MICROMORPHOLOGICAL CONTRIBUTION TO THE CHARACTERIZATION OF SOILS DEVELOPED ON TRIASSIC SEDIMENTS FROM SOUTHERN SPAIN

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Introduction

Some authors (e.g. Bellinfante, N. et al. 1.970)have emphasized the importance of lithological discontinuities in soils formed on sediments of Quaternary age in Southern Spain. Although not yet recognized as such, similar lithological discontinuities are frequent in soils developed on gypsum and marl deposits of Keuper age.

In several profiles an original layering in the parent material may easily be confused with a pedogenic horizon formation. The objective of the present micromorphologi - cal study is to contribute to the genetical knowledge of these soils.

Material and Methods

Four modal profiles were described and sampled in the region of Moron de la Frontera (Province of Sevilla, Southern Spain) (fig. 1). The geological substratum is composed of marls and gypsum of Keuper age (Upper Triassic) materials which are common in the South-Eastern part of the Guadalquivir river basin (I.G.M.E. 1.952 and 1,969). (Fig. 2).

This area is characterized by a dry-subhumid climate according to Thornthwaite's classification. An average total rainfall of 700 mm is recorded essentially during the wet season from October to March (with a maximum in No-

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vember-December and one in February-March). An absolute summer-drought of at least three to four months is noticed. Mean maximum temperature vary between 14ºC and 30ºC (respectively in January and August), mean minimum temperatures between 5ºC and 20ºC (same period).

Physico-chemical characterization was executed in the laboratories of the "Centro de Edafologia y Biologia Aplicada del Cuarto (C.S.I.C.), Sevilla. Micromorphological descriptions were made during the stay of the Senior author at the Geological Institute of the State University of Ghent (Belgium), according to the terminologies of BREWER 1.964, GEYGER & BECKMANN 1.967 and STOOPS & JONGERIUS 1.975.

Profile 1.

Location : "Pozo de los Bueyes", 37º08'00" -1º42'40".
Physiographic position : upper slope.
Slope : 20 %.
Elevation : 300 m.
Water erosion : strong.
Vegetation : Kermes oak, Spanish broom, graminaceous.
Parent material : Keuper marls on gypsum rock.
Classification : Lithic Xerorthent.
Description and micromorphology :

Ap 0 - 20 cm.

Olive brown (2.5Y 4/4) clay loam; strong coarse and fine crumb structure; sticky and plastic; porous peds;abundant fine roots; low biological activity; calcareous; clear smooth boundary.

Locally crumbly, grading to porous microstructure. Many large limestone fragments and irregular rounded nodules of pure grayish or reddish clay with unistrial or mosepic fabric, and without organic matter (fragments of ar-

gillite or residual clay, lithorelicts) included in a brownish gray open porphyric quartzopsamm/argiocalcopelmatrix. The aggregates contain partly humified organic matter, and are rarely covered by very thin (7-8 m) ferriargillans. Near the channels thin zones of yellowish clay occur. Caverneous hypidiomorphic quartz crystals are common.

C 20 - 50 cm.

Brown to dark brown, reddish brown or olive gray (10YR 4/3, 5YR 4/3, 5Y 4/2) clay loam; moderate medium subangular blocky structure; sticky and plastic, firm to hard; abundant fine and medium roots; small crystals of gypsum are frequent; calcareous; diffuse boundary.

Irregular jointed, locally fragmented microstructure with curved rough fissures and irregular rough open cavities and a few root channels. Yellowish monic argiocalcopel matrix; including many fragments of different limestone types and clay nodules as described above.

II R +50 cm.

Gypsum rock with medium (+ 130 μm) or coarse (4 mm) mozaic structure, locally stained by dispersed very fine reddish material. Near the soil contact patches of yellowish clay between the gypsum; in the voids very small ferri-argillans. Above the contact lenticular gypsum crystals in a matrix of clay and micro-crystalline calcite (fig. 3).

Analytical data : table I

Comments

Pedogenetic influences on the gypsum substratum are: (i) a solubilization of the gypsum with local accumulation of residual clay and (ii) a recrystallization of the granular gypsum (mozaic structure) to lenticular crystals. The numerous limestone fragments in the C and Ap horizons are probably of colluvial origin, this may be also the

case for the clay nodules. Pedoturbation is a apparently not strong enough to transform the latter to matrix-material. Small ferri-argillans in the Ap and R-horizons indicate an initial translocation of the clay fraction.

Profile 2.

Location : Las Capellanías. 37º03'30'' -1º46'01''.
Physiographic position : upper slope.
Slope: 15 - 20 %.
Elevation : 230 m.
Water erosion : strong.
Vegetation : Spanish broom, thistle, graminaceous; olive grove.
Parent material : Keuper marls on sandstone.
Classification : Typic Xerorthent.
Description and micromorphology :

Ap 0 - 15 cm.

Reddish brown (5YR 4/3) clay loam; coarse crumb structure; very sticky and plastic, friable and hard; few small fragments of limestone and sandstone; few very fine roots; low biological activity; calcareous; clear smooth boundary.

Crumbly microstructure; heterogeneous matrix of sand sized grains of quartz and muscovite, and brownish clay, mostly with a porphyric c/f-related distribution, locally gefuric and even chitonic; included coarse fragments of calcite nodules, limestone, claystone and sandstone, few reddish brown coarse clay cutans on crumbs.

C_1 15 - 95 cm.

Weak red, reddish brown and dusky red (2,5YR 4/2, 4/4 and 4/3) clay loam; strong medium and coarse angular blocky structure with slickensides; sticky and slightly plastic, firm to friable; abundant small gypsum crystals;

many fine and medium roots; calcareous; abrupt irregular boundary.

Irregular jointed microstructure; close porphyric quart - zosil/argiopel (reddish brown) c/f related distribution; layered. In some fissures micro- and mesocrystalline calcite, locally acicular.

II C_2 95 - 195 cm.

Olive gray (5Y 5/2) clay; strong angular blocky; slightly sticky and plastic, firm to friable; non calcareous except calcite tubes; gradual irregular boundary.

Micromorphology as above, but for presence of mica and grayish color of clay. Common ironoxihydrate and calcite soil nodules with diffuse boundaries.

III R 195 +

Grayish and yellowish sandstone.

Analytical data : table I.

Comments

Both C_1 and IIC_2 are pelitic rocks, rather undisturbed by pedogenetic processes, except drying and cracking and consequent crystallization of calcite in the fissures, and formation of iron oxihydrate nodules. No evidence of clay-illuviation could be found. The material of the Ap horizon seems of colluvial origin, its crumbly structure and the traces of a local clay translocation indicate a weak pedogenic activity.

Profile 3.

Location : La India; 3º 03' 50'' - 1º 48' 20''
Physiographic position: lower slope.
Slope: 8 - 10 %.

SOIL ON TRIASSIC SEDIMENT

Elevation : 240 m.
Water erosion : moderate
Vegetation : Spanish broom, thistle, graminaceous; olive grove.
Classification : Vertic Xerochrept.
Description and micromorphology :

ApB 0 - 25 cm.

Reddish brown (5YR 4/3) clay; strong coarse subangular structure; sticky and plastic, firm and hard; few fine roots low biological activity; calcareous; gradual irregular boundary.

Irregular jointed microstructure with common roots channels; fragments of limestone and irregular (mostly unistrial) clay nodules (lithorelict) embedded in a monic calco-argiopel matrix. Nodules of reddish soil material (cf. B-horizon) frequently occur.
Rare idiomorphic quartz grains.

B 25 - 45 cm.

Mottled reddish brown and yellow (5Y 3/3 and 2.5Y 7/6) clay ; strong medium and coarse subangular blocky structure; sticky and plastic; firm and hard; few fine and medium roots; calcareous; diffuse irregular boundary.

Irregular jointed microstructure; yellowish red, open porphyric quartzopsam/calco-argiopel matrix, few idiomorphic quartz crystals; fragments of limestone and clay lithorelicts common; cutans of coarse clay cover most voids and similar papules are frequent in the matrix; slightly humified remains of organic matter occur in the matrix.

BC 45 - 75 cm.

Mottled, reddish brown and gray (2.5YR 4/4 and 2.5YR-5/0) clay loam; moderate; medium and coarse subangular blocky structure with slickensides; slightly sticky and

plastic; frequent small fragments of gypsum and limestone few fine and medium roots; calcareous; diffuse, irregular boundary.

Irregular jointed microstructure; matrix composed of reddish, sepic clay, locally composed of diffuse clay papules (disrupted cutans), many fragments of pure lime stone and diffuse nodules of C-horizon material; many idiomorphic quartz crystals (fig. 4).

C + R 75 cm.

Mottled substratum composed of rock fragments and gyp - sum boulders.

Spongy microstructure with voids coated by reddish brown cutans of coarse clay; locally lenticular gypsum crystals in voids.

Pinkish monic argio-calcopel matrix, including clay nodules (decalcified marl ?) as lithorelicts. The parent rock is a coarse granular limestone with few argillaceous lenses (unistrial) and idiomorphic quartz grains.

Analytical data : table I.

Comments

As in the former profiles, colluvial influences are important in the Ap and B horizons as shown by an increase of lithorelicts (limestone fragments and clay nodules) and a marked decrease of idiomorphic quartz crystals, which form 20 % of the coarse fraction in the substratum. The B horizon is characterized by presence of translocated clay (fine and coarse) continuing in the C-horizon and even in the rock. Churning of cutans in the BC, the numerous papules and the sepic fabric indicate strong vertic movements. The spongy structure in the C-horizon is probably the result of dissolution.

SOIL ON TRIASSIC SEDIMENT

Profile 4.

Location : near "Sevilla". 37º08' 50'' - 1º43' 00''
Physiographic position : medium slope
Slope : 15 - 20 %
Elevation : 360 m.
Water erosion : strong.
Vegetation : Kermes oak, Spanish broom, graminaceous olive grove.
Parent material : Keuper marls on gypsum rock.
Classification : calcixerollic Xerochrept.
Description and micromorphology :

Ap 0 - 20 cm.

Brown to dark brown (7.5YR 4/3) clay; moderate medium crumb structure: slightly sticky and plastic; friable; few small limestone fragments; very few fine roots; medium biological activity; calcareous; gradual smooth boundary.

Spongy to crumbly microstructure with smooth cavities; open porphyric quartzopsam/calco-argiopel matrix , containing locally partly humified plant remains; some idiomorphic quartz crystals.

B 20 - 40 cm.

Brown and reddish brown (7.5YR 5/4 and 5YR 5/3) clay , moderate coarse subangular blocky structure: slightly and plastic; firm; many nodules of calcite and few of gypsum; calcareous; few fine and medium roots; diffuse irregular boundary.

Porous microstructure; open porphyric quartzo psamm/argio-calcopel matrix; with some idiomorphic quartz crystals and some limestone fragments; desintegrating organic matter in some voids.

BC 40 - 100 cm.

Mottled reddish-brown and gray (2.5YR 4/4 and 5YR 5/1) clay; medium and coarse subangular blocky structure; sticky and plastic, firm; calcareous; few fine and medium roots; diffuse broken boundary.

Irregular jointed and porous microstructure; heterogeneous: partly packing of rounded limestone fragments as in C, partly a reddish brown soil mass, composed of clay (asepic or with microcrystalline calcite), quartz grains, fragments of limestone and sandstone and idiomorphic quartz crystals.

Cca 100 - 120 cm.

Brown and pink (7.5YR 5/4 and 7.5YR 8/4) silty clay loam moderate medium and fine crumbly structure; slightly sticky and plastic; friable; abundant fine and medium roots; calcareous; soft poudery lime planes; clear wavy boundary.

Irregular jointed to porous microstructure; heterogeneous; zones of microcrystalline limestone, and pinkish zones of clay and microcrystalline calcite, including fragments of quartz, sandstone, coarse limestone, idiomorphic quartz crystals and nodules of reddish soil material. Some roots.

R 120 cm.

Gypsum rock of different types (red, gray, white); limestone.

More or less fragmented micro-crystalline limestone. In fissures thin cutans of coarse clay or coarse recrystallized calcite; acicular calcite mainly superposed to clay cutans.

Analytical data : table I.

Comments

All horizons are characterized by the presence of limestone fragments and of calcite microlites in the clay

fraction; only in the B C reddish decalcified soil clay is observed. Under this conditions no clay illuviation occurs as proved by the absence of clay cutans , except for the parent rock, where they may have however a relict cha - racter (because they are overgrown by acicular calcite). The microstructure indicates an important biological acti vity in the upper part of the soil.

Discussion

The four profiles under study are subject to an im - portant water erosion, as can be deduced from the field description. From the other hand, analytical data and es_ pecially micromorphology indicate that colluvionation con_ tributed much to the formation of the actual soil material. The increased content of limestone fragments in the Ap horizons of most profiles, and the appearance of clay-li - thorelicts in the Ap of profiles 1 and 3 are significant for this aspect. Also the very marked heterogeneity of the ma terial in thin sections could be attributed to this process. The existence of lithological discontinuities may be a con sequence. As only few traces of pedogenetic activity could be noticed, the soils are considered to be still in a young stage of development partly on relati vely recent co lluvium.

The most active process seems to be the mobilisa - tion of calcium carbonate responsible for the formation of calcite nodules, and the pelitomorphic calcite in the ma - trix. Even with respect to this process the soils seem on_ ly in an early stage of development (SEHGAL and STOOPS 1.972).

The BC- horizons of profile 3 are probably the re - mains of an older, truncated red soil, later covered by colluvial deposits. The B-character of these horizons are thus inherited from the parent material. In a similar way the BC-horizon of profile 4 represent the disturbed and

mixed deeper parts of a former red soil. The difference between the upper and the lower part of the profiles is the result of an addition of colluvial material, and corresponds thus rather to a lithologic discontinuity.

Clay translocation is probably restricted to a mass transport of the clay fraction (coarse and fine) in the top-horizons, maybe as the result of micro-erosion and deposition. It differs from the "real" clay-illuviation by the fact that the translocation is not restricted to the fine clay.

In most thin sections a specific type of quartz grains is observed. They are characterized by well developed geometric boundaries (fig. 5 & 6), i.e. they can be considered as idiomorphic, sometimes hypidiomorphic crystals. They are further characterized by coarse inclusions with birefringence colors of first order (fig. 5). In some cases the grains seem to be corroded by surrounding calcite crystals. Mostly these idiomorphic quartz grains belong to the coarse sand fraction, with sizes ranging between 300 m and 500 μ m. In some horizons they constitute more than 20 % of the coarse fraction (e.g. Prof. 4 BC- horizon : 20 %, Cca- horizon : 28 %).

A detailed survey of the geological substratum with respect to the occurrence of this feature could be of great importance to detect lithological discontinuities in-soils of this region, and interpret colluvial and alluvial apports nearby.

List of Figures .-

Fig. 1 : Schematic geological map of the region with the location of the studied profiles.

Fig. 2 : Typical landscape on Keuper marls in the area of Moron (Sevilla)

Fig. 3 : Contact between the substratum, composed of rock gypsum with an oriented granular (mozaic) structure (lower half) and the soil, containing pedogenic recrystallized lenticular gypsum (upper half). Profile 1, C + R. Crossed polarizers, 12 x.

Fig. 4 : Heterogeneous aspect of B horizon (profile 3). In the lower part of the micrograph the reddish matrix, in the centre a microcrystalline calcitic nodule, in the upper part the yellowish - gray matrix. Plain light, 12 x.

Fig. 5 : Idiomorphic quartz crystals with inclusions (C-horizon of profile 3). Plain light. 80 x.

Fig. 6 : S.E.M.- Pictures of a sandfraction (C horizon of profile 1). Note the difference between the idiomorphic quartz-crystals and the other grains. a: 530 x , b: 550 x.

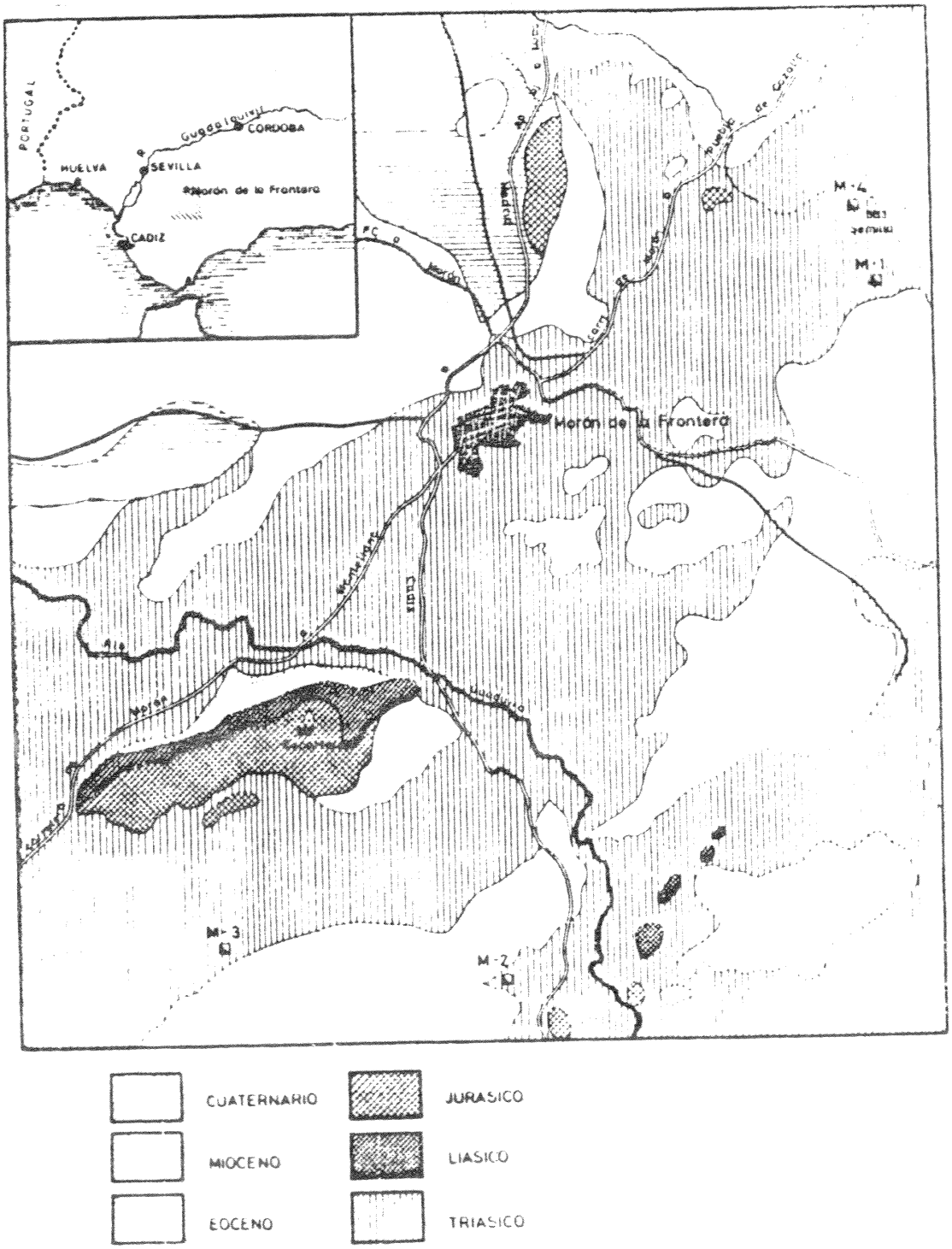
PORTUGAL
Guadalquivir
CORDOBA
HUELVA
SEVILLA
Morón de la Frontera
CADIZ
Morón de la Frontera
M-1
M-2
M-3
M-4
CUATERNARIO
MIOCENO
EOCENO
JURASICO
LIASICO
TRIASICO

Fig. 1

Table I : Granulometric & chemical data →

Horizon	Depth cm	Grain size distribution in % 2000-200 µm	200-20µm	20-2µm	<2 µm
Profile 1					
Ap	0-20	8.6	9.6	42.4	37.0
C	20-50	8.8	9.4	39.6	39.6
Profile 2					
Ap	0-15	8.7	33.6	22.9	33.6
C_1	15-95	6.8	20.6	43.7	28.2
IIC_2	95-195	5.7	16.4	31.5	44.3
Profile 3					
ApB	0-25	9.3	6.4	33.8	50.0
B	25-45	7.4	9.1	29.2	54.3
B C	45-75	19.2	13.4	28.1	39.2
Profile 4					
Ap	0-20	10.6	11.3	29.6	47.3
B	20-40	11.6	10.7	35.1	41.9
BC	40-100	12.4	13.8	28.3	44.8
Cca	100-120	3.2	8.1	52.9	35.6

pH		CEC	$CaCO_3$	O.M.
H_2O	KCl	meq/100g	%	%
7.7	6.9	19.0	20.0	1.00
7.8	6.9	17.0	16.0	0.88
7.5	6.6	12.0	18.8	0.74
7.4	6.5	15.0	7.6	0.65
8.0	6.4	20.0	10.4	0.60
7.7	6.6	18.5	23.6	1.38
7.8	6.5	22.0	26.4	0.74
7.6	6.6	10.5	32.8	0.74
7.4	6.6	20.0	30.0	1.59
8.0	6.5	19.0	30.0	1.16
7.8	6.6	17.0	27.2	0.74
8.3	6.5	20.0	40.0	0.74

RESUMEN

Es objetivo del presente estudio micromorfológico contribuir al conocimiento genético de los suelos desa - rrollados sobre sedimentos triásicos del Sur de España.

Se ha puesto de manifiesto la discontinuidad litológica existente entre dichos suelos y las rocas de yeso subyacentes del Keuper (Triásico superior). Los datos analíticos y especialmente la micromorfología, indican - que el coluvionamiento contribuye en gran manera a la formación del actual material suelo, que se considera en un estadío joven de desarrollo. El proceso más activo parece ser la sustitución del carbonato cálcico, responsable de diversas formaciones calcíticas en la matriz del suelo.

Se ha observado, en la mayoría de las láminas delgadas, un específico tipo de granos de cuarzo caracterizado por bien desarrolladas formas geométricas, que pueden considerarse como cristales idiomórficos y a veces hipidiomórficos. Se ilustran algunas de las características indicadas con microfotografías de láminas delgadas y SEM.

Los suelos estudiados en la catena se han incluido dentro de los grandes grupos Xerorthent (Lithic y Typic) y Xerochrept (Vertic y Calcixerollic).

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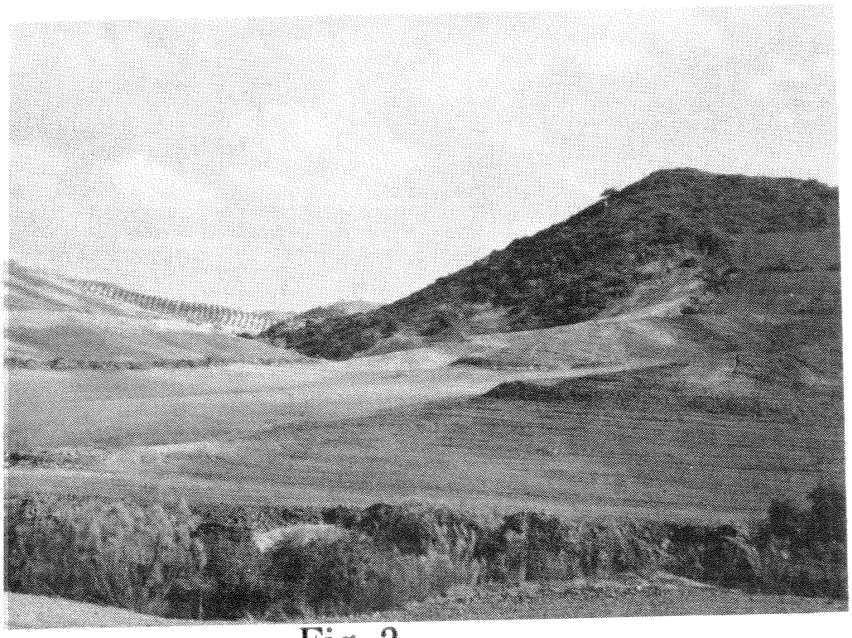

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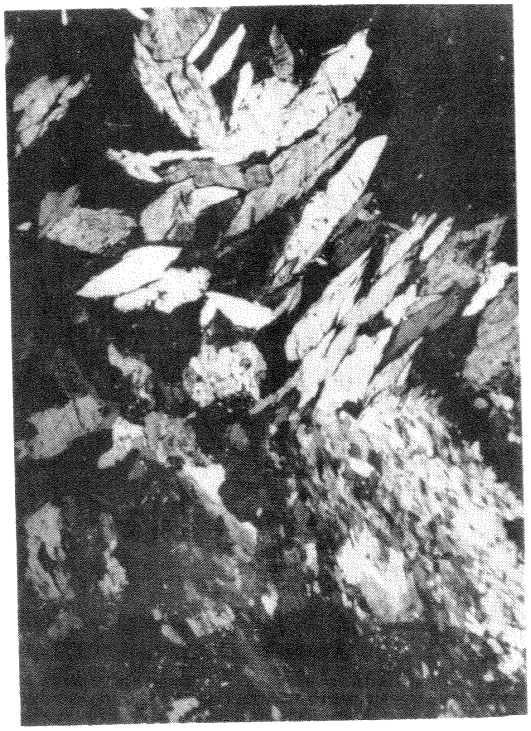

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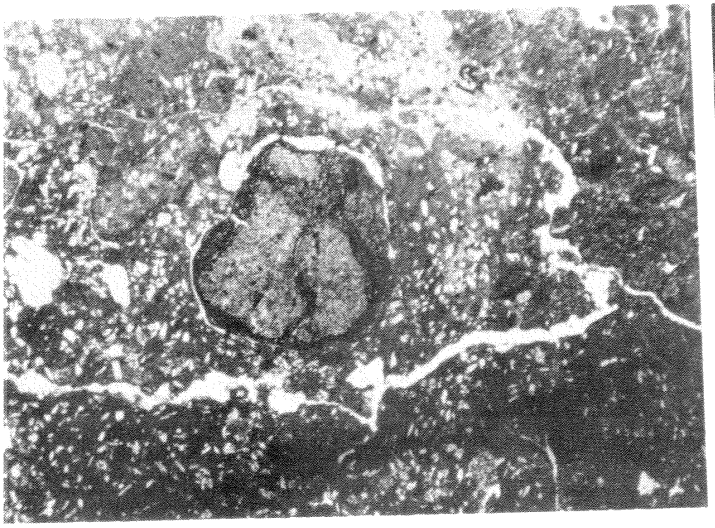

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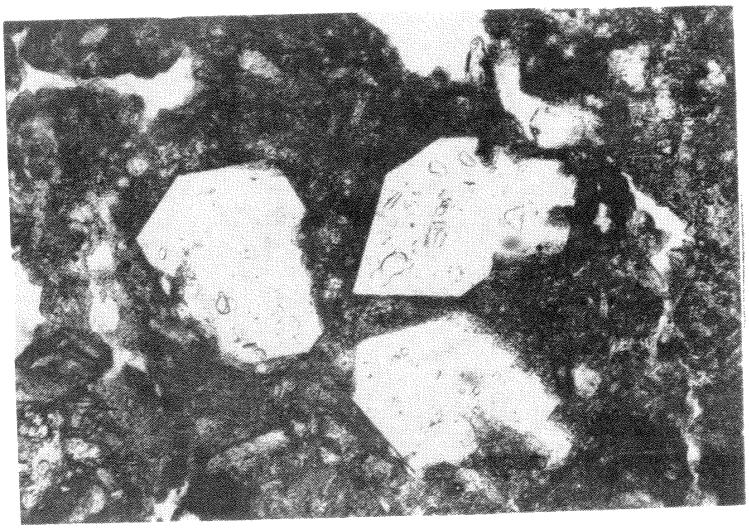

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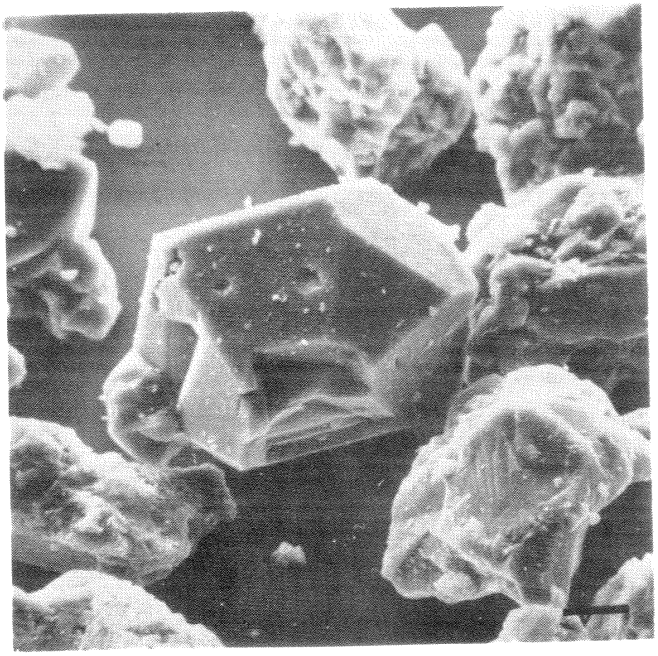

Fig. 6-A

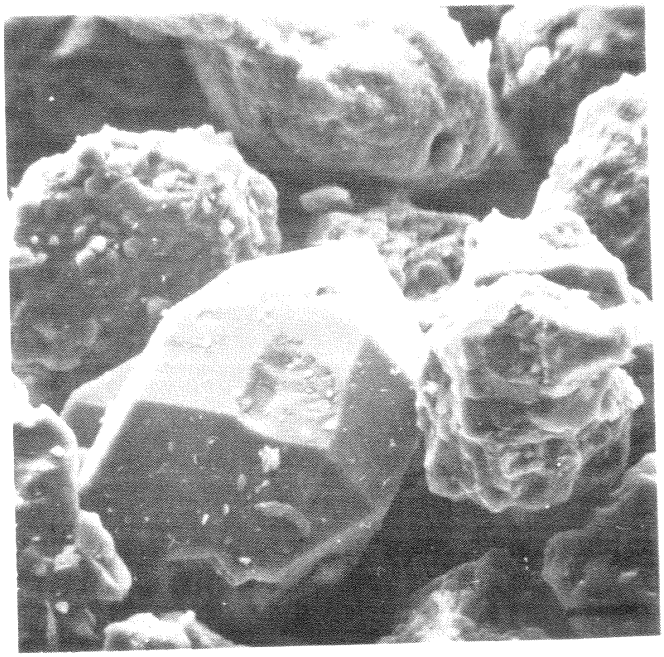

Fig. 6b

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