars (mainly an amount of Na_2O in potassium feldspars and CaO in natrium ones) I had not an opportunity to verificate; however, it is very probable that due to many inclusions result of such study could not be reliable.

Up to present is not solved a question whether the authigenic feldspars have different optical features than feldspars from eruptives (H. Füchtbauer, 1950, A. G. Kossovskaja—V. D. Šutov, 1957), or identical (J. Baskin, 1956). In accordance with H. Füchtbauer the angle of optical axes has to be more that 10 degrees in the authigenic albites and in the authigenic orthoclases lesser than 20 degrees in comparison with mean values in feldspars of intrusives. After J. Baskin (1956) there are no differences. Some orientation measurements in my material show rather the second possibility (I have to express my thanks to M. Šímová for a help during these measurements).

Orthoclase from the Muráň limestone (Lower Cretaceous of Hight Tatra): 2V (xx) = 62°; 63°.

Orthoclase from Liassic limestones of the mantle series near Donovaly: 2V (xx) = 63°; 63°; 62°.

Albite from the gypsum-carbonate rock of the Werfenian of Spišsko-Gemerské rudohorie (Rožňava): 2V (xx) = 78°.

The study of slides shows, that the origin of the authigenic feldspars took place in stabilizated rock. In isolated case on the Pl. IX, Fig. 2 we may see, that the last dynamometamorphic affection of rocks of the mantle series was younger that the origin of feldspars, which were during the last movements fractured and their fragments shifted to one another. The feldspars originated during the interval Lias — Upper Cretaceous. Sources of material of the authigenic feldspars we have to look up in the clastic admixture of limestones (mainly the clayey minerals, lesser the clastic feldspars). In any of the studied sequences is not known the tuffaceous admixture or hydrothermic affection of rocks. All occurrences are from the marine sediments, only those from the Keuper are from lagoonary to lacustrine environment; from the continental sediments the authigenic feldspars were not recorded.

Besides others there are some terminological questions. In the cases where the authigenic quartz exceeded 5 per cent of volume the rock may be named as siliceous limestone (M. Mišík, 1959). As far as the authigenic feldspars do not exceed in the studied rocks value of accessory constituent (less than 5 per cent), I do not use the names such as are: albitized limestone, resp. feldspatized limestone. More abundant were the authigenic feldspars only in the gypsum-anhydritic deposit Rožňava (bore hole G 1/2) in the Werfenian of Spišsko-Gemerské rudohorie (M. Mišík, 1962). For instance in the depth of 177 m there was an intercalation of the gypsum-carbonate rock with abundant authigenic feldspars, quartz and tourmaline; at the base of the deposit (225 m) there was recrystallized limestone with abundant feldspars and quartz. A frequent presence of the authigenic feldspars in the carbonate intercalations of the anhydrite-gypsum deposits explains M. Topkaya (1950) by action of infiltrating sulphatic solutions. However, the tendency of these rocks to recrystallization and unstable stress conditions have a great role.

REFERENCES

Baskin Y., 1956: A study of authigenic feldspars. Journ. of Geol. 64, 2. — Borza K., 1957: Bemerkungen über den Muráň-Kalk. Geol. sbor. SAV 8, 1, Bratislava. — Carozzi A., 1960: Microscopic sedimentary petrography, New York. — Emberger J., 1960: Esquisse géologique de la partie orientale des Monts des Ouland Nail. Théses. Univ. d'Alger 9, 1—385. — Fediuk F., 1956: Křemitá oolitická hornina v podkrkonošském permokarbonu. Časopis pro min. a geol. 1, 3. — Füchtbauer H., 1950: Die nichtkarbonatischen Bestandteile des Göttinger Muschelkalkes mit besonderer Berücksichtigung der Mineralneubildungen. Heidelberger Beiträge zur Min. u. Petr. 2, 3. — Henbest L. G., 1945: Unusual nuclei in oölites from the Morrow group near Fayttevilem. Arkansas. Journ. of Sedim. Petrol. 15, 1. — Cholodov V.

N., 1960: O nekotorych kriterijach pervičnosti ili vtoričnosti bitumov. Izv. AN SSSR, ser. geol. 4. — K o n t a J., 1954: Příspěvek k poznání genese cínoveckých záhněd. Rozpr. Českosl. ak. vied. 64, 4, Praha. — K o s s o v s k a j a A. G., Š u t o v V. D., 1957: Autigennyje polevyje špaty. Metody izučenija osadoč. porod, Moskva. — K o u t e k J., 1931: Geologické studie na severozápadě Nízkych Tater. Sbor. Stát. geol. ústavu 9, Praha. — K r y n i n P. D., H o n e s s A. P., and M y e r s W. M., 1941: Siliceous oolites and chemical sedimentation. Bull. pf. Geol. Soc. Amer. 52, — Ł y d k a K., 1956a: O występowanie kwarcu autogenicznego w wapieniach wóźnickych. Archiwum Mineralogiczne 19, 2. — Ł y d k a K., 1956b: Oolityczna skala krzemionkowa z permu Gór Kaczawskich. Archiwum Mineralogiczne 19, 2. — M i š í k M., 1959: Entwurf einer einheitlichen Klassifikation und Terminologie von gemischten karbonatischen Gesteine. Geol. práce, Zprávy 16, Bratislava. — M i š í k M., 1962: Príspevok k petrografii sádrovcovo-anhydritových hornín verfénu gemeríd. Geol. sbor. SAV 8, 1, Bratislava. — P e t r á n e k J., Š t e n g l o v á E., 1953: Authigenic quartz in the Devonian. Sbor. Ústř. ústavu geol. 20, Praha. — P e t t i j o h n F. J., 1949: Sedimentary rocks, New York. — P u s t o v a l o v L. V., 1956: V vtoričnych polevych špatach v osadočnych porodach. „O vtoričnych izmenenijach osadočnych porod." Trudy Geol. inst. AN SSSR, 5. — S t r a c h o v N. M., 1960: Osnovy teorii litogeneza II, Zakonomernosti sostava i razmeščenija gumidnych otloženij, Moskva. — T o p k a y a M., 1950: Recherches sur les silicates authigénes dans les roches sédimentaires. Université de Lausanne. — W e t z e l W., 1957: Selektive Verkieselung. Neues Jahrb. Geol. u. Pal. Abhandl. 105, 1.

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Explanations of the Pls. IX—XI

Pl. IX

Fig. 1. Abundant authigenic, partly idiomorphic quartz in oolitic limestone, apparently in connection with microcrystalline calcite. In right upper portion of picture is oomikrite (calcareous mud between oolites), in left lower portion of picture is oosparite (calcareous mud between oolites was outwashed by currents and wawes; in pores secondary crystallized rather coarse-grained calcite). Lias of the Križná unit, locality hill Kochľa, Small Tatra. ×29. — Fig. 2. Authigenic feldspars in carbonate rock with microcrystalline structure. Keuper (Upper Trias) of the Križná unit, locality valley of Veľká Lučivná; Small Fatra. ×43. — Fig. 3. Authigenic idiomorphic quartz grown up to the clastic quartz of the core of oolite. The oolite was later cut by microstylolite, which is in contact with the authigenic quartz along straight plain. The quartz in the upper portion still grew also afer an origin of microstylolite. Rhaet of the Križná unit, locality Rybná valley near Rajec. ×130. Photo L. O s v a l d.

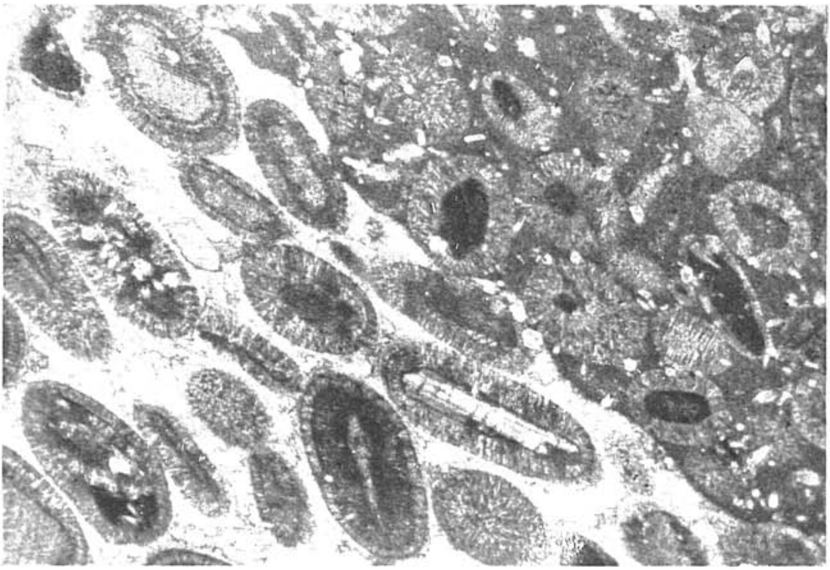
Pl. X

Fig. 1. Special mode of metasomatism of oolites by the authigenic quartz. Lias of the mantle series of Small Tatra; locality Sliačany near Donovaly. ×55, crossed nicols. — Fig. 2. Authigenic feldspar affected by younger stresses. The picture shows fracturing and replacement of fragments in limestone. Lias of the mantle series of Small Tatra; locality Sliačany near Donovaly. ×210, crossed nicols. Photo L. O s v a l d.

Pl. XI

Fig. 1. Authigenic plagioclase in the Muráň limestone (Lower Cretaceous of the Križná unit), locality Jatky, Belanské Tatry. ×135, crossed nicols. — Fig. 2. Authigenic feldspar intersecting crinoidal internode. Liassic limestone of the mantle series of Small Tatra, locality Hánesy near Donovaly. ×43, crossed nicols. — Fig. 3. Authigenic albite, compound crystals by Roc-Tourné rule (combined albite and Carlsbad compound crystals). Werfen limestone from below of gypsum sequence, locality Rožňava (G-1/2 255 m), Spišsko-Gemerské rudohorie. ×430, crossed nicols. — Fig. 4. Authigenic idiomorphic quartz with inclusions with relicts of zonal structure of oolite. Lias of the Križná unit, locality Iľanovská dolina, Small Tatra, ×130. Photo L. O s v a l d.

Translated by V. S c h e i b n e r o v á.



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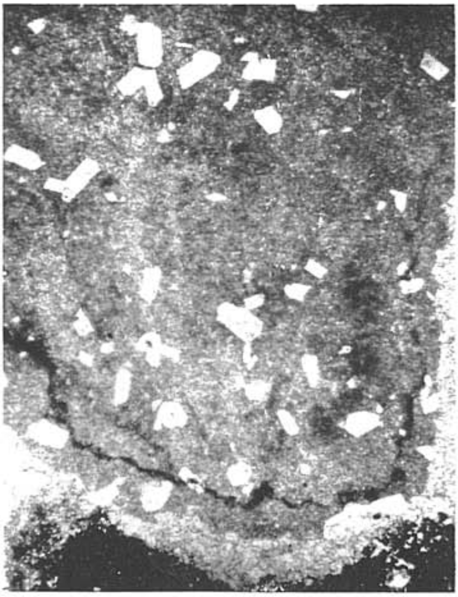

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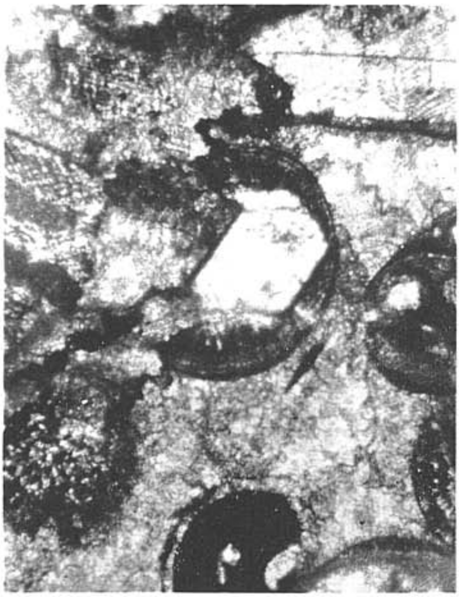

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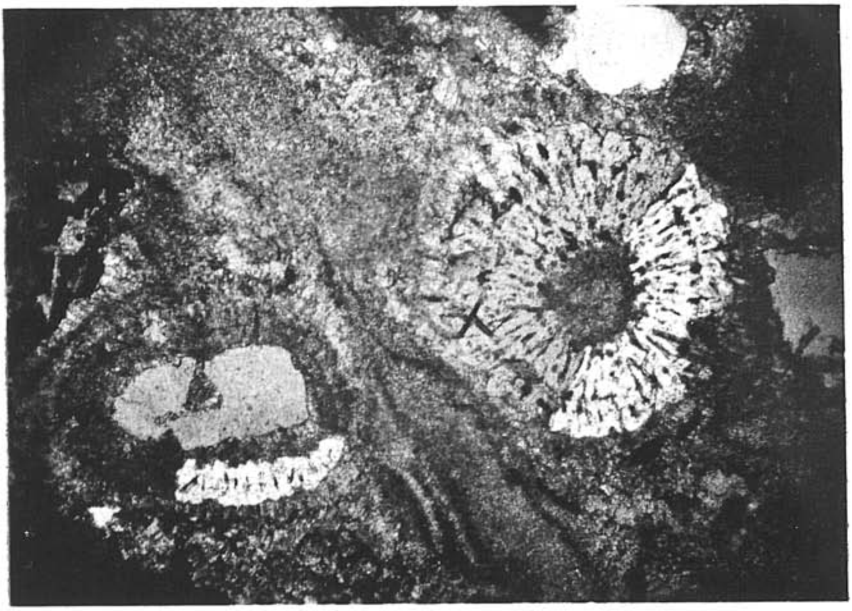

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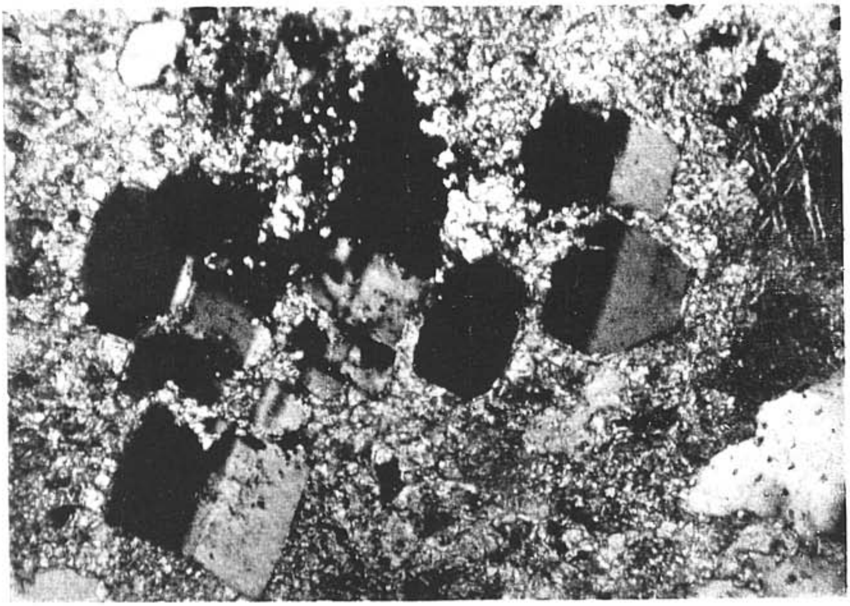

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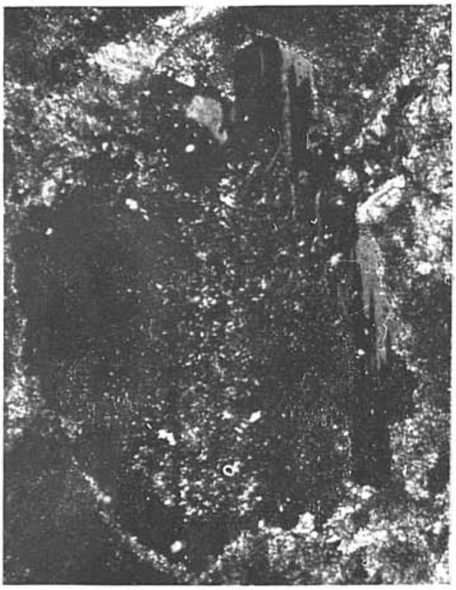

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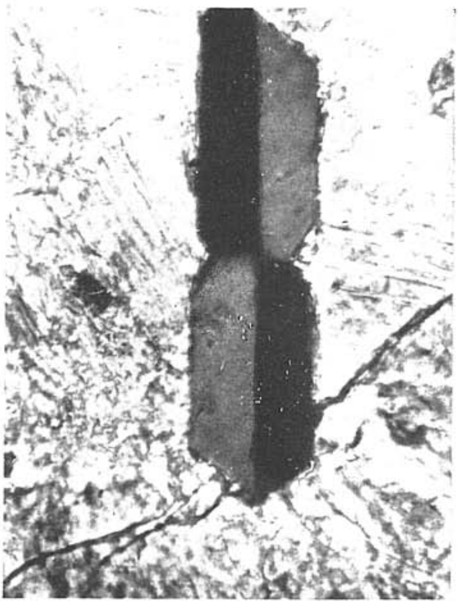

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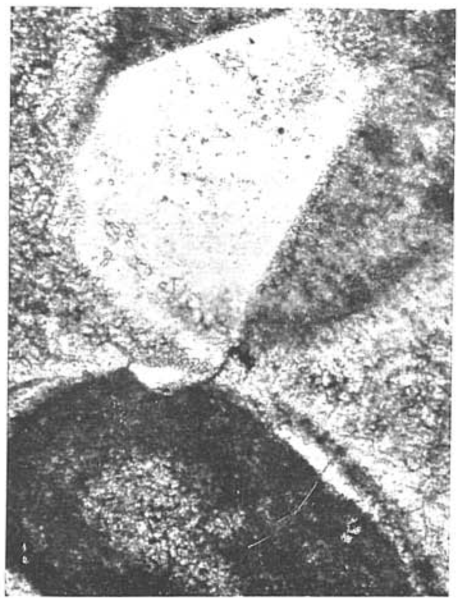

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