

MILAN MIŠÍK*

TENTATIVE MICROSCOPICAL CLASSIFICATION OF VEINLETS
IN LIMESTONES(based on the Tithonian and Neocomian Limestones of the Manín Group of the
West Carpathians)

(Plates XVII—XX, Textfig. 1)

Abstract: In pelagic limestones of the Tithonian and Neocomian of the Tethys geosyncline was studied a filling of veinlets to make clear a sense and speed of movements of individual rock blocks. The author has studied the age relationships of veinlets and phases of the tectonic strain and diagenetic processes. Besides the veinlets originated as a filling of cracks there are described two special types of veinlets: dashed veinlets originated by recrystallization — fusion of minute stockworks and veinlets crossed by intact organic remains.

The main part of the material studied comes from the Tithonian and Neocomian marly limestones of the Manín Group of the Klippen Belt, namely from the Butkov Klippen (from the bore holes of the Geological Research Žilina) and outcrops in the Manín Narrows. As this pelagic facies, represented by the Tithonian and Neocomian marly limestones with tintinnids and nannocones („Biancône“), occupies large areas of the Tethys geosyncline (compare for instance G. Colom 1955) and has constant features, the characteristics of their veinlets given here will have probably much larger validity.

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Microscopical Description of the Tithonian and Neocomian Limestones

The uniform complex of the Tithonian—Neocomian limestones we can divide on the basis of microscopical criteria into the following stratigraphical horizons:

6. Nannoconus limestones without tintinnids — probably Hauterivian—Barremian;
5. Nannoconus limestones with individual specimens of *Tintinnopsella carpathica* — Valanginian—Hauterivian;
4. Nannoconus limestones with frequent *Tintinnopsella carpathica* and *Calpionellites darderi* — Valanginian;
3. Muddy limestone with *Tintinnopsella carpathica* and *Calpionella alpina* — Berriasian;
2. Muddy limestone with frequent *Calpionella alpina* — Uppermost Tithonian;
1. Muddy limestone with *Crassicolaria* and *Saccocoma* — Upper Tithonian.

The horizons 1—3 I shall describe as *Calpionella* limestones (Upper Jurassic) and 4—6 as Nannoconus limestones (Lower Cretaceous).

1. *Calpionella* Limestones — Tithonian

The distinct feature of the Upper Jurassic *Calpionella* limestones is that they do not contain cherts; while these are frequent in the overlying Neocomian limestones. In the samples of the

* Doc. Dr. M. Mišík CSc., Department of Geology of the Faculty of Natural Sciences of J. A. Comenius University, Bratislava, Gottwaldovo nám. 2.

Calpionella limestones mentioned there are no traces of chalcedony, but the calcified radiolarians are quite frequent (similarly in the Manin Narrows).

In the typical samples, *Calpionella alpina* Lorenz and less *Calpionella elliptica* Cadish are dominating. Upward appears *Tintinnopsella carpathica* (Murg. et Filip.), downward increases a number of *Crassicolaria intermedia* (Durand-Delga). Besides the tintinnids mentioned very frequent is an alga *Globochaete alpina* Lombard. It occurs in larger individuals than those in the Neocomian limestones and only in this horizon we can find linear aggregates and zoospores attached on longer filaments. The third constituents are calcified radiolarians. Sometimes they are so assimilated by the basal muddy mass that also their outlines are nearly invisible. Probably some pseudoolites correspond just to the calcified granulated radiolarians. Quite frequent is *Stomiosphaera minutissima* (Colom). From among foraminifers there occurs *Spirillina* sp. (as well as in the Neocomian), minute lagenid forms, rare agglutinated forms and individual fragments of echinodermal articles or aptychus. Downward there increases a number of brachialia of the planktonic crinoid *Saccocoma*. The basal muddy mass lacks nannocones, only upward in the Berriasian we can see them in association with *Tintinnopsella carpathica*.

From the mineralogical view, besides calcite they contain a certain clay admixture (about 10–15%). Further there occurs brown metacolloid and colloid mineral (index of refraction almost identical with k. b.) belonging probably to the authigenic clay mineral. It occurs only in veinlets, microstyloliths and smudges. The clastic quartz of the silt size is very rare (usually less than 0.03 mm, 1–3 grains in one thin section). Phosphatized organic fragments occur only individual. Pyrite is rare, either in the form of pigment or in epigenetic cubes, younger than the secondary calcite of veinlets. Description of the secondary calcite will be dealt with within the Neocomian limestones.

2. Nannoconus Limestones and Siliceous Limestones with Cherts — Neocomian

Distinct feature of this complex are horizons with black cherts. Intercalations of siliceous cherty limestones with frequent radiolarians filled up by chalcedony are well differentiated. In the Nannoconus limestones, there are no traces of chalcedony and the find of calcified radiolarians is but occasional. This sudden intercalation was confirmed on the samples collected after each 10 cm.

2a. Nannoconus Limestones

Nannoconus is typical rock-forming organism. Under greater magnifications we see that this organism builds almost whole mass of rocks (M. Mišik 1958). It belongs to Coccolithophorids. *Nannoconus steinmanni* Kamptner occurs in masses, rare larger forms (more than 20–30 microns) belong to the *Nannoconus bermudezi* Bronnimann species. Rounded sections with broad central cavity belong probably to *Nannoconus globulus* Bronnimann as longitudinal sections with broad central cavity are lacking. Up to the present we found no criteria for zonation after *Nannoconus*; a mode of their preservation seems to be insufficient.

A number of other microorganisms varies to a considerable degree, from the typical micrite structure up to the biomicrite structure. *Globochaete alpina* Lombard is quite frequent in some samples. Individuals are much smaller than those in the Tithonian (the same observation was made by D. Patrušius 1964). There occur also bipartite forms, however, the linear arrangement is lacking. Foraminifers are rare: *Spirillina* sp. predominates. Optically it represents a monocrystal and is often corroded by the basal mass. Less frequent is *Lenticulina*, *Nodosaria*, *Textularia* and other agglutinantia, also fragments of lagenids with coarser shells clearly representing the thannatocoenosis. In each thin section there are rare ostracods with individual fragments of echinodermal articles (corroded by the basal mass). Scarcely occur representatives of the *Stomiosphaera* and *Cadosina* genera. Rarely occur spines of sea urchins, aptychi, spicules of holothurians, calcified radiolarians and probably fish scales. In lower horizons (Valanginian) there occur always some specimens of *Tintinnopsella carpathica* (Murg. et Filip.), sometimes also *Calpionellites darderi* (Colom). In some thin sections was found *Tintinnopsella oblonga* (Cadisch) and *Tintinnopsella cadischiana* Colom. In upper parts (probably Hauterivian) we can find only individual sections of *Tintinnopsella carpathica* and in uppermost parts (Hauterivian–Barremian) the tintinnids disappear.

Besides calcite, the rock studied contains the clastic admixture of clay minerals, brown colloid-disperse authigenic, probably clay mineral; very rare are grains of the clastic quartz

of the silt size, individual grains of phosphate (probably phosphatized fish scales), rare chlorite leaves, glauconite grains and quite frequent pyrite in varying amount, mostly limonitized (mainly in the form of irregularly dispersed pigment, globular metacolloid aggregates, irregular grains and also cubes up to 0.2 mm). Succession of these minerals see in description of the calcite veinlets.

2b. Siliceous Radiolarian Limestone with Cherts

The common constituents are radiolarians, almost always filled up by chalcedony, usually fine-grained, rarely radial. From their periphery inward we find frequently projected aggregates of calcite crystals, also in radiolarians are distinct rhombohedra (SiO_2 colloid supports recrystallization of calcite). Part of radiolarians is calcified. *Spumellaria* predominate, *Nasellaria* are rare. Another constituent form spicules or sponges, usually thinner and almost always calcified. Sometimes we see silicified echinodermal articles, foraminifers and phosphatized fish scales. In the basal muddy calcite mass we cannot distinguish nannocones as they were probably disintegrated by recrystallization. Transitions into cherts are not sharp, the contour lines are diffusing. The basal mass of cherts is formed of chalcedony; radiolarians are almost invisible only in the form of lighter small rings; calcitic admixture is frequent.

Veinlets in the Tithonian and Neocomian Limestones

If we want to make a microscopical division of apparently chaotic tangle of veinlets in limestones is necessary to reduce the whole problem to some most simple cases. In thin sections of muddy limestones densely crossed by calcite veinlets we can select irregular polygons, portions of undisturbed rock limited on all sides by the calcite veinlets. Such polygons mostly less than 1 cm³ we can call as elementary blocks. Further, we shall deal with processes between such two elementary blocks along their contact plane (in projection — i. e. from the view of thin section — in their contact line). Results of these processes are calcite veinlets.

After forming of cracks (after individualization of elementary blocks) there are the following possibilities:

- a) mutual withdrawal of blocks, relaxation;
- b) mutual approach of blocks, compression.

By withdrawal of blocks there originates a crack which after filling by the secondary calcite represents the most common type of veinlets in limestones. We distinguish these possible cases:

- a₁) Rapid withdrawal of blocks and later filling of the crack. Calcite has a form of the coarse-grained aggregate from approximately isometrical grains (fig. 1, a₁).
- a₂) Slow withdrawal of blocks and almost contemporaneous secretion of calcite. The calcite filling is formed of prismatic to rodlike individuals perpendicular to the course of the crack asbestoslike calcite, (fig. 1, a₂).

b) Simultaneously with compression of blocks occurs also solution of limestone. The crack changes into the micostylolith (fig. 1, b).

Up to the present we took into consideration only cases in which did not act replacement of blocks to sides, i. e. they were microdiaclasses (fig. 1, 1, a₁-b).

c) If the cracks originated by replacement to sides, then the cracks we can mark as microparaclases. The results of such cracks are minute reverse faults, normal faults etc. If the movement was fast and the crack was filled later by calcite this calcite aggregate would be composed of almost isometrical grains (fig. 1, c₁). During contemporaneous filling up there originate the calcite fibres with oblique or broken course reflecting certain phases of this movement (fig. 1, c₂).

These simple processes may repeat in the same crack or combine by several modes, for instance:

d) after relaxation accompanied by fast withdrawal of elementary blocks the crack was filled up by calcite aggregate composed of isometrical grains. In further stage the blocks moved to the opposite direction (against themselves — compression) the result of which is that one or both of the margins of the veinlet acquired the microstylolitic character (fig. 1, d). This type of veinlets is frequently seen in the Tithonian—Neocomian limestones of the Bulkov Klippen; however, the microstylolith did not develop along the whole margin of the veinlet. Possibly in some cases compression manifests only by the tectonic twinning of calcite grains of the veinlet.

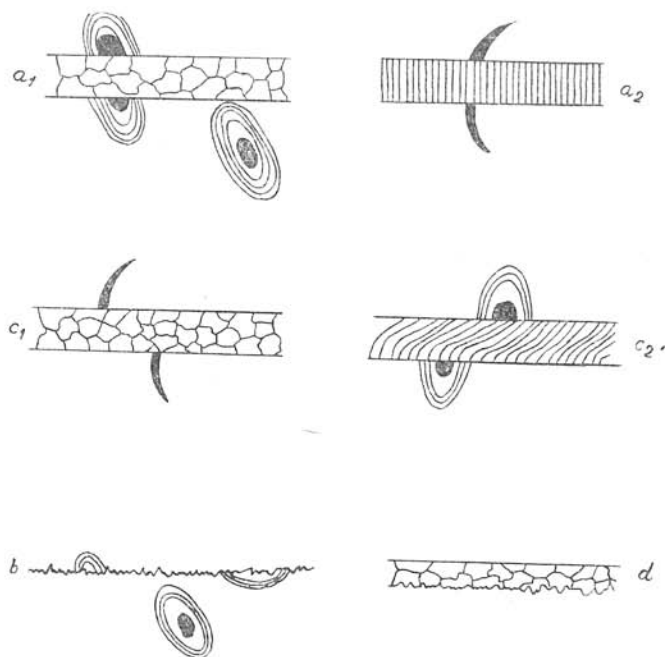


Fig. 1.

e) repeated origin of a crack at the same place (at the margin of calcite vein or directly in it) may lead to new removing, opening of the crack and its recover by new generation of calcite. Different age generations of the secondary calcite differ often by various granularity, colour, amount of dusty enclosures or presence/absence of the press twinning and undulose extinction. In the material studied, the older calcite was usually yellowish with numerous dusty enclosures and a younger calcite was much purer. Especially remarkable are cases in which the older generation is clearly twinned by compression but the younger one not (pl. XX, fig. 3). Here the course of events was the following: origin of crack, removing, filling up by the first generation of calcite, tectonic compression, reopening of the crack and filling up by the second generation of calcite. Repeated opening of cracks combined with lateral movement may lead to tearing out of rock fragments from the margin of the veinlet and to the origin of brecciated structure of veinlets (pl. XIX, fig. 3).

For the Tithonian—Neocomian are especially characteristic these special types of veinlets:

f) „dashed“ veinlets (pl. XVII, fig. 1). Calcite aggregate of veinlet contains enclosures in rows parallel to the margins of the veinlet. They are clearly remnants of muddy

marly limestone. These veinlets originated as seems by coalescence of very thin parallel veinlets densely arranged (pl. XVII, fig. 2), so that they fused themselves, assimilated the muddy mass between them by recrystallization and only parallel smudges remained. Sometimes part of the same grain (one optical individual) contains these characteristic enclosures and the second half of the grain is pure (pl. XVII, fig. 1). It shows a different degree of purification of mineral in repeated recrystallization and the origin of coarse-grained aggregate by grain growth. Dashed veinlets formed by recrystallization I found besides in the Tithonian and Neocomian of the Manín Group of the Klippen Belt also in the Neocomian of the Křižna Unit of the Small Fatra and Small Carpathians.

g) Veinlets crossed by intact organic remains, for instance an aptychus crossed without disturbance by calcite veinlet (pl. XVIII, fig. 1, 2), foraminifers (pl. XIX, fig. 1), fragments of lamellibranch shells, crinoidal articles; or organic remains only „penetrate“ into the calcite veinlet (echinodermal article — pl. XIX, fig. 2). This surprising phenomenon we can explain by two possibilities:

1. This veinlets originated by recrystallization and not a filling of the opened crack. Firstly originated the submacroscopic crack crossing also the organic fragment. Moisture in this submicroscopic crack caused recrystallization and assimilation of the surrounding muddy mass. As reach of recrystallization processes was in each point approximately the same, the result is the origin of calcite veinlet, in the case of the figured aptychus of about 0.14 mm in thickness, which does not disintegrate the crossed aptychus. However, this explanation has some disadvantages, namely that contours of the veinlet are quite sharper than one can suppose in the case of recrystallization of the muddy calcitic mass.

2. The second explanation is that these veinlets are the so called „atectonic veinlets“ forming already in hemiplastic deposit during compression, dehydration of the limy mud. In such case there have to originate the opened cracks which do not disintegrate the organic remains. In this mode of origin we could wait a partial peeling off of the organic remain and forming of the secondary calcite also on its periphery. It was seen the case that the calcite veinlet crossed the crinoidal article without disintegration of its optical homogeneity and internal structure, but in the place of the presupposed course of vein the crystal is purer, „cleaned“, which seemed to prove the first explanation mentioned.

The veinlets which did not disintegrate the organic remains were found besides the Tithonian and Neocomian of the Manín Group also on the Tithonian of the Křižna Unit of the Small Carpathians, in the Aptian of the Křižna Unit of the Small Fatra, Liassic of the mantle of the Small Fatra and Liassic of the Křižna Unit of the Low Tatras.

From the morphological view we can distinguish veinlets straight, arched, of constant thickness or with constrictions and extensions, branching in various modes, coulisse-like, fragmentary etc. (details see in the work by E. K. Smechov and coll. 1962).

From the mineralogical view, in the veinlets of the Tithonian and Neocomian limestones of the Manín Group were besides calcite found: brown colloid-dispersed clay mineral, pyrite, chalcedony, authigenic quartz, in one case the authigenic albite. The brown colloid-dispersed mineral (clay mineral with index of refraction near $k. b.$) in majority is younger than the mass of the calcite veinlets. Thin veinlets with the brown colloid-dispersed mineral cross the calcite veinlets and often pass into the microstyloliths. Some of the oldest calcite veinlets evidently existed before the concentration

of the siliceous acid into the cherts and acted as barrier against migration of SiO_2 colloids (pl. XX, fig. 1). Chalcedony and authigenic quartz occur in the form of constituents of veinlets very rarely, only in siliceous cherty limestones. Chalcedony concentrates at margins of veinlets. Authigenic quartz passively fills space between individuals of the secondary calcite (pl. XX, fig. 2), i. e. it represents a younger constituent. It has often undulose extinction, very rare in authigenic quartz and shows renewed press action after its origin. The only find of partially idiomorphic albite does not allow sure conclusions, in the case described seems to be crystallization more-or-less contemporaneous with the calcite filling. Pyrite in the form of limonitized cubes has been in all cases younger than calcite of veinlets. Succession of minerals of the veinlets is approximately the following: calcite — chalcedony — calcite — albite — calcite — authigenic quartz — calcite — brown colloid clay mineral — calcite — pyrite.

Geologically more interesting are data connected with period of forming of the calcite veinlets in a certain limestone, with time relation to diagenetic processes and tectonic processes.

Forming of the first, oldest cracks might come during sedimentation. They are the so called atectonic cracks, mainly the surface cracks of drying up (shrinkage cracks) as well as those in deeper parts of hemisolid sediment originated in consequence of dehydration. Filling of such cracks may come very quickly. Rapid forming of the cement calcite is shown for instance by the fact that the Pleistocene limestone sands from the area of Bermuds are well cemented to calcarenites (G. M. Friedman 1964); also in thin sections from the Subrecent reefal sediments from Cuba cost I observed that the main part of cavities was already filled up by coarse-grained aggregate of the secondary calcite. In the above-mentioned explanation was suggested the possibility that in the case of veinlets crossed by organic remains without interruption is possible to regard the cracks as originated already in soft sediment. On the whole, the atectonic (or pre-tectonic) veinlets in limestones are very rare.

The main part of veinlets in the Carpathian Triassic, Jurassic, and Cretaceous limestones is necessary to deduce from the period of overthrust of the nappes, the top phases of the Alpine orogenesis. Their age succession we may deduce from the current rules of crossing, mineralogical details of their fillings and relation to diagenetic changes as was mentioned formerly. Probably, during these phases of the tectonic strain the diagenetic mobility of some rocks was the most intensive.

One of the most difficult tasks will be that to decode the dynamic affects on the veinlet fillings, press twinning of calcite grains, curving of twin lamelles, undulose extinction of calcite and authigenic quartz and traces of disintegration; further we must solve effects of pressure, traction or „Durchbewegung“. Certain answer may give comparison with results of experimental deformation of calcite crystals and calcareous rocks (F. J. Turner, D. T. Griggs, H. Heard 1954; M. G. d'Albissin 1963) connected with application of small tectonics in outcrops. In the present the situation seems to be especially complicated due to a plenty of interfering facts, composing and analysing of forces along the both large and small blocks, mechanical inhomogeneity caused by intercalations etc.

In some, clearly youngest veinlets is clear their post-tectonic character. They are filled up by calcite aggregates optically intact in contrast to other present veinlets (pl. XX, fig. 3). They are the healed cracks originated in subsidiary gravitation balance when the forces leading to reduction of the space ended their action.

To solve the problems of structure of the Carpathian Mesozoic, where possibilities

of megatectonics were to considerable degree exhausted, it is necessary to use the investigation of veinlets as a supplement to such study.

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Review by K. Borza.

Explanations of the Plates

Plate XVII

Fig. 1. Dashed veinlets with parallel enclosures of the muddy basal mass originated by recrystallization from the parallel hair veinlets. The thickness of the veinlet is 0.7 mm. Marly limestone of the Neocomian of the Manín Group. St-7, 160–170 m, Butkov Klippen, Ladce, 43 × magn. — Fig. 2. The picture explains probable origin of veinlets of the above figured type. During recrystallization of the hair parallel veinlets the muddy mass between them is absorbed in the calcite crystals except for remains of „dushes“. The veinlet of younger calcite is crossing. St-6, 32 m, the locality as above, 23 × magn. Photo L. Osvald.

Plate XVIII

Fig. 1. *Aptychus* crosses without interruption the veinlet of the secondary calcite (recrystallization or atectonic veinlet). Marly limestone of the Tithonian of the Manín Group with *Calpionella alpina*, *Crassicolaria intermedia*, *Globochaete alpina* and calcified radiolarians. St-6, 134 m, Butkov Klippen, Ladce, 43 × magn. — Fig. 2. The same as above in polarized light. *Globochaete* forms characteristic black crosses. The rock as above. The thickness of the veinlet 0.14 mm, 43 × magn. Photo L. Osvald.

Plate XIX

Fig. 1. Lagenid foraminifer crossing without interruption the calcite veinlet. Explanation of the origin as above. Neocomian of the Manín Group. LC-0, 35–40 m, Butkov Klippen, Ladce, 55 × magn. — Fig. 2. Echinodermal article partially penetrating into the calcite veinlet. Marly *Calpionella* limestone of the Tithonian of the Manín Group. LC-5, 6, 25–30 m, Butkov Klippen, Ladce, 55 × magn. — Fig. 3. Calcite veinlet showing multitude movements of blocks. In the left part filling of the prismatic to filamentous calcite originated during slow removing of blocks. Near the right margin brecciated structure of veinlet originated during the lateral movement of blocks. Neocomian, LC 06, 35–40 m, Butkov Klippen, Ladce, 6 × magn. Photo L. Osvald.

Plate XX

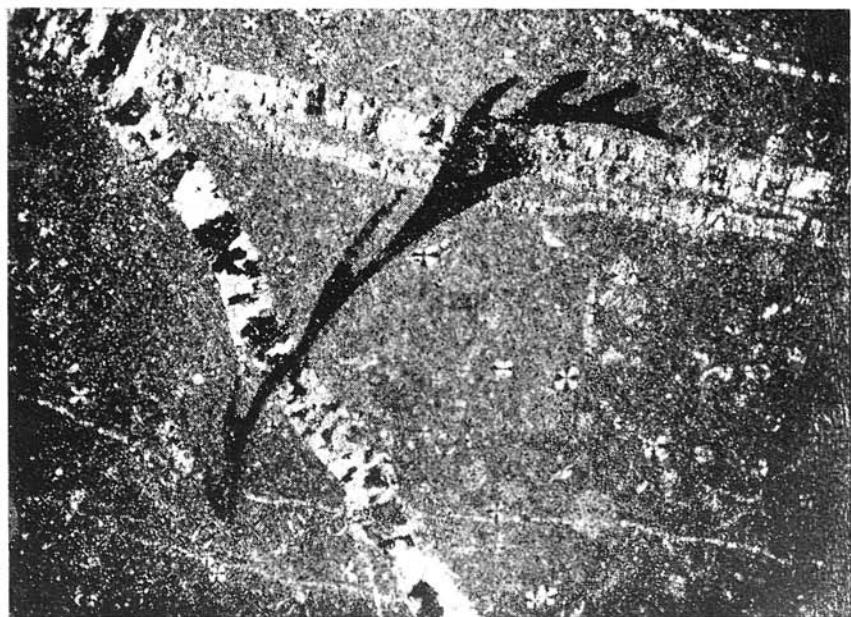
Fig. 1. Siliceous radiolarian limestone with cherts — Neocomian of the Manín Group. The chert has usually not sharp margins — (see the gradual transition in the right half of the picture). Rarely sharply ended on older calcite veinlets which represented the barrier of migration of SiO_2 (see the left side of the picture). LC 0-6, 60–65 m, Butkov Klippen, Ladce, 23X magn. — Fig. 2. Authigenic quartz (white) fills up spaces between calcite grains in the veinlet. Neocomian of the Manín Group. Št-6, 56 m, Butkov Klippen, Ladce, 30X magn. — Fig. 3. Older calcite veinlet with twinned lamelled calcite („pre-tectonic“) crossed by younger veinlet with intact grains („post-tectonic“). Št-6, 114 m. The rock as above, 30X magn. Photo L. Osvald.

Translated by V. Scheibnerová.





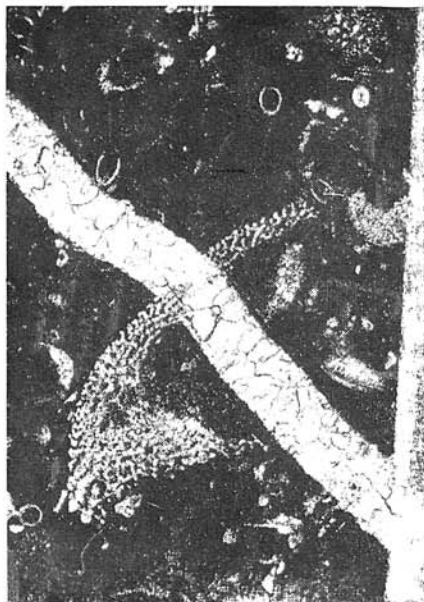
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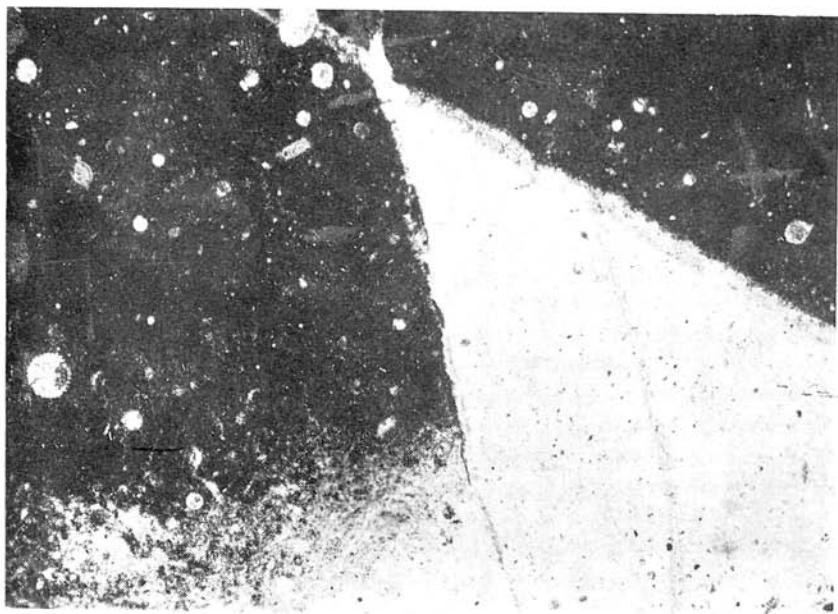
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