

PROTEROZOIC MICROFOSSILS FROM THE SEDIMENTARY ROCKS OF THE LAPPAJÄRVI IMPACT CRATER

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The Proterozoic microbiota of acritarchs is reported from the siltstone deposit of Lappajärvi. Diversity is low, with sphaeromorphs dominating the taxa, which also includes some coenobial and ovoidal specimens and a fragment of filament. The undisturbed structures and horizontal layering of the sedimentary rocks and the good state of preservation of the microfossils indicate that the siltstone occupies the marginal zone of the meteorite impact.

Key words: sedimentary rocks, microfossils, acritarch flora, meteor craters, Proterozoic, Lappajärvi, Finland

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Introduction

Lake Lappajärvi, western Finland (Fig. 1.), occupies a circular basin long interpreted as the crater of an ancient volcano (Eskola 1921, cf. Cohen 1990, Nicolaysen 1990). However, from petrological evidence it would appear to be an astrobleme (Svensson 1968, Lehtinen 1970, 1976, 1990. The ^{40}Ar — ^{39}Ar age of the karnäite is 77 Ma (Jessberger & Reimold 1980), but palaeomagnetic studies suggest an age of >200 Ma (Pesonen *et al.* 1984). Lehtovaara (1982) points out that the crater should be considerably older because of the slow rate of erosion of the Fennoscandian Shield.

The Geological Survey of Finland drilled a hole in the central depression (Pipping 1989, Kivekäs *et al.* 1990) and later another in the rim, where a sequence of sedimentary rocks was penetrated and sampled (Pipping & Vaarma 1990). The following gives the results of biostratigraphic dat-

ing based on the acritarch assemblage of the sedimentary rocks.

Lithostratigraphy

At the site of drill hole K 52/302, sedimentary rocks attaining a total thickness of about 18 metres were intersected between depths of 74.35 and 92.40 m, between the overlying Late Pleistocene sediments and basement rocks consisting of weathered mica gneiss.

The basal part of the sedimentary rocks is a 4.10-m-thick yellowish conglomerate with well-rounded quartz grains. The sequence continues as a 30 cm layer of claystone, which in turn is overlain by fine-grained greenish sandstone. There is a 10 to 20 cm thick greenish, horizontally layered siltstone with some glauconite grains at a depth of 82.30 m. The colour of the siltstone is reddish and light brown, and at a depth of 81.00 m it

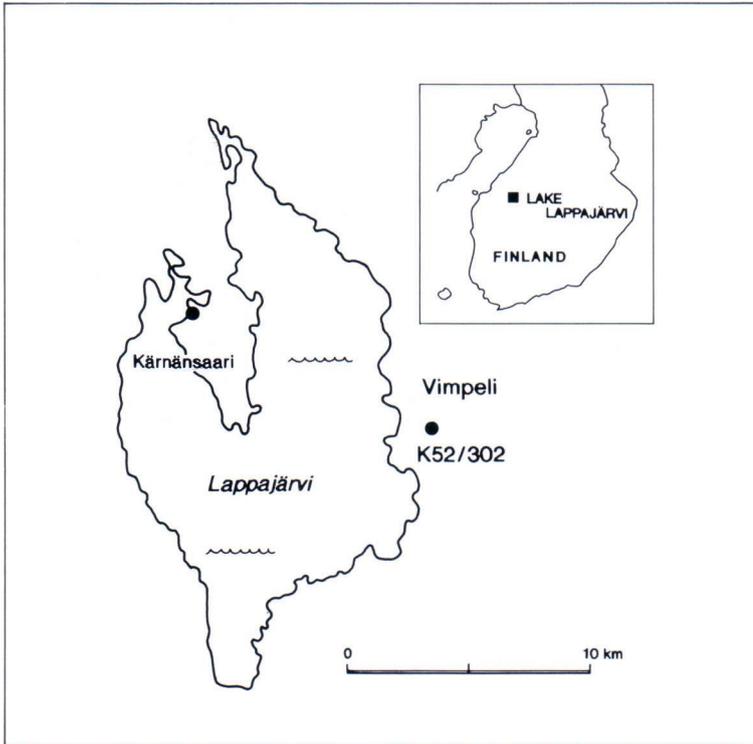


Fig. 1. The drilling site at Vimpeli, east of Lake Lappajärvi.

turns ochre. The dip of the layers is ca. 60° . The uppermost part of the sedimentary rocks (74.35—82.30 m) is greenish siltstone, with sharply angular feldspar grains and 0.8—1.2 mm thick undulating layers of sand (Fig. 2.).

Thirteen samples were investigated for the purpose of biostratigraphic dating. The samples were processed using HF and HCl. Sodium polytungstate (specific gravity = 2.2 g/cm^3) was used for gravity separation. The samples were mounted with glycerine jelly. Light microscopy was performed with a Leiz Wetzlar Orthoplan research microscope, and photographs were taken on Kodak Panatomic-X 32 film using a Leica camera.

Microfossils

The organic-walled microfossils of the Lappajärvi sedimentary deposit belong to the Group Acritarcha Evitt 1963. Acritarchs were found

only in the middle part of the strata studied. The diversity is low, and psilate sphaeromorphs are the most common in the present material. The specimens are generally well preserved. However, acritarchs from underlying weathered mica gneiss are poorly preserved, being strongly thermally altered and deformed due to mechanical stress.

Simple sphaeromorphs (Pl. I:1—2) (*Leiosphaeridia* spp.) dominate the microbiota. The vesicle is spherical to sub-spherical, thin-walled and psilate or slightly shagrinata and the largest ones are folded. The specimens are usually light yellow or light brown in colour. Their diameter ranges 7—416 μm , mode 15—24 μm (depth levels 83.00—95.55 m, $n = 549$).

Sphaeroids 7—66 μm in diameter may be identified as species of *Leiosphaeridia asperata* (Naumova) Lindgren 1982 or *Leiosphaeridia crassa* (Naumova) Yankauskas 1989, with many synonyms, both including the species *Kildinella hyper-*

Vimpeli K 52/302

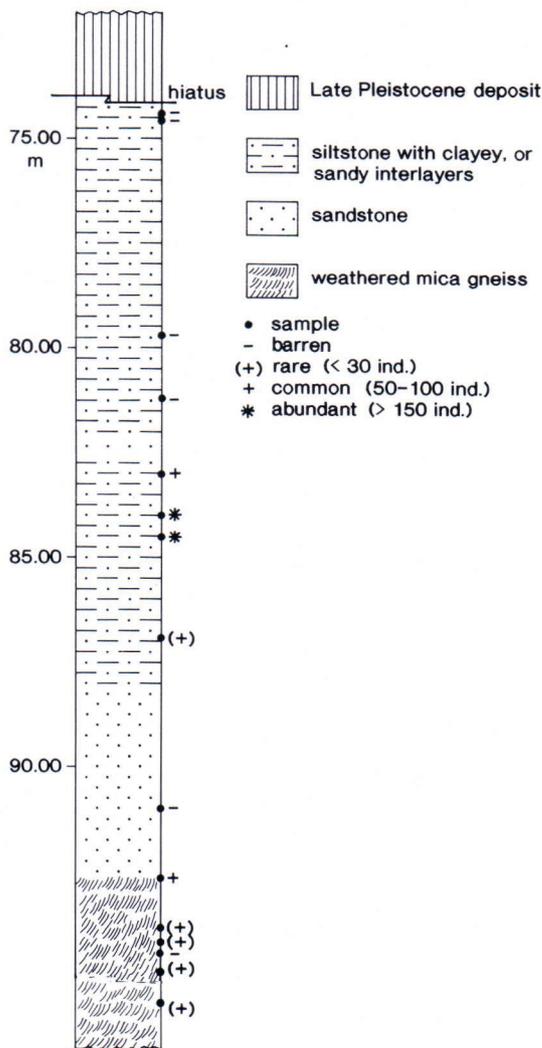


Fig. 2. The drill core sequence from the Lappajärvi sedimentary rocks.

boreica Timofeev 1966. The time range of all these is Late Riphean to Cambrian (Lindgren 1982, Yankauskas *et al.* 1989).

The species *Leiosphaeridia tenuissima* Eisenack 1958 /*Leiosphaeridia giganteus* Schepelova 1963 measures 75–200 μm , and the species *Kildinella jacutica* Timofeev 1966 measures 150–250 μm , both with many synonyms.

The time range of the former is Late Riphean to Ordovician (Yankauskas *et al.* 1989) and that of the latter Riphean (Timofeev 1966, 1969).

Large thin-walled psilate sphaeromorphs have been recorded by Peat *et al.* (1978) (up to 600 μm) from Roper Group, Australia and by Horodyski (1980) (up to 440 μm) from Little Belt Mountains, Montana, Canada.

Thick-walled sphaeromorphs (Pl. I:3) are the next most common. The vesicle is spherical to subspherical and thick-walled (2–3 μm) with an irregularly meshy surface. The specimens range from light yellow to dark brown in colour. Their diameter is 14–22 μm , mean 17.7 μm , bimodal 15 μm and 18 μm ($n = 27$, depth levels 83.00–86.85 m).

Only a few medium-sized thick-walled sphaeromorphs are reported from the Proterozoic material. Manum (1967) has recorded Late Precambrian Form F with a porous surface from southern Norway.

The material includes three coenobia of thin-walled psilate subspherical vesicles (Pl. I:4). The diameter of a single vesicle is 10 μm (depth levels 84.00–84.45 m) and 10–20 vesicles are loosely and irregularly connected together (*Synsphaeridium* sp.). The vesicle is transparent or light yellow in colour.

The specimen resembles the psilate *Synsphaeridium sorediforme* Timofeev (1959) 1966 but is smaller in size. In *Synsphaeridium conglutinatum* Timofeev (1959) 1966 the vesicle has a shagrinated surface. Single vesicles resemble small individuals of *Leiosphaeridia asperata*, which, according to Lindgren (1982), includes coenobia. However, the vesicles are spherical and larger (34–40 μm) and form regular coenobia, although some are in clusters composed of a few vesicles. Eisenack (1965) has reported Palaeozoic *Synsphaeridium* species with an ornamented surface.

A similar psilate, *Synsphaeridium* sp., has also been recorded as Late Riphean: from Finland, Muhos formation (Tynni & Siivola 1966, Tynni 1978, Tynni & Uutela 1984); as Riphean to Ear-

ly Palaeozoic: from the U.S.S.R. (Yankauskas *et al.* 1989); and as Vendian: from Finland, Hailuoto (Tynni & Donner 1980, Johanson 1988) and Taivalkoski (Tynni & Uutela 1985).

The material also contains one asymmetrical ovoidal species (Pl. I:5) (?*Archaeoellipsoides* sp.), with one side straight, and one curved and rounded poles. The surface is shagrinated and it is sepia in colour. It is 14 µm wide and 30 µm long (depth level 84.45 m).

The specimen, having asymmetrical sides, differs from the genera *Brevirtichoides* Yankauskas 1980 and *Leiovalia* Eisenack 1965. The ellipsoidal to pear-shaped and sausage-shaped *Archaeoellipsoides grandis* has a smooth surface (Horodyski & Donaldson 1980).

One fragment of an empty hollow filament (Pl. I:6) is reported in the present material. It is thin-walled, unbranched and non-septate. The surface of the filament is psilate, but some parts are slightly and irregularly rugose. Its length is ca. 120 µm and width 8 µm (depth level 86.85 m). The filament differs from the rugose *Siphonophycus keston* Schopf 1968. Knoll (1984) has described *Siphonophycus* sp. (width 5–45 µm) from Late Precambrian deposits in Svalbard, Spitzbergen. Tynni and Uutela (1984) have described similar unbranched filaments from the Late Riphean Muhos formation (width 8–13 µm). Uutela (1986) has recorded one fragment (width 20 µm) from Ryydys, and Johanson (1988) many from the Vendian Hailuoto formation (5–20 µm).

Similar filaments 9 µm wide are very common in the Vendian Taivalkoski siltstone. In Canada, Hofmann and Aitken (1979) have described similar filaments of equal and greater width (max. 62 µm) from Late Riphean deposits, and Hofmann (1984) from Late Riphean to Early Cambrian deposits.

Discussion

The present material is characterized by a low diversity assemblage dominated by only a few

taxa. The Late Riphean assemblage is dominated by sphaeromorphic acritarchs (including *Leiosphaeridia asperata*, *Kildinella hyperboreica* and *Synsphaeridium* sp.), which are also present in the Early Vendian. However, *Octoedryxium* and *Vandalosphaeridium*, which are indicative taxa of the Early Vendian, are absent from the present material, as is *Bavlinella faveolata*, which indicates the Middle Vendian (Varangerian) glacial epoch (Vidal & Knoll 1982, 1983).

A similar assemblage, although more diverse, has been described from the Precambrian Muhos formation (Tynni & Siivola 1966, Tynni 1978, Tynni & Uutela 1984). The formation has been dated with microfossils to 1200 Ma (Tynni & Uutela 1984), although K-Ar and Rb-Sr determinations give an age of 1300–1400 Ma (Simonen 1980).

The microfossil assemblage in the Visingsö Group in Sweden is also more diverse (Vidal 1974, 1976), its Late Riphean age being dated to ca. 800 Ma (Vidal & Bylund 1981, Vidal & Siedlecka 1983) and its Vendian age to ca. 700 Ma (Vidal 1976).

In the Vendian Hailuoto formation (ca. 600 Ma) the diversity of species is marked. The taxa includes not only simple spherical and filamentous forms but also cylindrical (*Volyniella*) and multicellular filaments (*Oscillatoriopsis*) (Tynni & Donner 1980, Johanson 1988), as in the Taivalkoski formation (Tynni & Uutela 1985).

Although the material lacks all indicator species, the Vimpeli sedimentary deposit is probably as old as the Muhos formation, or slightly younger, *i.e.* Late Riphean, but it is older than the Vendian deposits at Hailuoto and Taivalkoski.

The low-diversity assemblages dominated by one or a few taxa indicate inshore, particularly lagoonal, environments (Vidal & Knoll 1982). This finding is supported by the sedimentary structures. At that time, Lake Lappajärvi was an inshore, shallow marine or non-marine basin.

The largerly undisturbed structures and

horizontal layering of the sedimentary rocks and the good state of preservation of the microfossils indicate that the basin was formed before the deposition of siltstone. The assemblage of acritarchs can be related with the Proterozoicum better than with later eras.

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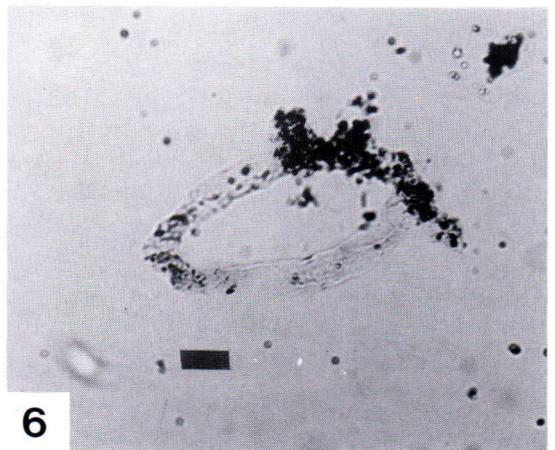
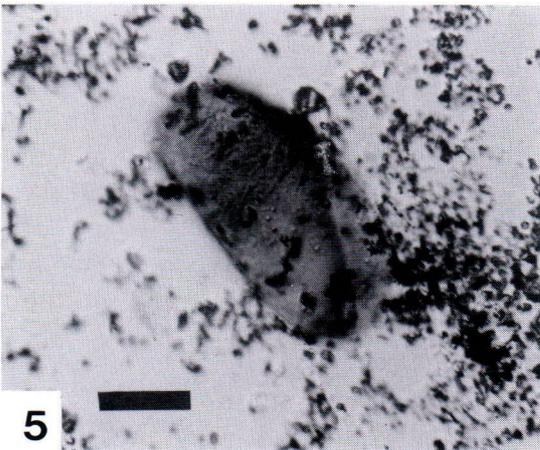
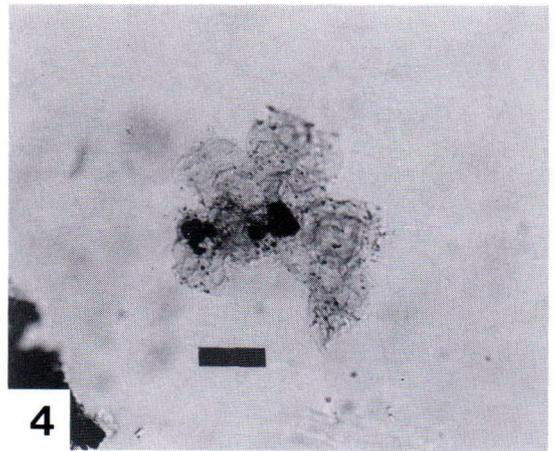
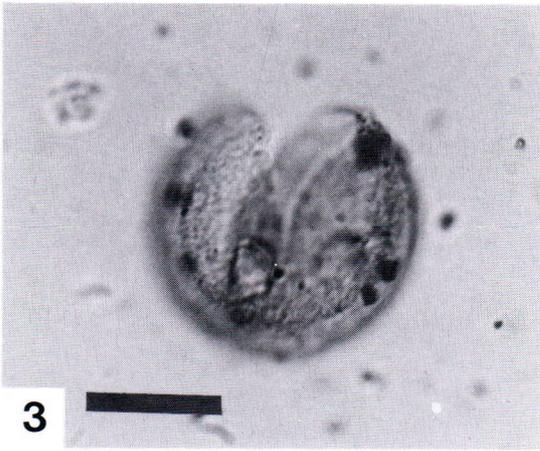
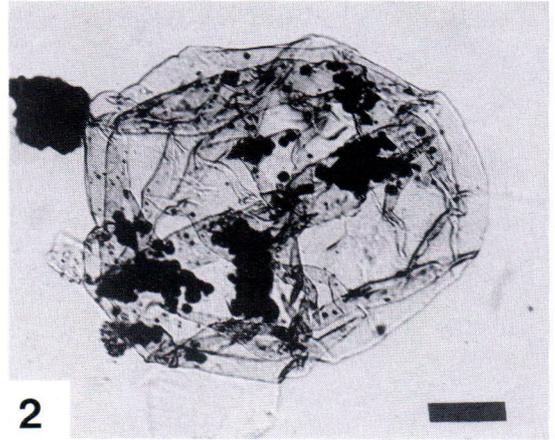
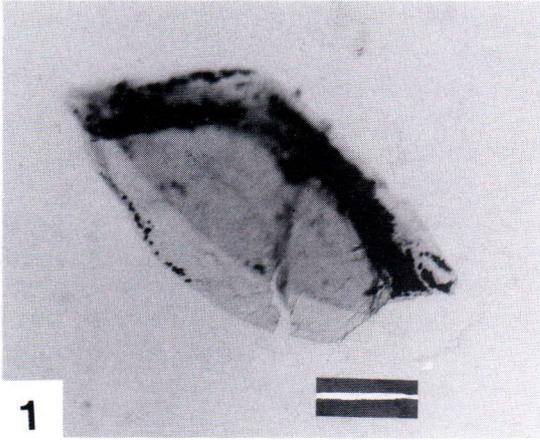
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Pl. I. 1. Microfossils from the Lappajärvi sedimentary rocks. 1—2 Sphaeromorphs, 3. thick-walled sphaeromorph, 4. coenobia, 5. ovoid and 6. fragment of filament. Bar equals 10 μm , double bar 100 μm .