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Dolomitization Phenomena in Limestones of the Kuzuu District, Tochigi Prefecture, Central Japan

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Abstract

Dolomitization of selected areas within the Kuzuu district can be related to primary porosity and permeability as well as to fracture porosity within the lithified limestone.

Location

The Kuzuu Limestone occurs in a horseshoe-shaped basin structure in Tochigi Prefecture, about 70 km north of Tokyo. The commercial exploitation is carried out both in multistoried open pit fashion (Hanezuru Quarry and many others) and underground (Yoshizawa Mine). The limestone is primarily used for aggregate, fluxstone, fertilizer and in cement making. Within the limestone occurs a belt of partial and complete dolomitization, and the dolomite is also used for raw materials of fertilizer, dolomite plaster, and in steel and glass making.

Method of Study

A set of 98 hand specimen samples was collected over the surface outcrop and in the mine workings. Each specimen was cut by a rock saw, the cut surface was etched for 15–30 seconds in dilute hydrochloric acid and then washed in tap water. This is an excellent method for preparing the sample for a quick examination under the binocular stereomicroscope. Prior to the examination, the sample was wetted with tap water or with a mixture of glycerine and water.

To check on the accuracy of visual estimates, nineteen specimens were also chemically analyzed for bulk composition.

Results

The Kuzuu Limestone, otherwise known as the Nabeyama Formation, is divided in surface exposures into three zones, a Lower Black Limestone member, a Middle Dolomite, and an Upper Light-coloured Limestone member. Fossil content indicates a Middle Permian age. While it is not too cumbersome to map the three units in outcrop exposures, and it appears to be very difficult to follow the upper and lower boundaries of the dolomite member in the subsurface.

Sample examination shows partial dolomitization in the limestones close to the dolomite boundary and incomplete dolomitization in many parts of the dolomite member.

Dolomitization appears to have altered a pre-existing calcareous sediment that contained various quantities of skeletal debris, mainly derived from fusulinids and crinoid stems (Plate 7–1, 2). Evidently, the original sediment graded locally from calcilutite to calcisiltite to calcarenite. During or after lithification, a first generation of sparry calcite filled most of the voids in fusulinids and in other skeletal fragments as well as some minor fractures. Lime muds that are of the churned and partially

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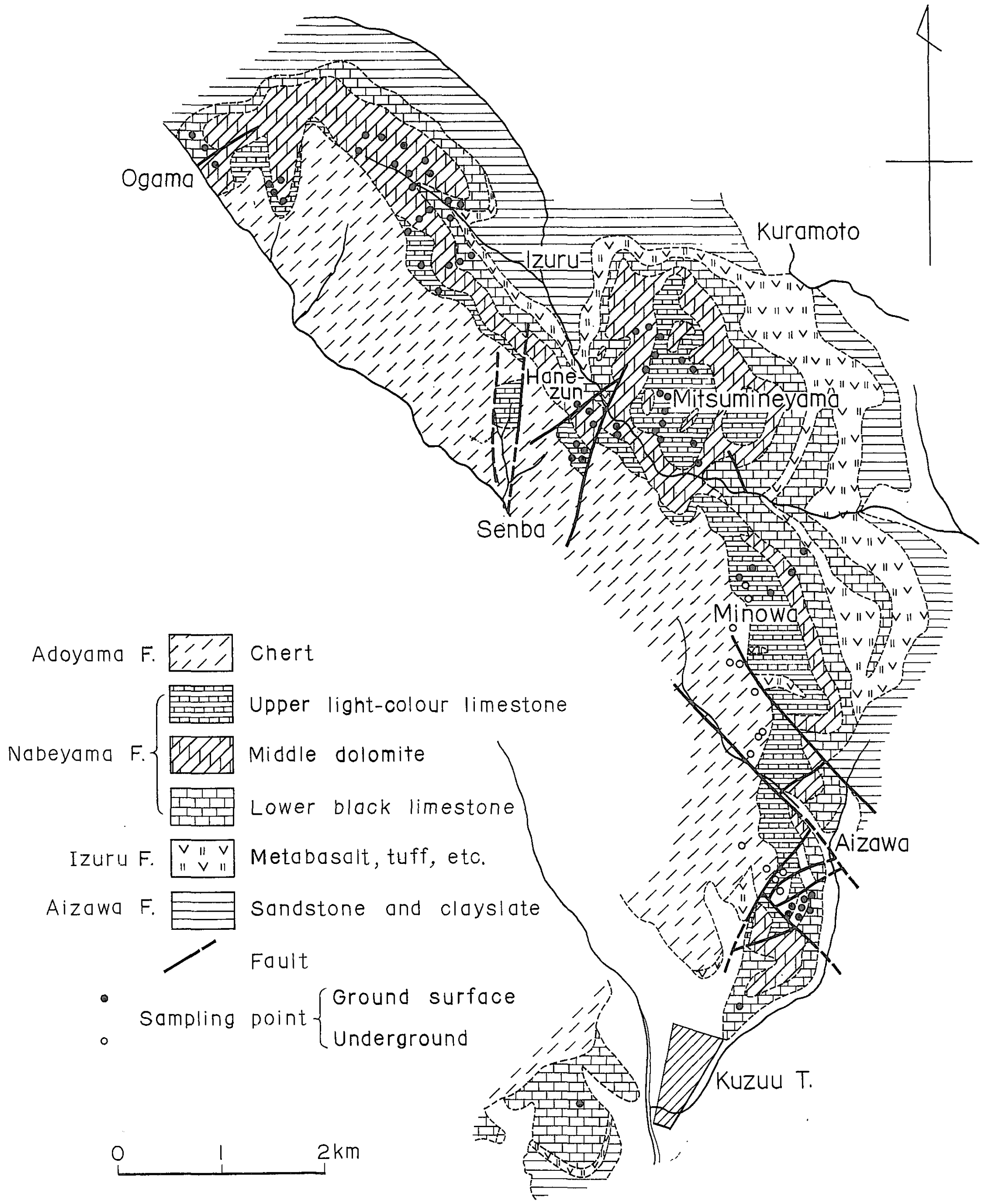
Ogama
Kuramoto
Izuru
Hane-zun
Mitsumineyama
Senba
Minowa
Aizawa
Kuzuu T.
Adoyama F.
Chert
Nabeyama F.
Upper light-colour limestone
Middle dolomite
Lower black limestone
Izuru F.
Metabasalt, tuff, etc.
Aizawa F.
Sandstone and clayslate
Fault
Sampling point
Ground surface
Underground
0
1
2km

Fig. 1

pelletized variety also show sparry calcite as infilling.

While the Lower Black Limestone has kerogen in varying quantities finely dispersed throughout (Plates 10–2, 12–2), and the Upper Limestone has been invaded after lithification by carbonaceous material only along a set of fractures (Plate 7–1). These fractures precede dolomitization and have not been permeable to dolomitizing solution.

The fossiliferous sediment was again brecciated at various localities into angular fragments floating in a finer-grained matrix, and this brecciation also seems to have preceded dolomitization. The brecciation might be associated with an early set of faults (Plate 8–1, 2).

Dolomitization has altered preferentially coarse-grained skeletal calcarenites (biosparites and biopelsparites). Some ghost structures of skeletal fragments remain in form of different crystal packing or a different crystal orientation. Dolomitization also proceeded along the matrix of brecciated material or along fractures. Ultimately, dolomite crystals dispersed either throughout micritic limestone or formed clusters in it. Complete dolomitization did not destroy all evidence of earlier textures (Plates 8–1, 9–2).

At least one later set of calcite fracture fillings can be found; there is some evidence of such three sets of fracture fillings displacing each other (Plate 10–1, 2). Such one set of calcite infilling also invaded a set of shear fractures. This indicates that the rock has been subjected to stresses more than once and faults of more than one age can be found.

In many places both limestone and dolomite contain finely disseminated hematite flakes and yellow ferruginous fracture fillings. These are possibly associated with an ancient erosional surface, as the presence of hematite requires the exposure of iron compounds to large quantities of oxygen normally not present in subsurface waters. The ferruginous material penetrates the matrix of brecciated specimens in analogy to the penetration of dolomitization (Plate 11–2), and also on occasion attacks partially leached vein calcite (Plate 11–1).

Consequently it is surmised that the iron entered the rock sequence alongside magnesium, forming complex carbonates. These were later converted into iron hydroxides and partially altered to iron oxides as a weathering phenomenon under relatively dry conditions. The absence of any pyrite or anhydrite suggests that sulphate or sulphide ions were not involved in this migration. Instead, it may be assumed that bicarbonates were the prime cation carriers.

This is supported by the observation that many dolomite crystals show a black coating uniform throughout any one sample. Uncoated and coated crystal clusters coexist side by side, and the coated ones usually are less tightly packed (Plate 13–1).

Dolomitization seems to have preferentially attacked fossil specimens (Plate 14–1), as shown by H. TAKAHASHI. (1958), or preferentially attacked the matrix (Plates 14–2, 7–1), depending on where permeability was the greater.

Both Upper Limestone and Dolomite members are essentially free of dispersed kerogen suggesting that the dolomite represents an altered lower part of the Upper Limestone. However, some bands of dolomite have been found in samples of the Lower Black Limestone indicating that has not altogether escaped the replacement process (Plate 12–2).

Conclusion

The dolomite boundaries do not appear to be depositional boundaries, but seem to be a facies-

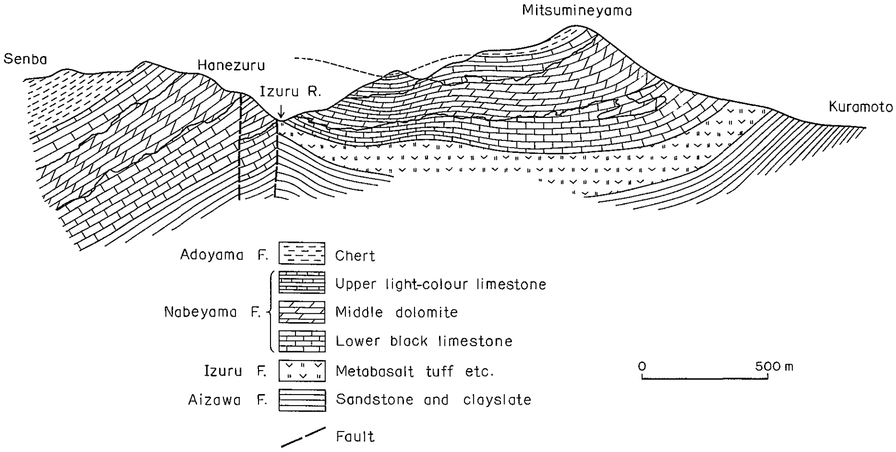

Fig. 2

controlled post-depositional phenomenon, controlled by permeability and porosity distribution remaining after an initial calcite infilling. The dolomite is, therefore, not a separate stratigraphic unit in the sequence, but an alteration feature of both Upper Light-coloured Limestone member and Lower Black Limestone member (see Fig. 2).

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栃木県葛生地方の石灰岩中のドロマイト化作用について

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要 旨

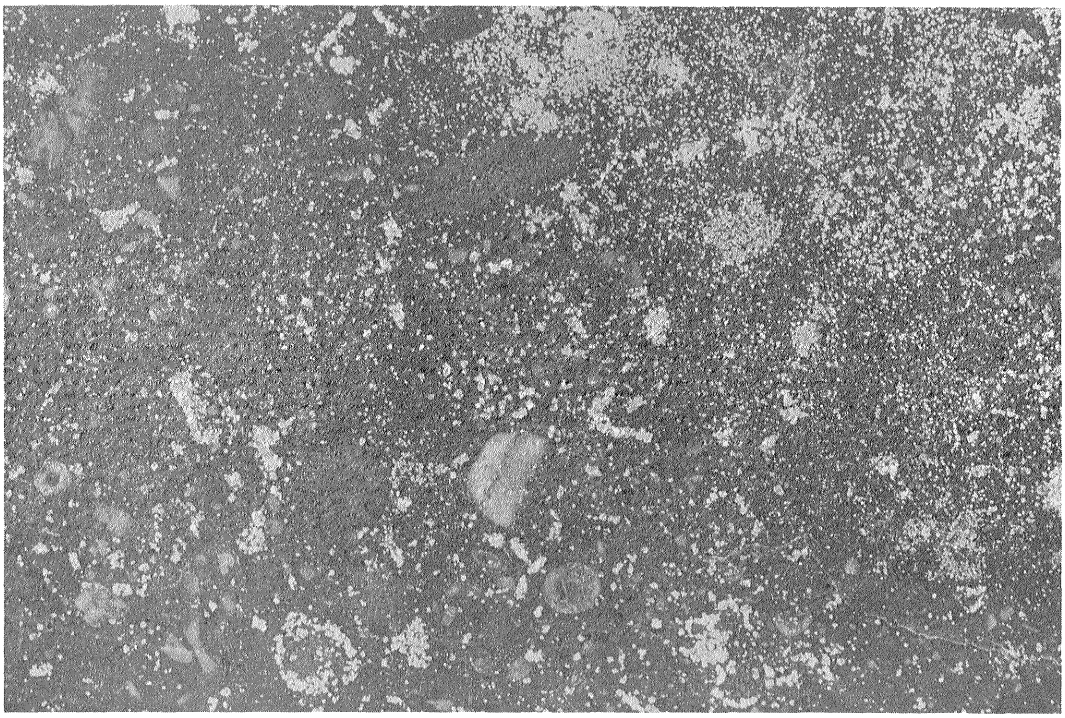
栃木県葛生地方のドロマイトの岩石学的検討を行なった．

本地方で現在盛んに石灰石・ドロマイトが採掘されている地層は鍋山層とよばれ，その岩相により，下部石灰岩（山菅石灰岩部層），中部苦灰岩（羽鶴苦灰岩部層）および上部石灰岩（唐沢石灰岩部層）に3分されている．

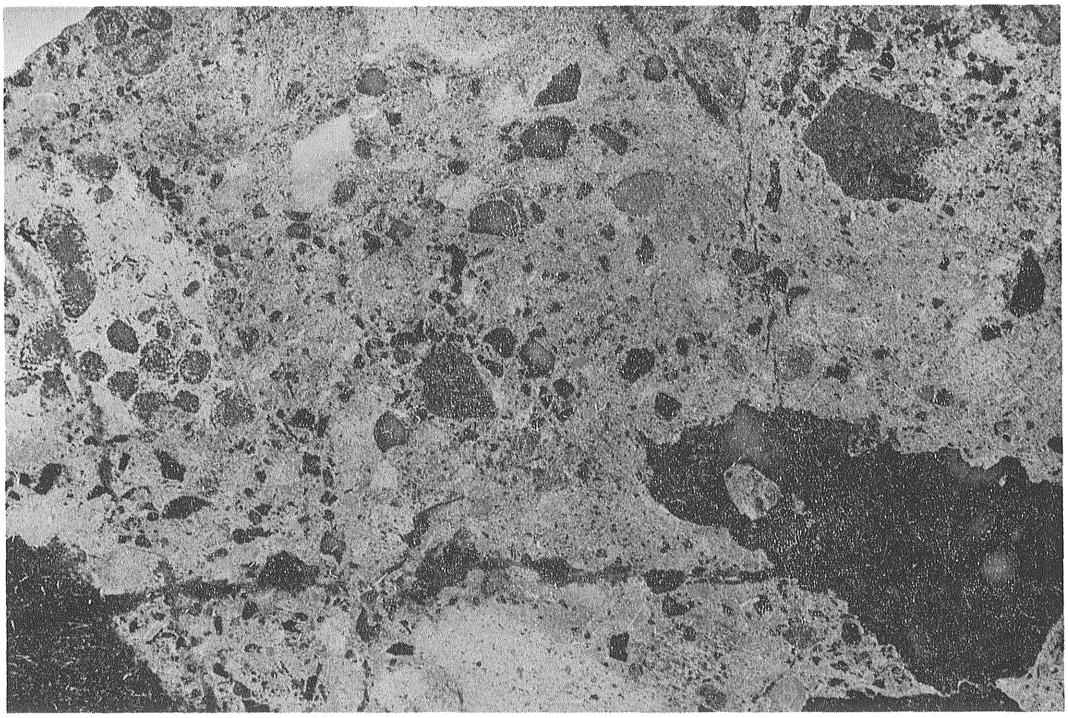
筆者らの観察では，ドロマイトと上・下部の石灰岩層との間の境界は明瞭ではなく，堆積時の境界とは考えられず，ドロマイトは炭酸塩堆積物の堆積後の変質交代によって形成されたと考えられる現象が観察された．ドロマイト化作用に関与する要因としては，炭酸塩堆積物の孔隙と浸透性が大きな役割りを果したと考えられるが，岩石として固結したのち破砕作用によると思われるドロマイト化作用も観察された．

したがって，本地方のドロマイトは層序学的に独立した一つの単元としての部層ではなく，下部黒色石灰岩層と上部白色石灰岩層の一部を交代変質したものと推定される．

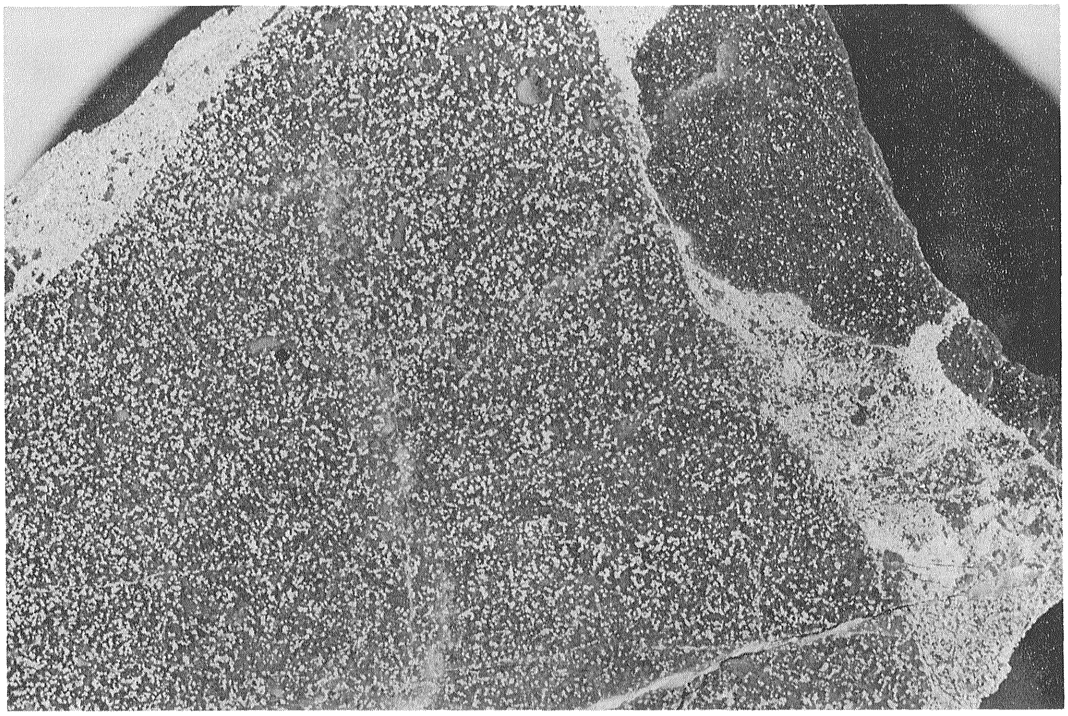
1. Upper Light-coloured Limestone, brownish grey, composed of coarse crinoid and fusulinid fragments, with finely disseminated dolomite crystals in the matrix. Black carbonaceous material in stringers and as coating of dolomite crystals (Sample No. 612–06, from the Hanezuru Mine) ×2.6



2. Lower Black Limestone, blackish grey, composed of coarse crinoid and fusulinid fragments in a black matrix. Dolomite crystals in clusters disseminated throughout the matrix (Sample No. 23–07, from Izuru) ×2.6

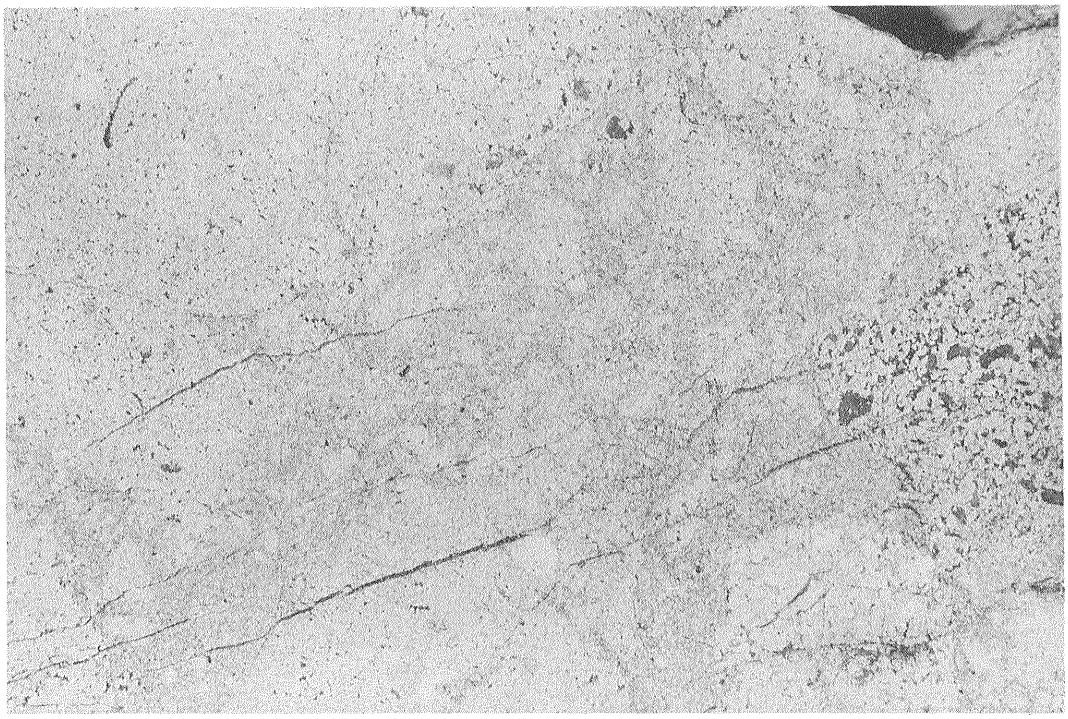


1. Limestone Breccia, brownish grey, composed of very coarse fragments of fusulinid-bearing lime mud. Dolomite crystals arranged in bands throughout the matrix. (Sample No. 25–16, from Ogama) ×2.6

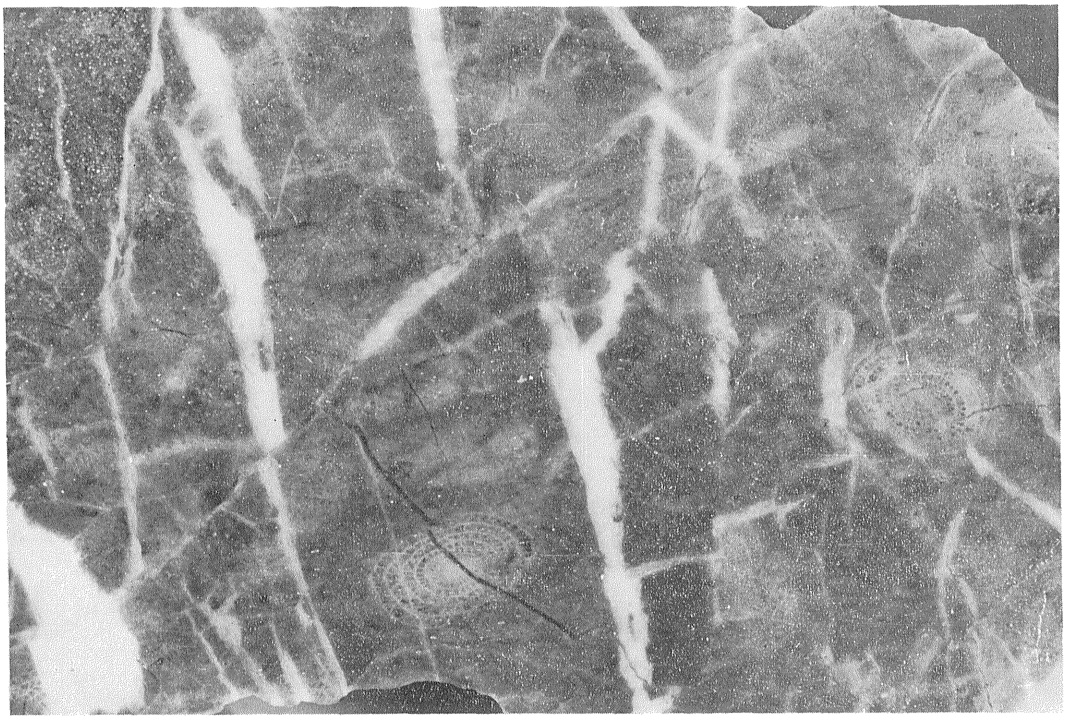


2. Dolomite Breccia, light grey, composed of large fragments of a calcarenite made up of rounded crinoid and fusulinid fragments. Dolomite crystals dispersed throughout the interstices between fossil fragments and concentrated in the matrix between brecciated fragments. (Sample No. 25–07. from Mitsumineyama) ×2.6

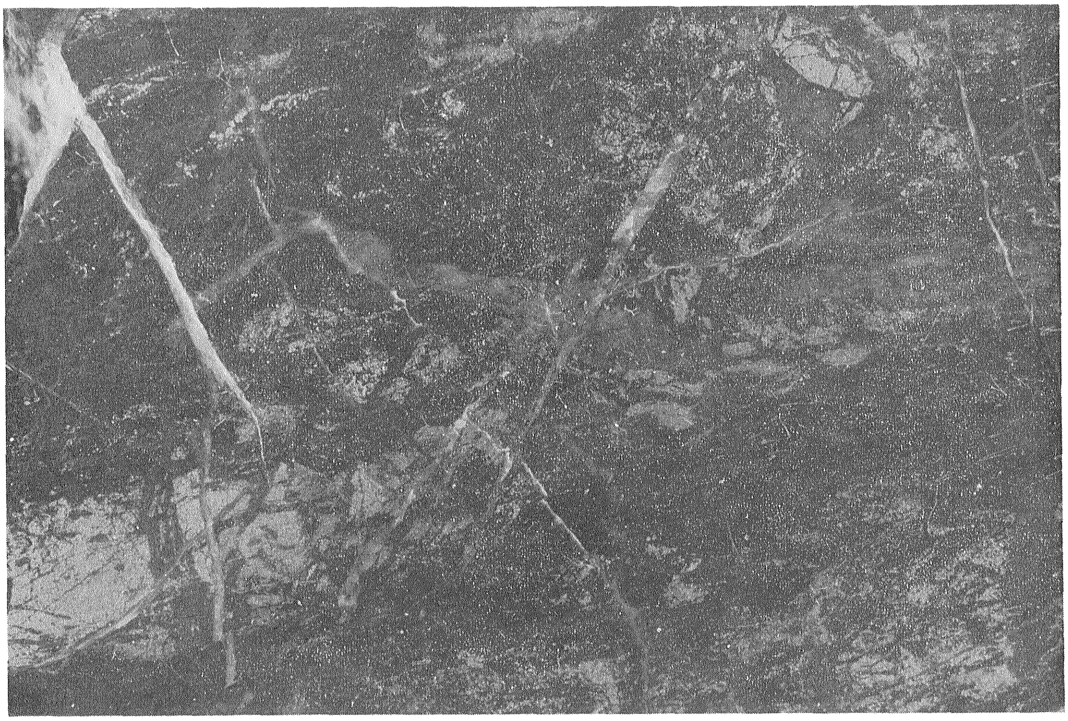
1. Dolomite, light grey, medium crystalline, with some sparry calcite filling microvugs. Some skeletal fragments still recognizable as differences in crystal size. (Sample No. 24–07, from Izuru) ×2.6



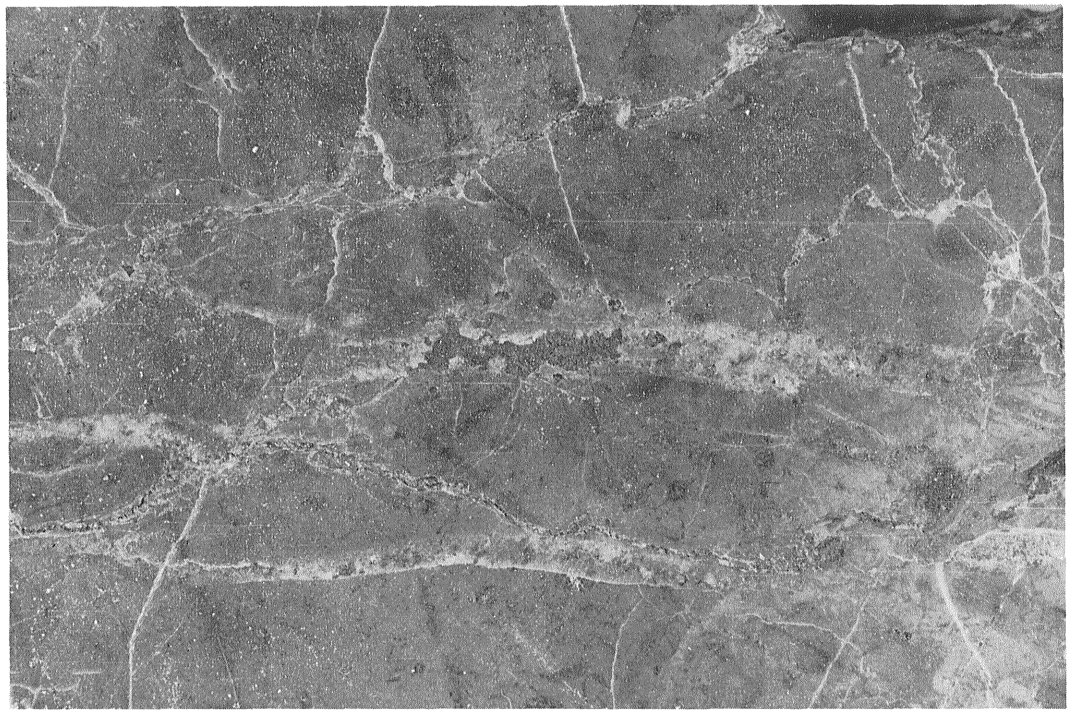
2. Dolomite, light grey, medium crystalline, with some sparry calcite filling microvugs. Brecciated nature of the original fossil fragment bearing lime mud still recognizable in differences in crystal size. (Sample No. 27–06, from Hanezuru Mine) ×2.6



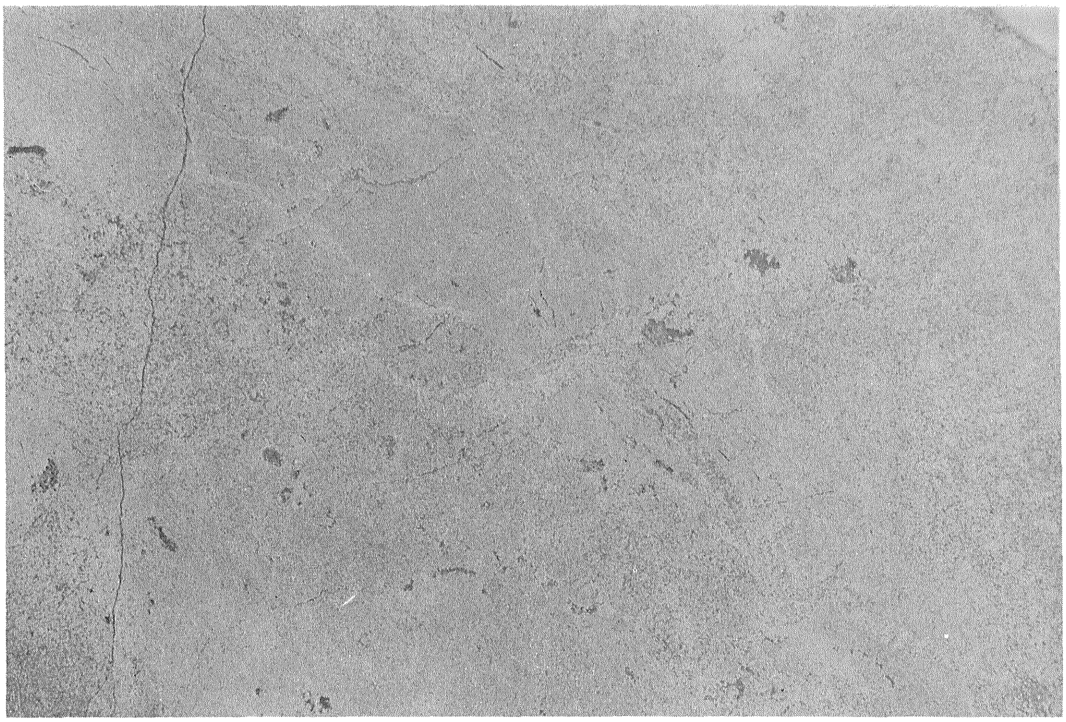
1. Limestone, light brownish grey, composed of fusulinid fragments in a fine grained, slightly darker coloured matrix. The rock is crisscrossed by white calcite fracture fillings, which are arranged in a shear pattern in a corner of the specimen. A set of sparry calcite fractures offsets the white calcite fractures. (Sample No. 25–03, from Mitsumineyama) ×2.6



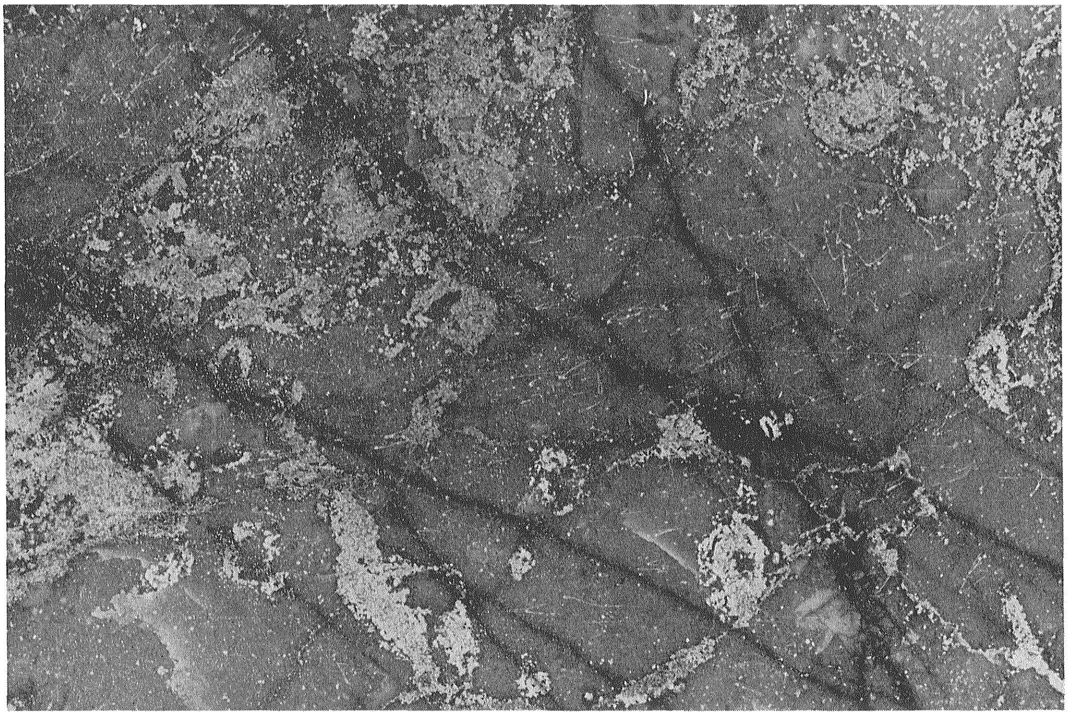
2. Limestone, blackish grey, composed of micrite incompletely soaked in black discolouration. Several sets of white calcite fracture fillings offset each other. (Sample No. 27–10, from Hanezuru Mine) ×2.6



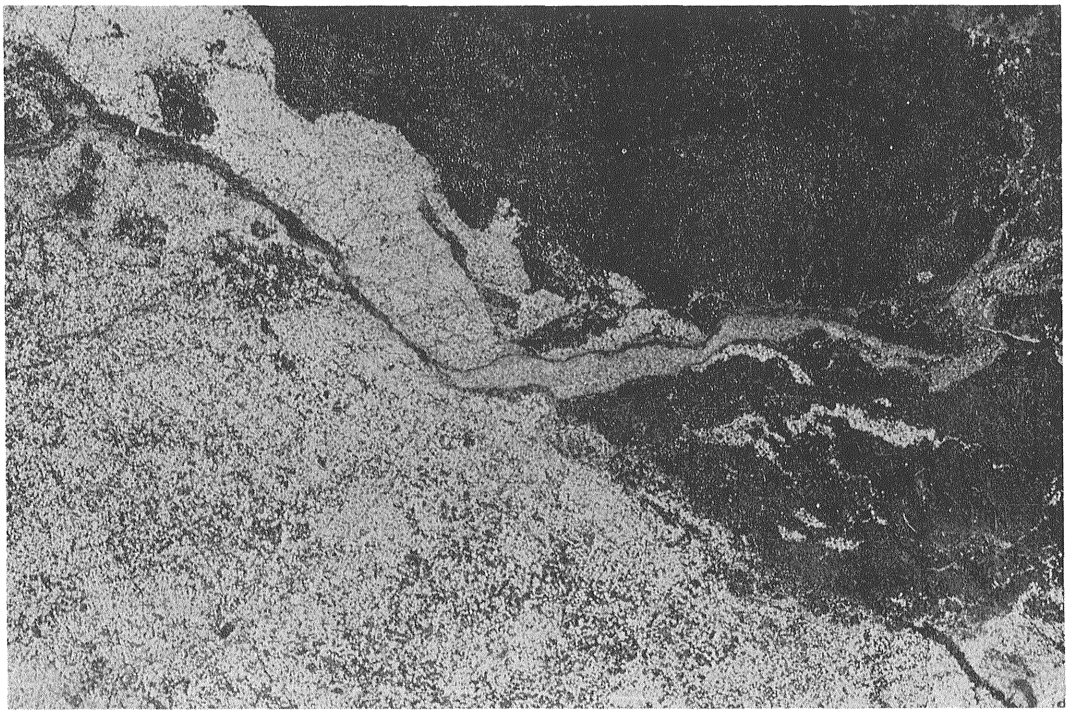
1. Limestone, light brownish grey, composed of lime mud with few broken up foram fragments. A set of white calcite fracture fillings is in part replaced by brown limonitic filling (Sample No. 23–02, from Izuru) ×2.6



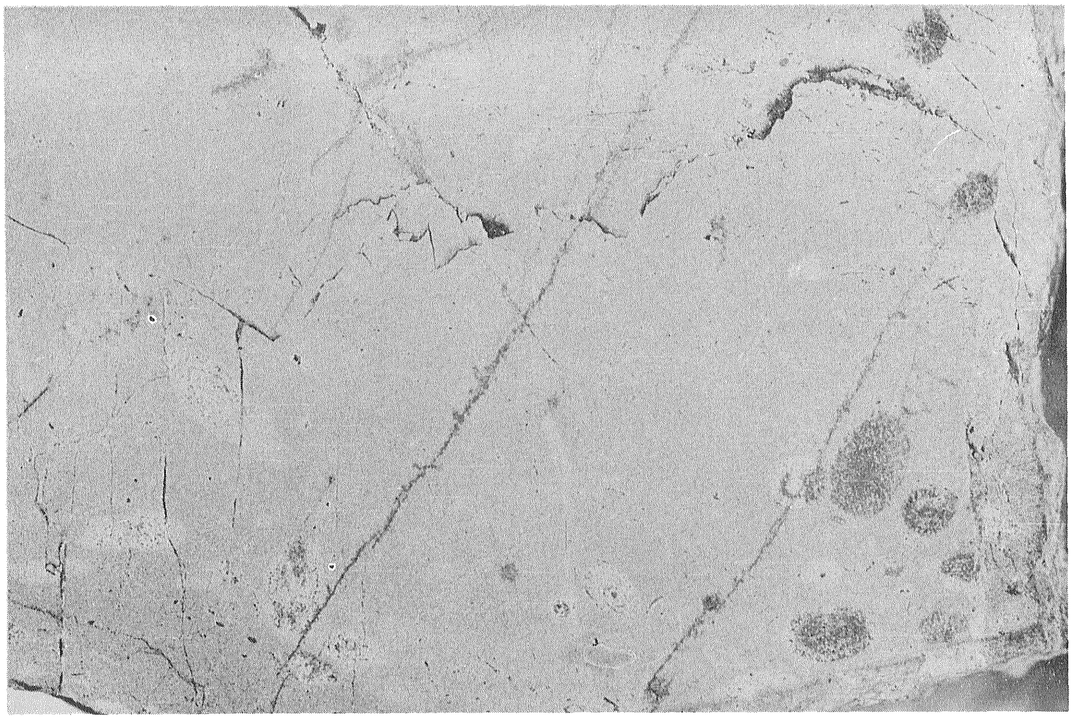
2. Dolomite, light grey, medium crystalline, which appears to be a breccia with coarser crystalline matrix. Interstices between dolomite crystals in the breccia matrix are filled with yellow ferruginous material and some red hematite flakes (Sample No. 24–02, from Izuru) ×2.6



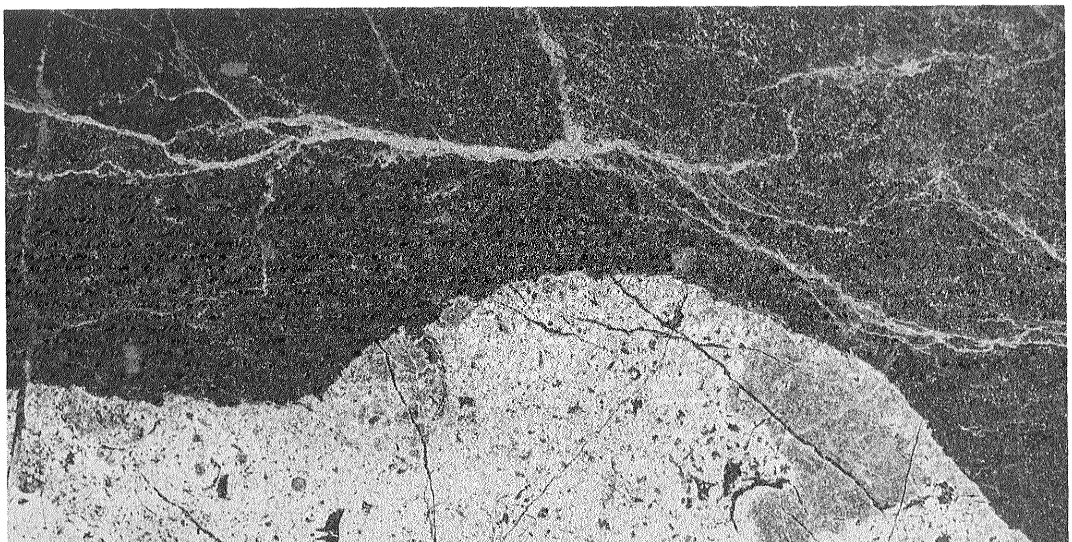
1. Limestone, light brownish grey, composed of micritic lime mud with a variety of floating forams. A set of black fractures filled with cabonaceous material is unaffected by dolomitization trends. (Sample No. 24–13, from Izuru) ×2. 6



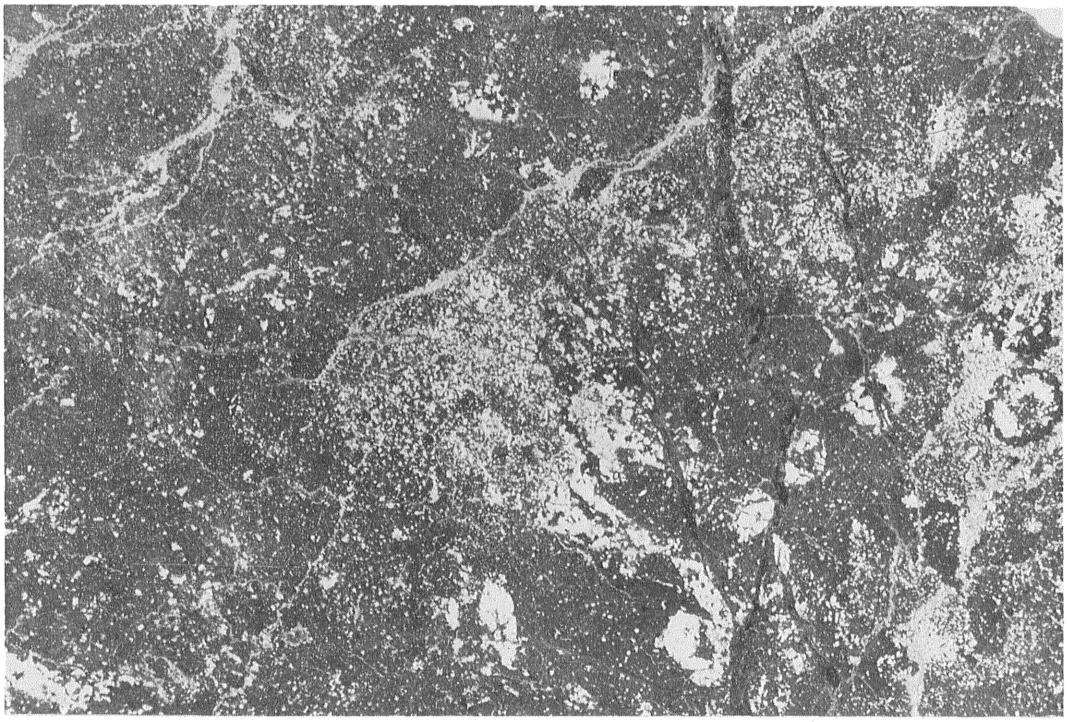
2. Limestone, blackish brown, composed of lime mud with pockets of calcisiltite. The rock is extensively crisscrossed by black fractures, which considerably darken the overall colour. A band of dolomitization crosses the specimen. The background of this band is composed of silt-sized skeletal debris. (Sample No. 27–12, from Nabeyama) ×2. 6



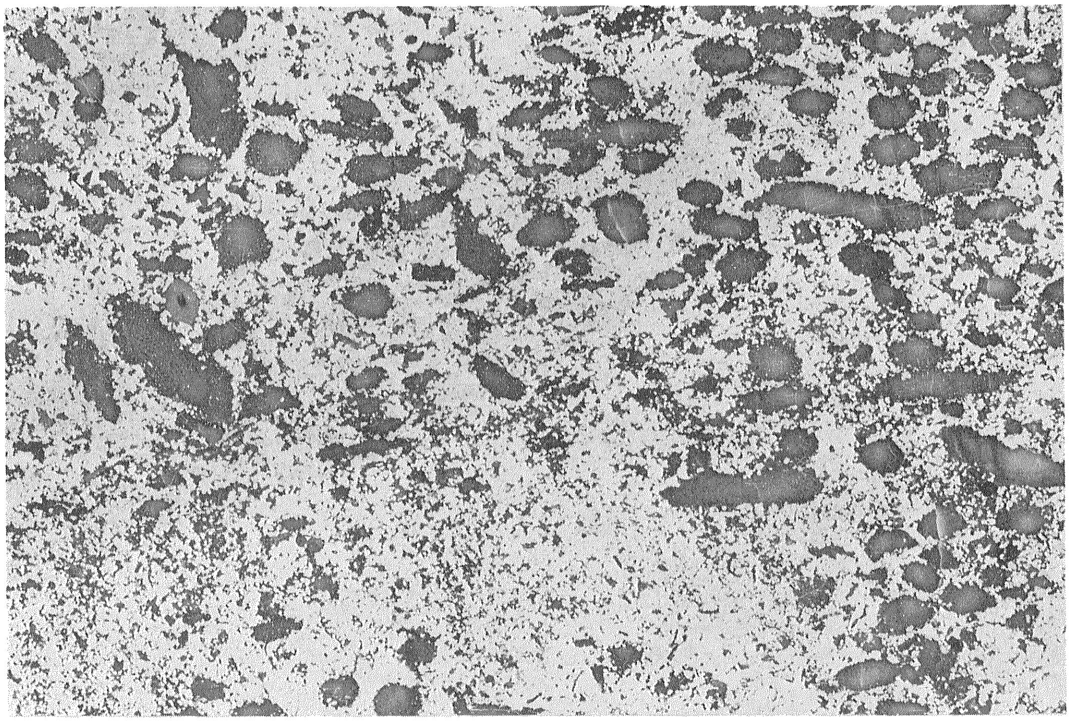
1. Dolomite, light grey, medium crystalline. Part of the specimen is a breccia, the other part shows dolomitized floating fossil fragments. The dolomite crystals in some fossil fragments are coated with black carbonaceous material. In one corner of the specimen is a fragment showing the black coating. Fracturing preceded coating. (Sample No. 26–05, from underground of Ogano area) ×2.6



2. Limestone, brownish grey, composed of crinoid and fusulinid fragments floating in a micritic matrix. Both dolomite and ferruginous material utilize the fracture and permeability paths. Calcitic crinoid fragments in a dolomite matrix are found next to crinoid fragments replaced by limonite. (Sample No. 610–01, from Yamanoi Quarry) ×2.6



1. Limestone, brownish grey, composed of lime mud with floationg fossil fragments. Crinoids are perferentially dolomitized over surrounding matrix (Sample No. 26–16, from underground of Minowa area) ×2.6



2. Limestone, brownish grey, composed of fusulinids in a calcisiltite matrix. The matrix is almost completely dolomitized; the fusulinids contain only few isolated dolomite crystals, are mainly filled with sparry calcite (Sample No. 25–21 from Ogama) ×2.6