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The Occurrence of Vitric Tuff in Quaternary Deposits of Gljev in Dalmatia (Southern Croatia)

Ante **ŠUŠNJARA**, Biserka **ŠĆAVNIČAR** and Anto **GABRIĆ**

Key words: Vitric tuff, Quaternary deposits, Heavy minerals, Transport by wind, Gljev, Dalmatia, Croatia

Abstract

For the first time in the Dinaric region of Dalmatia vitric tuff has been discovered in the clayey Quaternary deposits. Petrographic, heavy mineral and X-ray analyses revealed fine volcanic ash, illitic material (as an alteration product of glass shards), rare feldspar grains and an abundance of monoclinic pyroxene in the heavy mineral fraction. Pyroclastic quartz grains were not observed. It is postulated that explosive volcanism of basic or neutro-basic character occured and the finest particles were transported over a large distance by wind. From the heavy mineral composition the investigated tuff differs from the underlying and overlying Quaternary clay sediments, as well as from the tuffs found in Neogene deposits of Central Dalmatia.

1. INTRODUCTION

In the central part of Dalmatia in the area of Gljev (NE of Sinj) tuff has been discovered within the Quaternary deposits at three localities. This is the first discovery of Quaternary tuffs at outcrop in the Dinaric region of Croatia (Fig. 1).

The bauxite bearing area of Gljev is dominantly composed of Upper Cretaceous Rudist limestones and younger Palaeogene Foraminifera limestones (forming the foot-wall), and of the clastic-carbonate "Promina" deposits of the younger Palaeogene (forming the hanging-wall) of the bauxite deposits. The Quaternary sediments, which occupy morphological depressions, consist of gravels, sands and carbonate-rock fragments, overlain by clay sediments and terra rossa. Numerous outcrops and deposits of bauxite have been established and investigated in the same area.

For the first time well-bedded tuff has been found at outcrop at the top of the south-east steep slope of the "Jagnjića dolac" bauxite body. Here, the Upper Cretaceous limestones are overlain by terra rossa deposits with an interstratified tuff bed (Fig. 2). During bauxite exploitation, and partially due to erosion, a profile through the Quaternary deposits in Jagnjića dolac has been opened.

The tuff is 1.5 m thick. Rudist limestones (2-3 m thick) at the base of outcrop, have a very karstified upper surface. In small depressions, 20-40 cm thick layers of sandy and bauxitic clay have been deposited. This is overlain by 3 m of terra rossa with interstratified tuff beds (Fig. 3). Sharp flat boundaries separate the tuff from the terra rossa.

In the vicinity of Jagnjića dolac, at Močare and Čačijin dolac, two new deposits of the same tuff, lying subhorizontally within the terra rossa deposits, have been observed.

Tuffs are represented mostly as thin lenticular bodies, gently thickening towards the centre of the sedimentary environment, where other Quaternary products also accumulated on the karstified carbonate bedrock.

2. ANALYTICAL RESULTS

Petrographic, heavy mineral and X-ray analyses showed that the tuff from the three localities has the same mineralogical composition, as well as identical structural and textural features.

The tuff has an earthy, pelitic appearance and varies in colour from white to grey-white. Thin-section analyses allow identification of a very fine-grained vitric tuff (Pl. 1, Figs. 1 and 2), composed of cellular, flattened and gently arcuate shards, typical of volcanic ash. The majority of vitric particles are partially or completely altered to a cryptocrystalline and microcrystalline clay mineral, unfavourable for microscopic determination. In thin-section this clay mineral has low interference colours and frequently occurs along the borders of the vitric shards. When volcanic ash particles are completely altered into clayey material, the original outlines (ghosts) of ash shards may be seen, well preserved in thin-section, providing evidence for an authigenic origin of the clay mineral. Volcanic crystaloclasts are dispersed as very small grains and belong mainly to feldspars. Pyroclastic quartz grains have not been established with certanity. Accessory heavy minerals which were noted in thin sections of the tuff, have been analysed and separately determined in the heavy mineral fraction.

Heavy mineral analyses highlight further significant features of the tuff (Table 1). The most abundant and important transparent heavy mineral is pale green monoclinic *pyroxene* (Pl. 2, Figs. 1 and 2). It is more frequently represented by elongate prismatic or needle-like

Institute of Geology, Sachsova 2, 41000 Zagreb, Croatia.

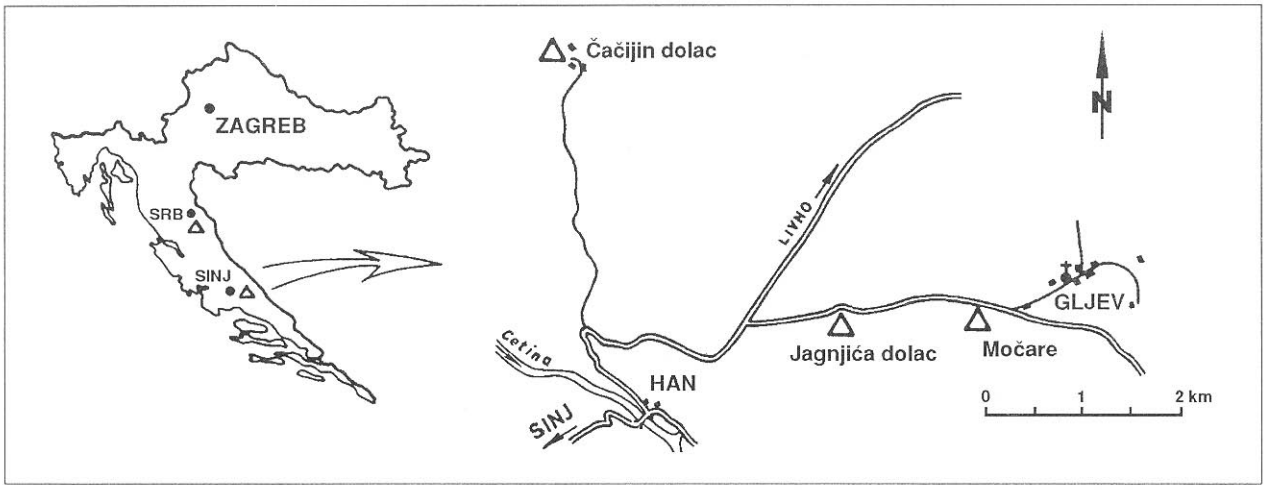

Fig. 1. Location map of the Quaternary tuff occurences.

crystals, with or without terminal plates. Sometimes the crystals contain glassy inclusions. Pyroxenes rarely occur as irregular or broken grains. Green *biotite* (Pl. 2, Fig. 3) is a common heavy mineral, but always in subordinate quantities. It is ordinarily present as irregular flakes, but sometimes the hexagonal shape is preserved. *Apatite* is consistently present in short prismatic grains with acicular glassy inclusions. Other heavy minerals, including *chlorite*, *rutile*, *zircon*, *amphibole*, *garnet*, *epidote* and *zoisite*, can be found sporadically, as rare grains. Elongate prismatic carbonate grains, found only in the tuff of Čačijin dolac locality, belong to authigenic *aragonite*. Opaque grains (not counted) comprise *magnetite*, *limonite* and *ilmenite*.

In the light fraction (Table 2) clay mineral particles predominate, with unaltered or partially altered particles of volcanic ash. Partial alteration, of optically isotropic, vitric shards of volcanic ash, into microcrystalline, optically anisotropic, clay minerals excludes a detrital origin for the clay mineral. Small, fresh, prismatic feldspar grains are also present. Rare quartz grains present are probably detrital impurities, although their origin is not established with certainty.

Optical determination of the heavy and light mineral fractions was confirmed by X-ray powder diffraction (Philips diffractometer, Cu-radiation, graphite monochromator). A very sharp diffractogram of the heavy fraction could be interpreted as belonging mainly to *diopside* with the relative reflection intensities and interplanar distances approaching the data of Card 11-654 of the Powder Diffraction Files (JCPDS, Philadelphia, 1972). *Biotite* was also recognised.

The light fraction of a sample, as determined from the powder diffractogram, contains *potassium feldspar* - intermediate orthoclase to sanidine, *plagioclase* and *micas*, whose broad reflection and absence of swelling with ethylene glycol indicates illitic material.

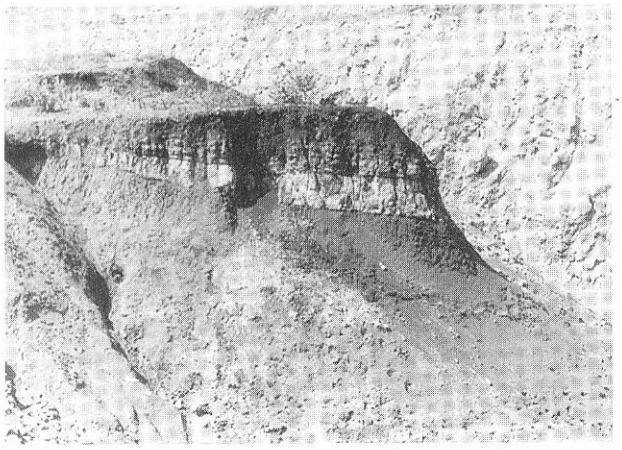

Fig. 2. Open outcrop at the Jagnjića dolac location.

3. COMPARISONS

The heavy mineral composition the explored tuff differs distinctly from the underlying and overlying Quaternary clay sediments (terra rossa, clay, sandy clay). These terrigenous sediments have another and more complex heavy mineral assemblage due to their heterogenous origin (Table 3). Among their transparent heavy minerals a group of zicron-tourmaline and a group of metamorphic minerals are prominent. It was observed that authigenic tourmaline occurs as well as the secondary growth of colourless or green tourmaline on the abraded detrital core of green or brown tourmaline.

The light fraction of the terra rossa and sandy clay is also different, again frequently containing (besides different clay components) a considerable amount of detrital quartz and carbonate grains (Jagnjića dolac), subangular feldspar grains, some muscovite flakes and rock particles (chert, schists, quartz-bearing rocks).

The physical features of the heavy and light minerals in the Quaternary clay sediments vary from anhedral, subrounded and subangular grains to angular grains and from broken to euhedral crystals. It is common to see corroded grains of some heavy minerals, such as amphiboles, pyroxenes and garnets. Sometimes authigenesis of quartz and secondary growth on the abraded detrital quartz grains may be observed.

Locality	Sample	co	bi	py	ap	zr	ru	am	g	st	cy	ep	zt	carb
Jagnjića dolac	JD-7	+	11	71	13	2	2	+	+	-	-	-	-	-
Jagnjića dolac	JD-7/1	1	12	78	7	+	+	1	+	+	+	+	-	-
Čačijin dolac	ČD-1	4	17	51	7	-	+	1	3	-	-	2	3	11
Močare	Mo-1	+	4	89	6	-	-	-	1	-	-	+	+	-

Table 1. Transparent heavy minerals from Quaternary tuffs of Gljev (number of grains in %). Legend: co - chlorite; bi - biotite; py - pyroxene; ap - apatite; zr - zircon; tu - tourmaline; ru - rutile; am - amphibole; g - garnet; st - staurolite; cy - kyanite; ad - andalusite; ep - epidote; zt - zoisite; ct - chloritoid; ti - titanite; an - anatase; br - brookite; crsp - chrome-spinel; carb - carbonate grains; q(d?) - quartz (detrital?); f - feldspar; pel - pelitic particles; vi - vitric particles; - - trace; + - few; ++ - enough; +++ - considerable.

Locality	Sample	q(d?)	f	pel	vi
Jagnjića dolac	JD-7	+	-	+++	++
Jagnjića dolac	JD-7/1	1	+	+++	++
Čačijin dolac	ČD-1	4	+	+++	+
Močare	Mo-1	+	+	++	++

Table 2. Light fraction from Quaternary tuffs of Gljev (participation of light minerals, pelitic and vitric particles). For legend see Table 1.

Locality and sediment type	Sample	co	bi	zr	tu	ru	ap	am	g	st	cy	ad	ep	zt	ct	ti	an	br	py	crsp
Jagnjića dolac - terra rossa	JD-7	-	-	24	12	6	7	-	18	-	+	-	13	10	1	5	1	-	-	2
Jagnjića dolac - terra rossa	JD-5	2	1	20	8	6	1	13	8	3	-	1	16	3	+	3	+	-	9	5
Jagnjića dolac - sandy clay	JD-8	1	1	11	5	5	8	15	13	1	+	-	13	8	+	3	-	+	9	6
Jagnjića dolac - sandy clay	JD-10	+	-	21	28	5	3	1	9	1	2	2	16	5	-	3	+	-	+	1
Jagnjića dolac - clay	JD-11	5	+	15	15	8	2	+	15	1	1	-	15	5	1	2	1	-	+	3

Table 3. Transparent heavy minerals from Quaternary sediments of Gljev (number of grains in %). For legend see Table 1.

The above data indicate that the composition and characteristics of accessory minerals in clay sediments of Gljev are clearly distinct from the accessory minerals found in the described tuff.

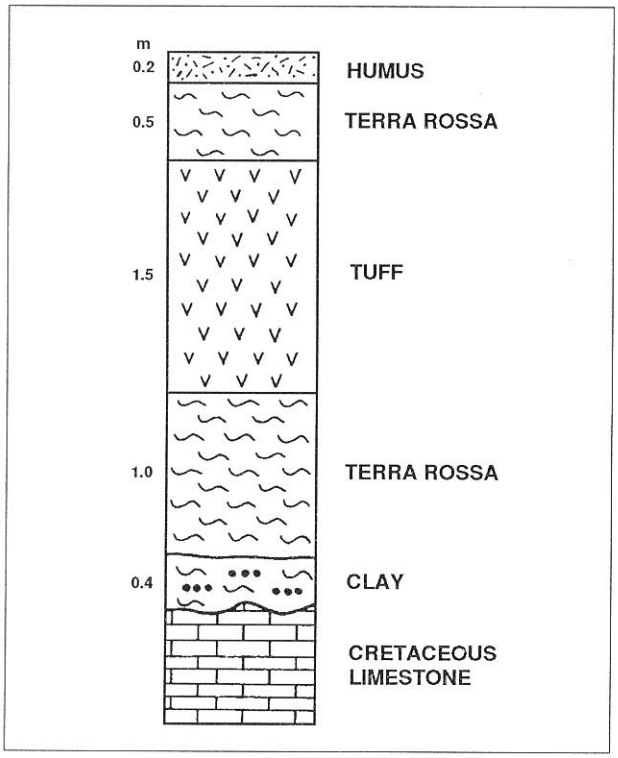

Fig. 3 Lithologic column.

In the region of Lika in the area of Kunovačko Kupirovo, to the south of Srb, Permian evaporites and clastic rocks, as well as clastic rocks of the Triassic are developed over a large area (ŠUŠNJARA et al., 1992). They are covered to a great extent by different Quaternary deposits. Beneath a small accumulation of talus, a small outcrop of light yellow-grey, vitric tuff has been found. In a thin-section of one sample optically isotropic volcanic ash was discovered with rare, very fine-grained, pyroclasts which were unfavourable for microscopic determination. The accessory heavy minerals are different to the heavy mineral association in the described tuff of Gljev. Further investigation of the Kupirovo tuff is continuing.

The explored tuff of Gljev differs from tuffs described in the Neogene deposits of many localitites in Central Dalmatia (ŠUŠNJARA & ŠĆAVNIČAR, 1974). Distinctions exist in their structural and textural features, mineral composition, products of devitrification and in their heavy-mineral assemblages.

4. CONCLUSION

Investigation of the vitric tuff, interstratified in the Quaternary clay sediments around Gljev, revealed it to be composed of very fine-grained volcanic ash. Partial or complete alteration of vitric particles to illitic material is frequently observed. Feldspar grains were observed, and determined by X-ray diffraction as potas-

sium feldspar (intermediate orthoclase to sanidine) and plagioclase. Quartz grains of pyroclastic morphology were not precisely determined in thin-sections. Some anhedral quartz grains were observed in separated light fractions. Quartz has not been determined by X-ray analyses.

An abundance of pyroxene (diopside) in the heavy mineral fraction may be important for genetic interpretation. The tuff is probably a product of explosive volcanism of basic to neutro-basic character. The finest particles could have been transported by wind over a large distance. It may be supposed that the volcanic ash was derived from the volcanos of Southern Italy. This assumption can be supported to certain degree by the similar character of the heavy and light fractions of Quaternary tuffs from the Adriatic Sea (VAN STRAATEN, 1967; DAMIANI, 1965). However some others source areas can not be excluded.

As noted earlier the heavy fraction of the tuff (Table 1) differs essentially, by their mineral composition and physical features, from the more heterogenous heavy fractions of terra rossa and clays of the same localities (Table 3).

Significant differences in mineral composition also exist between the tuff of Gljev and tuffs found in Neogene deposits in Dalmatia.

Fine volcanic ash carried by wind currents was partly deposited on the plateau in the region of Gljev. The preserved occurrences of tuff are found on the sites of small, shallow lakes with underlying clayey terra rossa sediments. This explains the purity and the original composition of the tuff.

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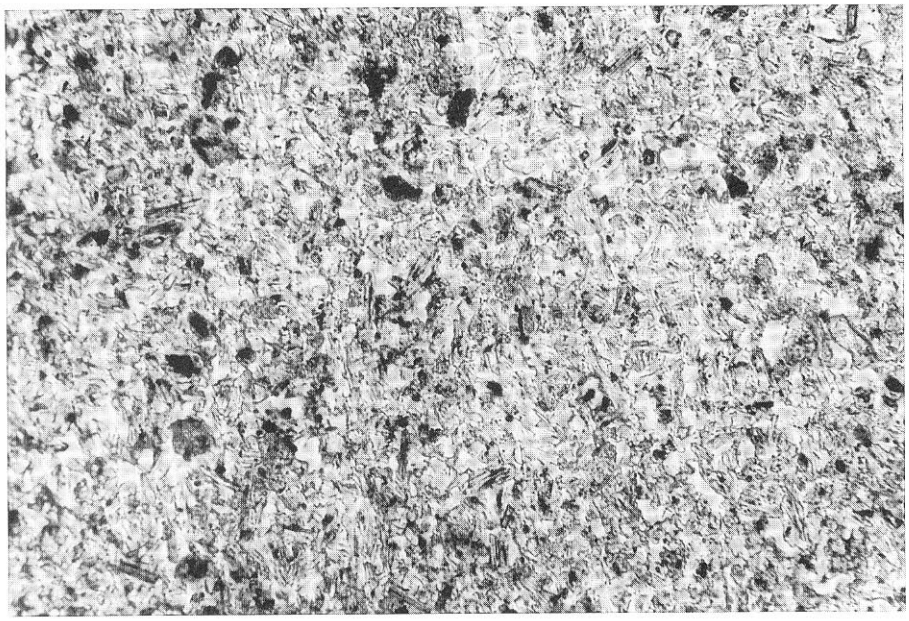
PLATE I

1 and 2 The texture of vitric tuffs at the Jagnjića dolac location.

PLATE II

1, 2 and 3 Heavy minerals from the tuff samples at the Jagnjića dolac location.



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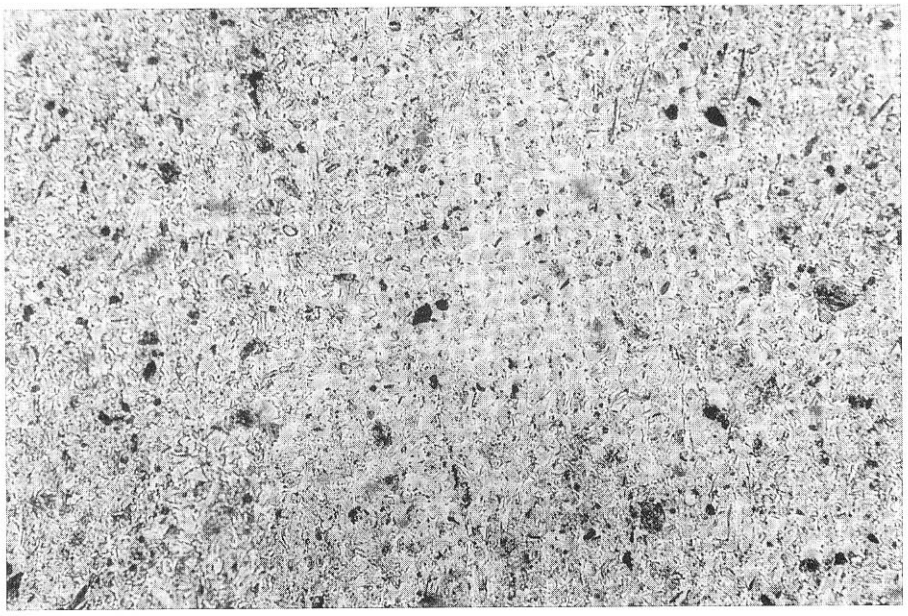

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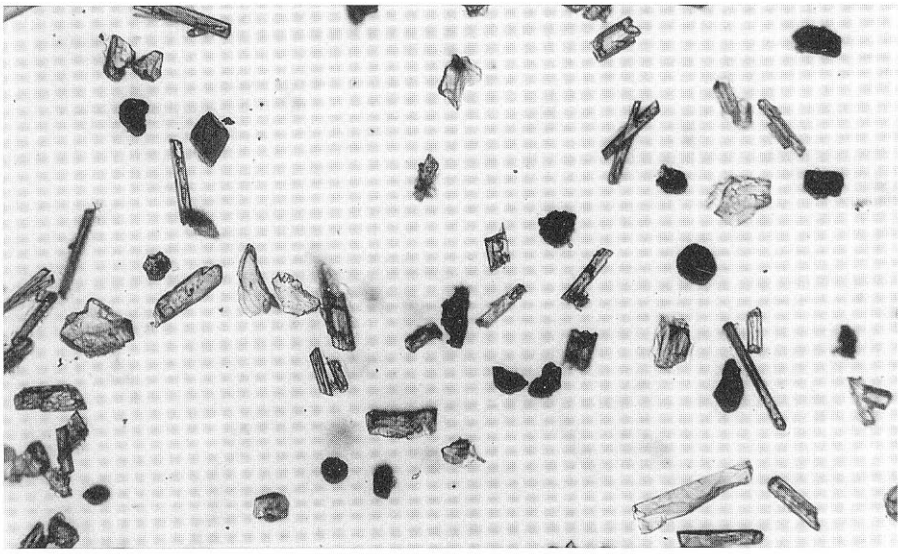

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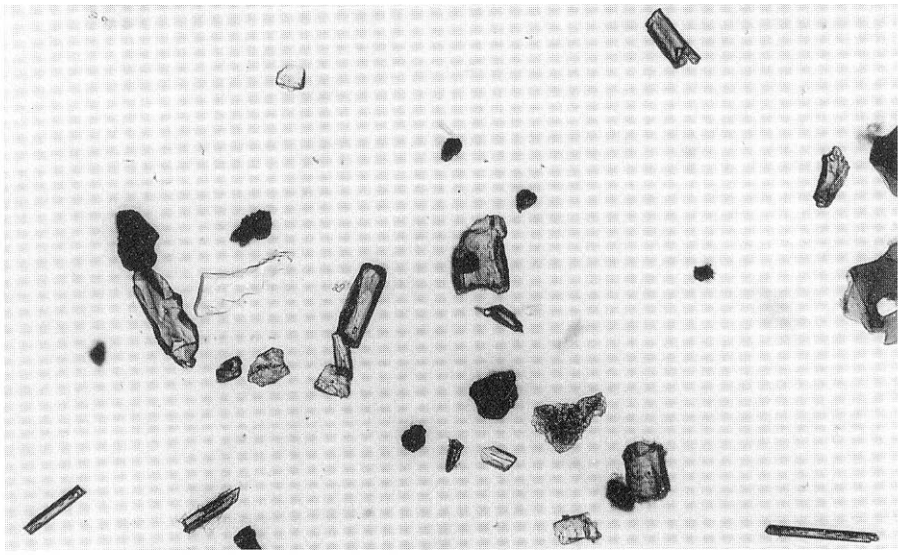

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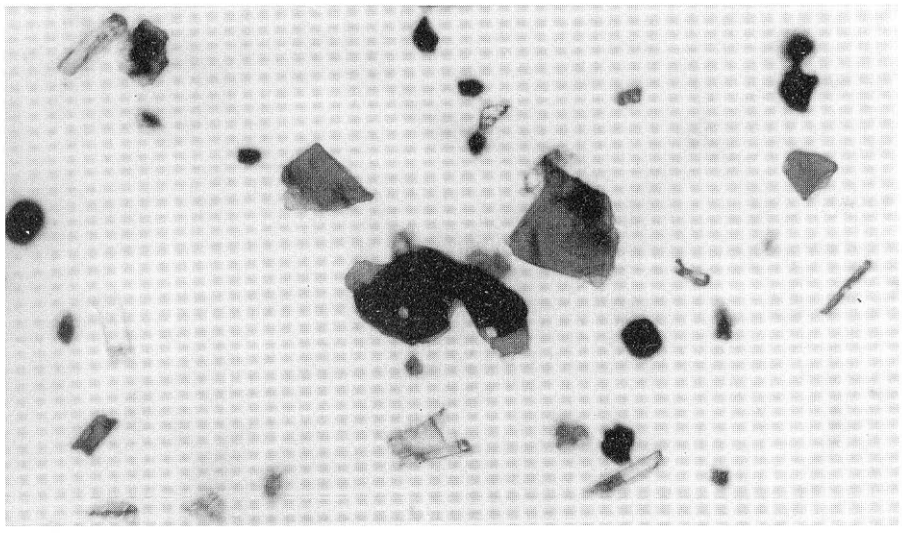

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