MODIFICATIONS OF THE SIZE AND DISTRIBUTION OF SOIL MACROPORES INDUCED BY SOME MICROBIAL - DEXTRANS

by

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INTRODUCTION.

Many soil scientists have already shown the effectiveness of polysaccharides in binding soil particles into more stables aggregates but some aspects of the modifications of physical properties of the aggregates have not been fully clarified. A previous study on the conditioning effect of microbial dextrans added to natural soil aggregates (Pagliai, Guidi and Petruzzelli 1976) has shown that a water stability index of soils, determined by wet-sieving, improved with the increasing molecular weight of the used dextrans.

The purpose of this paper was to investigate, by micromorphological techniques, other modifications, like porosity, induced in clay soils by bio-polymers. Actually porosity is one of the most important physical properties of soils, expecially from the agronomic point of view, and strongly influences the seed bed preparation, seedling emergency and crop yield, overall in clay soils. A full knowledge not only of the total porosity, but also of the pore size distribution, may give a thorought insight into the influence of biological activities as well as the effect of factors like swelling and shrinkage, on soil formation and properties.

MATERIALS.

The soils used were taken from the A1 horizons of

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two Italian clay soils at different location. Field samples of each soils were thoroughly mixed and then sieved to obtain the 1-2 mm fraction. In all cases the soils contained appreciable amounts of aggregates of this size and no crushing was required.

The dextrans were supplied by Pharmacia Fine Chemicals, Sweden, and used without any other purification. Their molecular weight was 10, 000 for T-10, 500, 000 for T-500 and 2, 000, 000 for T-2000. Other characteristics of soils and polymers used have been reported previously (Pagliai, Guidi and Petruzzelli 1976).

METHODS.

Samples (40 g) of the two soils were moulded with aqueous solution of the dextrans (40 ml) until they became fluid and were then poured into cubic boxes (4x4x4 cm). The concentration of the added dextrans was 0. 5% on a dry basis. Control trials were performed using water alone. Samples were then air-dried at constant temperature (25 º C). Trials were performed in triplicate.

Thin sections were prepared by usual procedures.

Using an electro-optical procedure (Petruzzelli, Guidi and Sequi, 1976) porosity was investigated in thin sections by a Leitz Classimat apparatus, which is similar to Quantimet B previously used by Jongerius, Schoonderbeek, Jager and Kowalinsky, (1972).

A Leitz plus-contrast coating chamber was used to enchance a sufficient contrast between voids and quartz grains, which have almost the sâme optical intensity, by coating the surface of investigated objects with particles originating in a iron cathode. The whole process takes place in the presence of a gas discharge, in this case oxygen. The procedure gives different colours to the different chemicals components of the thin sections and allows an excellent detection of voids, also by means of trasmitted light.

With the help of an "elimination circuit", the Classimat can determine the distribution of pores area in a fully automatical way. Size classes of 65 µm width were selected in measuring the frequencies of the percentage area of pores. Besides, the connected desk calculator displays the following statistic parameters :
Percentage area content.
Particle number per unit area.
Mean value of length, height, area and volume of particles.
Form factor.
Since the form factor (the ratio of the mean length to the mean height of the particles) is one for round pores, the value of this parameter can help to understand the pore orientations in soil. (Heinrich 1972).

Pores measurements were carried out with a 2.5 × objective. A 1.7 × 1.1 mm^2 measuring field was set by means of a stage micrometer. This evaluated measuring field is represented in Figure 1. The mean value for the three replicates of each sample were given directly by the desk computer

RESULTS AND DISCUSSION

High differences in porosity and pore size distribution were always found in treated samples with respect to the untreated ones (Tab. 1).

The percentage area of total porosity of the untreated Vicarello soil was very low (1.1 %). The total porosity strongly increased after T-10 treatment (17.6 %) whilst decreased after T-500 and T-2000 addition (5.2 and 2.9 % respectively).

The same pattern was observed for La Cardosa soil.

From the low value of the control sample (3.1%) the percentage area of total porosity reached a maximun after treatment with the T-10 (41.4 %) and decreased after treatment with T-500 (6.2 %) and T-2000 (5.9 %) until about twice the original value.

The pore size distribution in control samples of Vicarello soil showed little difference with respect to samples treated with T-500 and T-2000 (Fig. 2 a, c, d). On the contary it changed considerably in samples treated with T-10. In fact in this case pores larger than 585 µm accounted alone for more than 50 % of the total area (Fig. 2.b).

Samples of La Cardosa soil treated with T-10 (Fig. 3 b) behaved in the same way as Vicarello T-10 treated samples, even though the porosity distribution in control samples was very different for the two soils. Noticeable differences were also found among La Cardosa control samples and those treated with the other two polymers (Fig. 3 a, c, d,). In fact in control samples the maximum contribution to the total area was given, above all, by the pores of mean diameter until 65 µm while in samples treated with either T-500 or T-2000 pores were distributed in all classes and the highest frequencies were found for pores until 130 µm and those larger than 585 µm.

Vughs and interconnected vughs were predominant in both soils treated with T-10 (Fig. 4 and 5). In samples of La Cardosa soil, treated with T-500 and T-2000, the presence of vesicles, which have a banded distribution pattern parallel to the surface, was also noticed (Fig. 6). Pictures for all other samples are not reported because pores were exclusively small and subsferical.

In table 1 other parameters, that allow a better understanding of previous data, are reported. For example figures of control samples of the two soils show great difference between the number of pores per mm^2 of the two soils (12.9 and 131.0 for Vicarello and La Cardosa respectively) and the mean value of area, volume, length and height of pores (all higher in Vicarello soil). Considering the pore size distribution reported in Fig. 2a and 3a, for La Cardosa soil, the total porosity was practically given by pores belonging only to a dimentional class (0-65 μm) while for Vicarello soil the total porosity was lower and pores were distributed in more dimentional classes. This fact explains the lower density of pores per mm^2 and the higher mean value of area, volume, length and height of pores of Vicarello soil with respect to La Cardosa soil.

In both soils treated with T-10 the number of pores per mm^2 decreased and both the percentage area of pores and the mean value of area, volume, length and height of pores increased, therefore indicating that the maximum contribution to the total porosity was given by pores belonging to different dimentional classes, i.e. pores larger than 585 μm instead of smaller than 130 μm.

It seems reasonable to conclude that our methodological approach has been found suitable for studying variations occurring when some physical properties of soil were modified by addition of organic substances. Besides classical micromorphological observations, modifications can be quantified and integrated with other accesory parameters by using the electro-optical procedure.

Table 1 - Analytical parameters of soil pores as determined by Leitz Classimat.

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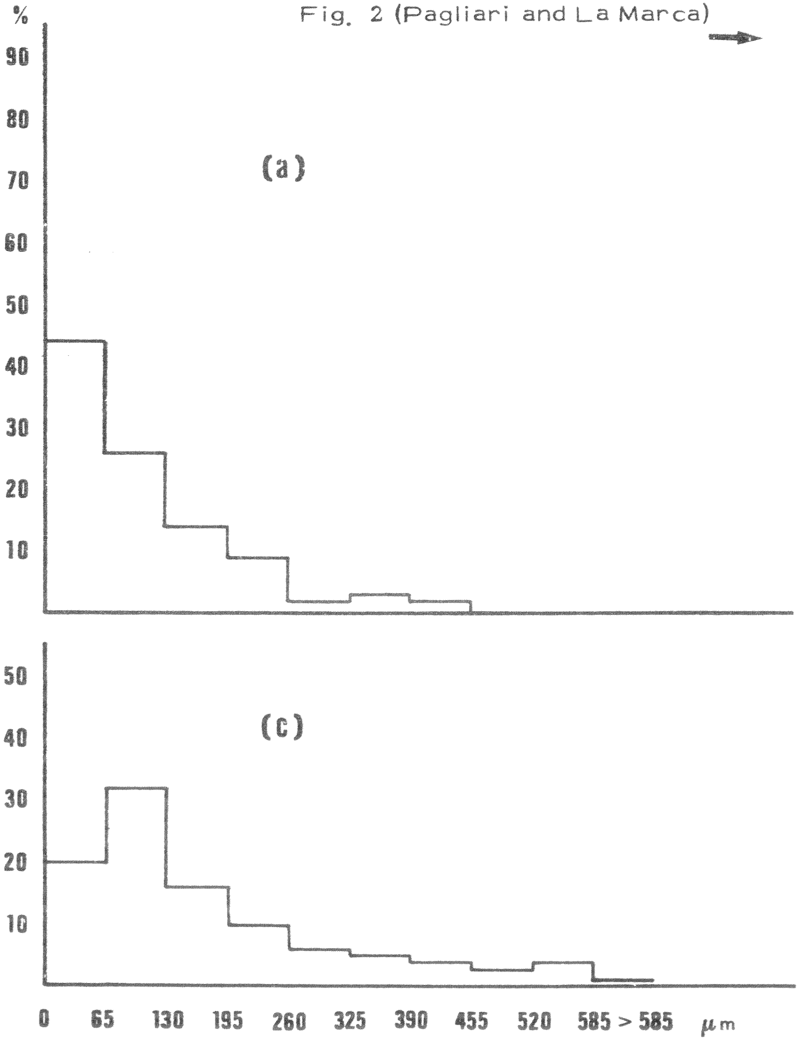
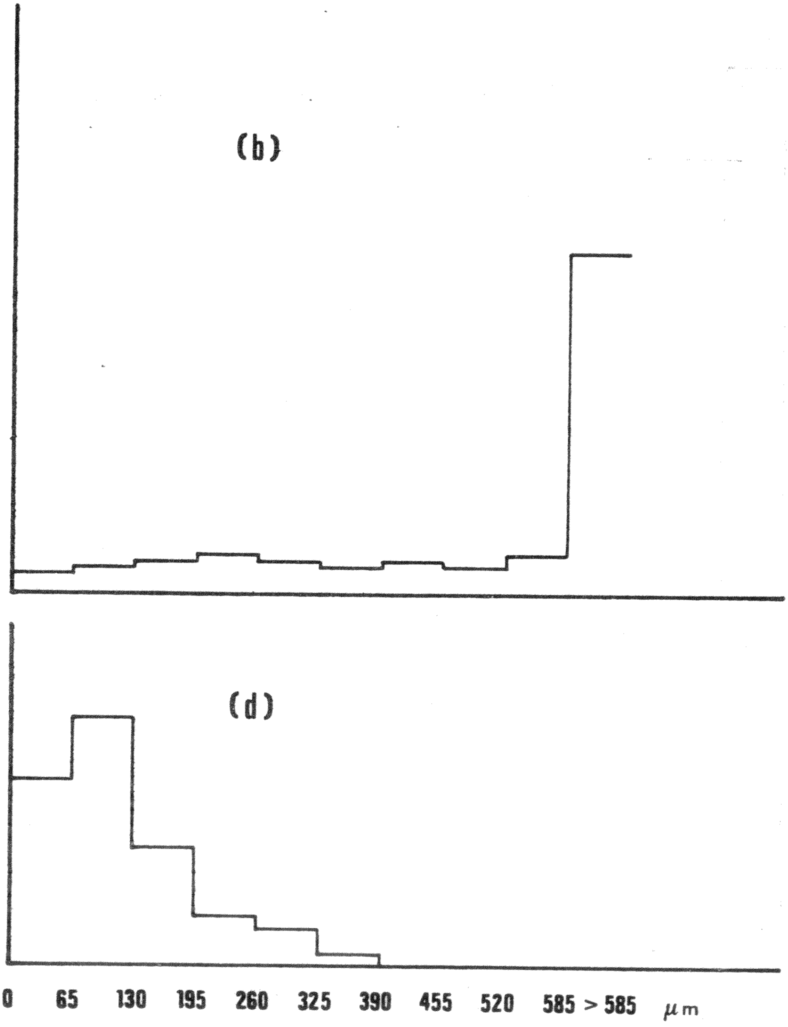
	VICARELLO			
	Type of added dextran			
	Control	T-10	T-500	T-2000
Percentage area of pores	1.1	17.6	5.2	2.9
Number of pores per mm^2	12.9	10.1	18.2	20.8
Mean value of pores area (μm^2)	0.8×10^3	17.4×10^3	2.8×10^3	1.4×10^3
Mean value of pores volume (μm^3)	0.04×10^6	3.6×10^6	0.2×10^6	0.08×10^6
Mean value of pores lenght (μm)	22.4	62.5	27.5	24.1
Mean value of pores height (μm)	18.1	60.8	26.5	23.4
Form factor	1.24	1.02	1.03	1.02

LA CARDOSA

Type of added dextran			
Control	T-10	T-500	T-2000
3.1	41.4	6.2	5.9
131.0	42.2	35.8	23.7
0.3×10^{3}	9.3×10^{3}	1.7×10^{3}	2.6×10^{3}
0.008×10^{6}	1.5×10^{6}	0.1×10^{6}	0.2×10^{6}
14.8	42.3	21.6	30.4
14.8	42.9	23.5	22.9
1.00	0.99	0.92	1.32

Fig. 2 (Pagliari and La Marca) →




(b)
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65
130
195
260
325
390
455
520
585
> 585
µm

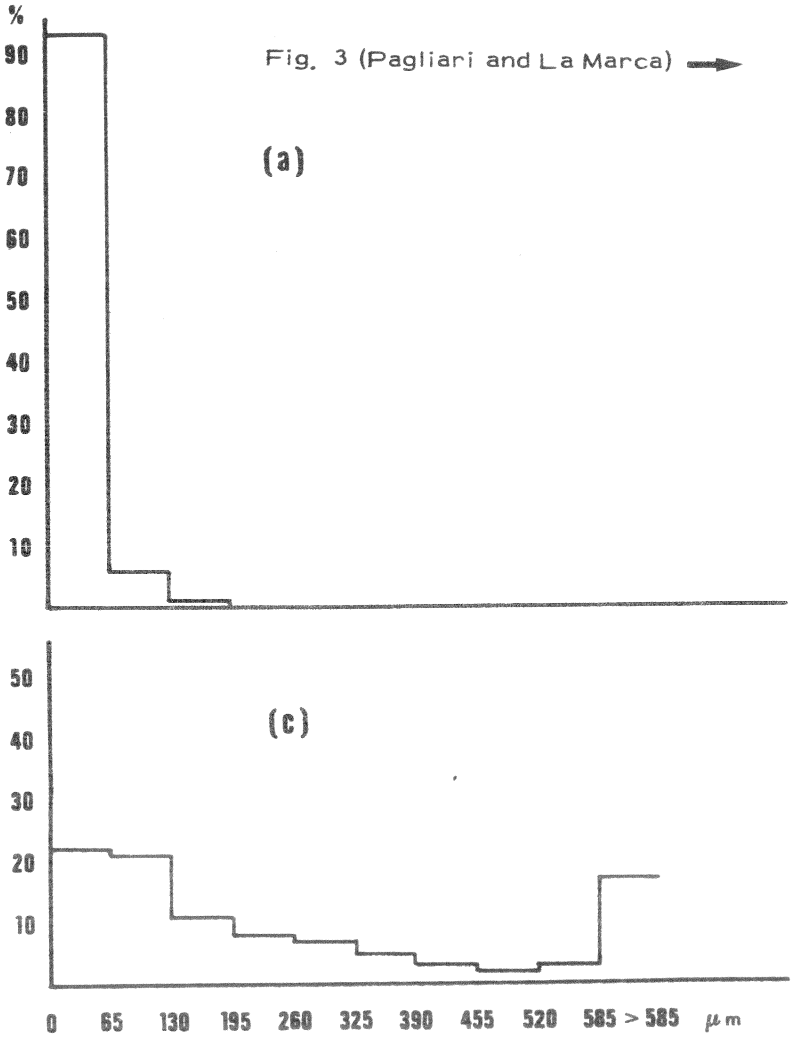
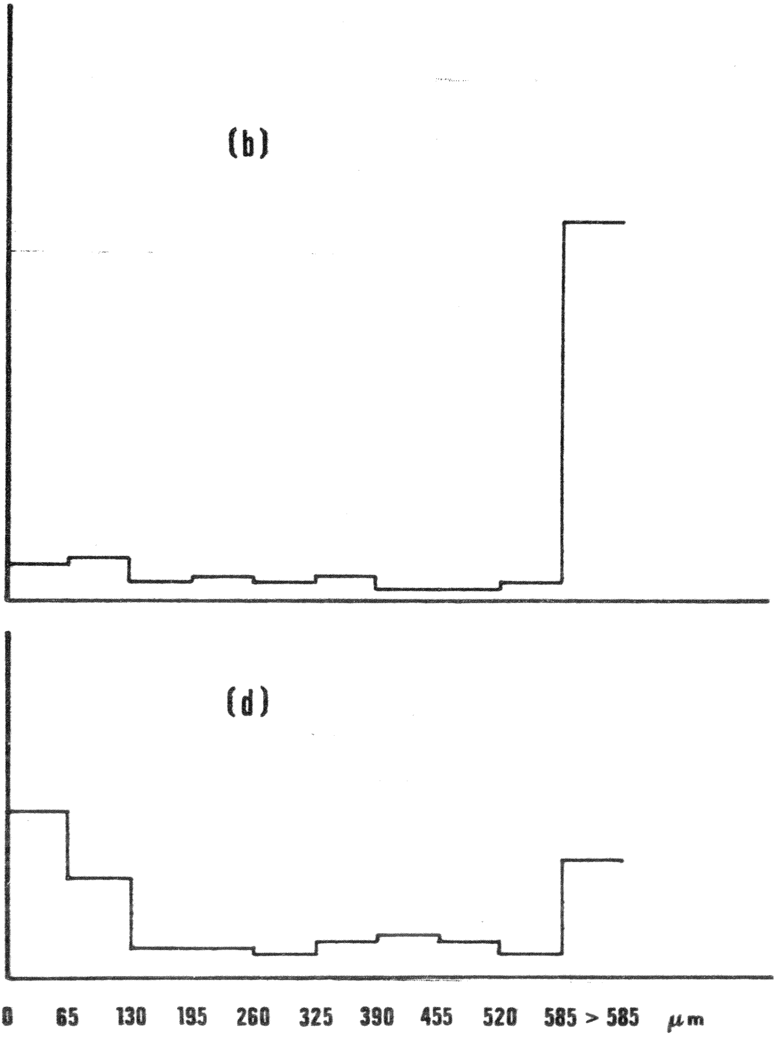


Fig. 3 (Pagliari and La Marca) →


(b)
(d)
0
65
130
195
260
325
390
455
520
585 > 585
μm

CAPTION TO FIGURES

Fig. 1. - Photograph of the evaluated measuring field.

Fig. 2. - The pore size distribution of Vicarello soil (a) without addition of dextrans and after addition of (b) T-10, (c) T-500, (d) T-2000 dextrans.

Fig. 3. - The pore size distribution of La Cardosa soil (a) without addition of dextrans and after addition of (b) T-10, (c) T-500, (d) T-2000 dextrans.

Fig. 4. - Characteristic pores in samples of Vicarello soil treated with T-10 dextran. (a) crossed polarized light; (b) plain light.

Fig. 5. - Characteristic pores in samples of La Cardosa soil teatred with T-10 dextran. (a) crossed polarized light; (b) plain light.

Fig. 6. - Vesicles of samples of La Cardosa soil treated with T-500 dextran. Crossed polarized light.

SUMMARY

Changes in the total porosity and pore size distribution due to treatment of microbial dextrans on two Italian clay soils were studied by micromorphological techniques. Molecular weight of dextrans ranged from 10,000 to 2,000,000. The measurements were carried out with a Leitz Classimat apparatus using an electro-optical procedure. Besides, a Leitz plus-contrast coating chamber was also used to produce a sufficient contrast between voids and quartz grains, so that voids could be detected also by means of transmitted light.

Noticeable differences were found both in the total porosity and in the pore size distribution between treated and untreated samples.

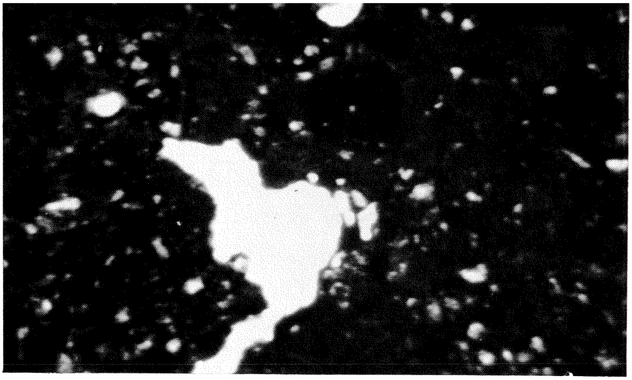


Fig. 1

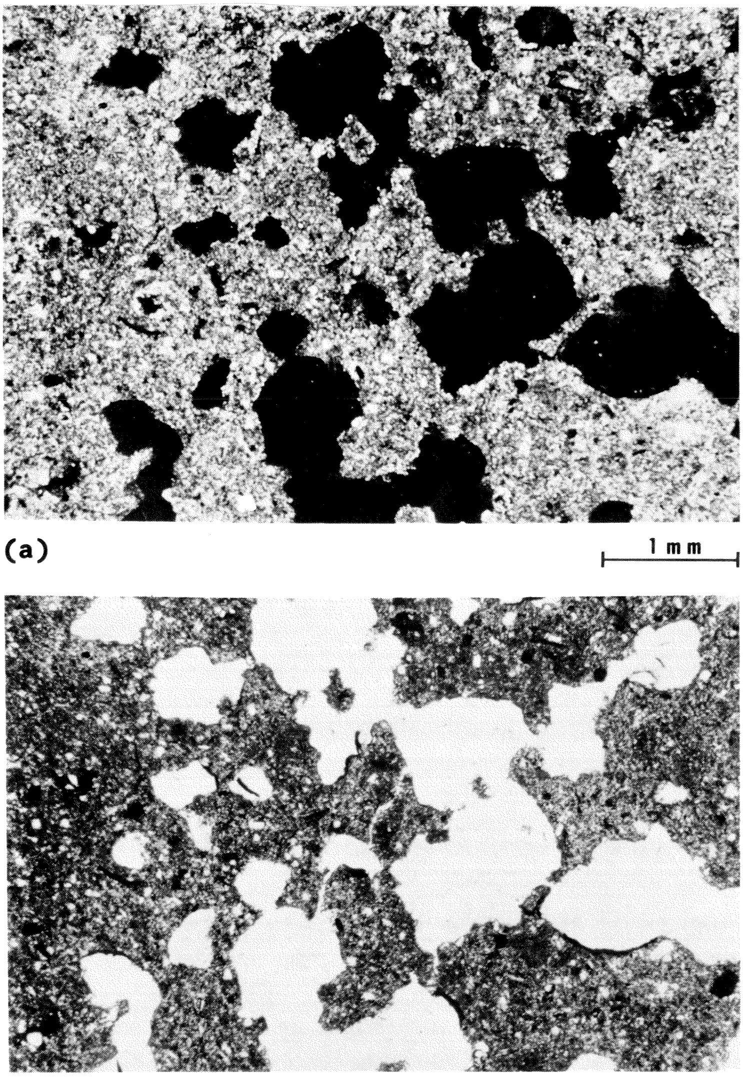


Fig. 4

Fig. 5

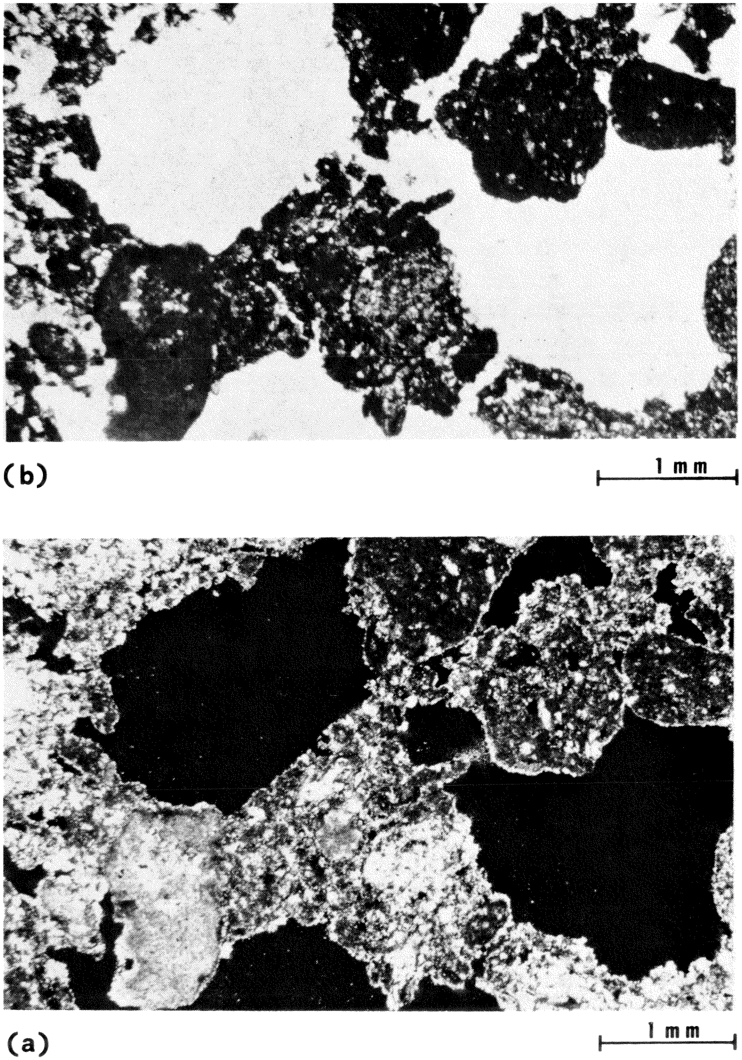
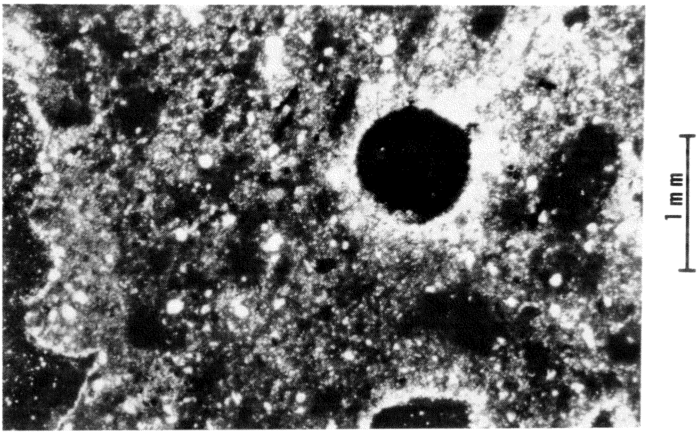


Fig. 6



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