

# PROTEROZOIC AND EARLY PALAEOZOIC MICROFOSSILS IN THE KARIKKOSELKÄ IMPACT CRATER, CENTRAL FINLAND

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The Karikkoselkä impact crater is located at Petäjävesi (Lat. 62°13.3' N, Long. 25°14.7' E), in central Finland. The crater is filled with impact-generated breccias and redeposited sedimentary rock yielding microfossils. The assemblage consists of Proterozoic, Cambrian and Ordovician acritarchs, cyanobacteria and green algae thoroughly mixed in the deposit. The late Ordovician acritarch *Diexallophasis striatum* indicates the maximum age of the impact event in the Keila Regional Stage, middle Caradocian in British Series, 458–449 Ma or later. A till sample overlying the sediments that infill the crater yields only Quaternary pollen and spores, indicating that the impact event occurred prior to the Fennoscandian Ice Age. The most likely palaeomagnetic age of 260–230 Ma (late Permian to early Triassic) is neither excluded nor supported by the microfossil results. However, other palaeomagnetic ages are excluded leaving this the most likely age. This article presents new evidence of Proterozoic and early Palaeozoic deposits that covered central Finland.

*Key words:* impact craters, sedimentary rocks, microfossils, acritarchs, cyanobacteria, Chlorophyta, Paleozoic, Proterozoic, Karikkoselkä, Finland

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## INTRODUCTION

Thus far, nine meteorite impact structures have been recorded in Finland: six of them are filled with Pre-Quaternary sedimentary rocks containing fossils, i.e. Lappajärvi (age 77 Ma) (Svensson 1968, Lehtinen 1976, Jessberg & Reimold 1980, Utela 1990, 1998) and Söderfjärden (age 530–510 Ma) (Laurén et al. 1978, Tynni 1978, 1982a, Lehtovaara 1984, 1985, Hagenfeldt 1989a, b, Abels et al. 2000) in western Finland, Iso-Naakkima (age 1000–650 Ma) (Elo et al. 1993) in central Finland, Lumparn in Åland (age 600–443 Ma) (Tynni 1982b, Svensson 1993, Abels et al. 2000) in south-western Finland, Saarijärvi in northern Finland (unknown age between 2450–500 Ma) (Tynni & Utela 1985, Öhman et al. 2000), and the Karikkoselkä impact crater – the subject of this paper.

The Karikkoselkä impact crater is located in the municipality of Petäjävesi (62°13.3' N, 25°14.7' E, Fig. 1), in central Finland, ca. 25 km west of the town of Jyväskylä and 230 km north of Helsinki. During the first field trip in summer 1995, Dr Martti Lehtinen, and later in autumn 1995 together with Dr Lauri Pesonen, found shatter cones *in situ* on shoreline outcrops, the first evidence of the impact origin of the Karikkoselkä circular structure (Lehtinen et al. 1996, Pesonen et al. 1997, 1998). Acoustic surveys were made during 1996 and 1997 to determine the topography of the lake bottom and to estimate the thickness of sediments. In winter 1996, Geological Survey of Finland carried out the first deep drilling, but the Proterozoic rock basement was not reached, however, in 1998, two drill cores were drilled successfully (Fig. 1). Moreover, estimations of the impact origin of the Karikkoselkä structure were supported by extensive fracturing of target rock, shock metamorphic features in breccias, and shatter cone like features in outcrops of porphyritic granite (Pesonen et al. 1999, Arkonsuo 2000).

This well-preserved, simple impact structure has a diameter of 2.1–2.4 km. The lake is deep (26.5 m) with steep shores, which is exceptional in central Finland where typical Quaternary lakes are shallow, generally less than 10 m deep. The diameter of the lake itself is 1.2 km and it is situ-

ated at 110.9 metres above sea level.

The gravity and electromagnetic models are mutually consistent and suggest a depth of ca. 120 m for the bottom of the sediment and/or breccia layer, thus implying an anomalously shallow structure (depth/diameter < 0.1). According to Pesonen et al. (1999), palaeomagnetic data suggest an age of 260–230 Ma (Late Permian to Early Triassic) for the impact, but older age interpretations are also possible, i.e. 560–530 Ma (late Neoproterozoic to early Cambrian) and less likely, 1760–1650 Ma (late Palaeoproterozoic) (Fig. 2).

In addition to palaeomagnetic dating, fossils are valuable tools for age determination. Because the Karikkoselkä impact crater is filled with sedimentary rocks (mudstone and sandstone), fossils can help in estimating the age of the impact event. Fossils can also provide evidence for pre-impact deposits and serve as an important reservoir of Phanerozoic geological history, which has been largely eroded by continental ice elsewhere in the country.

## MATERIAL AND METHODS

The Karikkoselkä crater is filled with chaotically occurring, redeposited sedimentary rocks and breccias with shock-metamorphic features. The

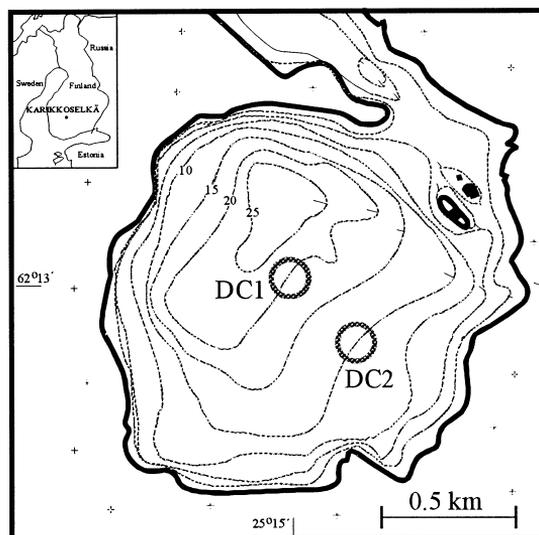


Fig. 1. Location of Lake Karikkoselkä and sites of drill cores DC1 and DC2. Water depth contours are in metres.

Eon	Era	Period	Ma
Phanerozoic	Cenozoic	Quaternary	1.8
		Tertiary	65
	Mesozoic	Cretaceous	145
		Jurassic	213
		Triassic	284
	Paleozoic	Permian	286
		Carboniferous	360
		Devonian	410
		Silurian	440
		Ordovician	505
			Cambrian
Precambrian	Eon	Neoproterozoic	900
		Mesoproterozoic	1600
		Palaeoproterozoic	2500
		Archaean	3800
			4500

Fig. 2. The geologic time scale (Hansen 1991, Topinka 2001).

sedimentary rocks of greenish, greyish and brownish mudstone and siltstone yield organic-walled microfossils, i.e. cyanobacteria, green algae (Phrasinophyceae) and acritarchs (Group Acritarcha). The term acritarch is used later in the text to refer to these three collectively.

Arkonsuo (2000) has given a detailed description of the lithology of drill cores, and Figure 3 shows a simplified description of them.

In drill core DC 1 (62°13.2'N, 25°14.9'E, dip 65.65° south) sedimentary rocks occur from 33.90 to 161.20 m (a total of 127.30 m), overlying Proterozoic porphyritic granite target. The lowermost sample (a depth of 168.00 m) consists of mudstone clasts among breccia. The major part of the deposit is polymictic allochthonous breccia with angular, subangular or rounded grey mudstone clasts

which is intercalated with mudstone and siltstone layers at a depth of 144.20–133.65 m and 123.70–99.30 m. Porphyrite granite is intercalated with polymictic allochthonous breccia at a depth of 45.70–45.00 m, 44.65–43.50 m and 40.80–39.00 m. Variably red and grey siltstone underlies Quaternary till at a depth of 39.00–33.90 m.

Drill core DC2 is located 260 m southeast of DC1. In DC2 (dip 88.10° south) sedimentary rocks occur from 26.10 to 131.00 m (totalling 104.80 m), overlying porphyrite granite target with breccia dikes. Pebbly grey sandstone at a depth of 131.00–123.20 m is intercalated with polymictic allochthonous breccia with angular, subangular or rounded grey mudstone clasts at a depth of 127.20–123.45 m. At a depth of 123.20–92.45 m, polymictic allochthonous breccia with clay clasts underlies reddish siltstone (92.45–81.50 m), brown mudstone (81.50–66.65 m) and brown mudstone with silty or sandy layers (66.65–26.10 m), the overlying 35 m part of the deposit being subvertically laminated. The uppermost sample at a depth of 13.80 m consists of Quaternary till.

For microfossil analysis, 51 samples from DC1 and 27 samples from DC2 were treated with HCl and HF before filtering the residue through an 8 µm nylon sieve (Vidal 1988), about 50 g of material was used for each sample. The sample interval is irregular, because only greenish or greyish mudstone samples and pebbly sandstone with greenish and greyish pebbles of mudstone were prepared based on previous studies of barren brownish or reddish material. Occurrence and distribution of the microfossils found in the drill cores are shown in Tables 1 and 2. All the microfossils were counted.

## RESULTS

Generally, the acritarchs are well preserved, and, although some specimens are mechanically broken, no signs of thermal heating have been observed. In the Karikkoselkä impact crater, the acritarch assemblage is a mixture of Proterozoic and early Palaeozoic, i.e. Cambrian and Ordovician species. Taxonomic diversity is low, a total of 19

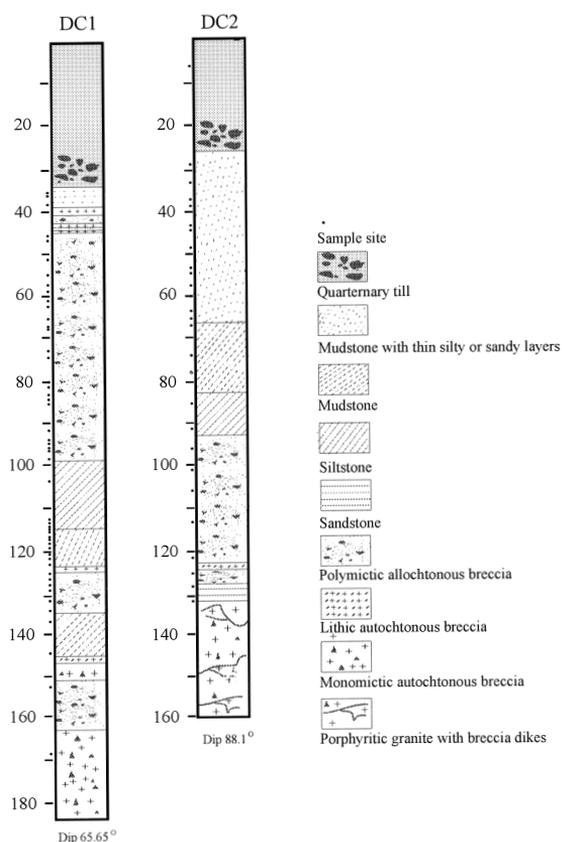


Fig. 3. Lithological description of drill cores DC1 and DC2 (modified after Arkonsuo 2000), and sample sites.

species was recorded from DC1: five Proterozoic, three Proterozoic to Cambrian, five Cambrian and six Ordovician species. *Leiosphaeridia* species are presented separately because of their minor stratigraphic value (Table 1). Of the six species recorded in DC2, two are Proterozoic, two Cambrian and two Ordovician (Table 2). The nomenclature is partly modified after Sarjeant and Stancliffe (1994).

Nearly 80% of all the specimens belong to the genus *Leiosphaeridia* Eisenack, 1938. Despite being thin walled they are well preserved. Their colour is light yellow, and neither signs of heating nor mechanical destruction were observed. The diameters of the cells vary from less than 10  $\mu\text{m}$  to more than 200  $\mu\text{m}$ , and more than 55% of the specimens are smaller than 40  $\mu\text{m}$  in size. The dating value of *Leiosphaeridia* species is generally small, because of their long living range, i.e. from Protero-

zoic to Tertiary (Moczydlowska 1991).

The number of acritarchs at different depths in the drill cores is shown in Tables 1 and 2. Among the acritarch assemblage, none of the species have ranges restricted to the Mesoproterozoic Era.

Only a few species are restricted to the **Neoproterozoic Era**. Thick-walled cells or cell fragments of *Chuarina circularis* Walcott, 1899 emended Vidal & Ford, 1985 (4 specimens and one fragment, Plate I, Fig. A2) were recorded only in DC1 from a depth of 66.50 m to 80.55 m. The cell diameter is more than 300  $\mu\text{m}$ , and its large size differentiates the species from other smooth and thick-walled sphaeromorphic species, e.g. *Leiosphaeridia*-species (Hofmann & Jackson 1994). *Chuarina circularis* is recorded from numerous occurrences worldwide (Samuelsson & Strauss 1999), and its stratigraphic range is restricted to early Neoproterozoic (Vidal et al. 1993). In Finland this species has been previously recorded in Vendian, i.e. Neoproterozoic deposits at Hailuoto (Tynni & Donner 1980).

The irregularly reticular surface of the thick-walled cell of *Trachysphaeridium laminaratum* Timofeev, 1966 (4 specimens in DC1) is the characterizing feature of the species. In the present material their size is ca. 30  $\mu\text{m}$ , which is smaller than in the original diagnosis by Timofeev (1966), Samuelsson (1997), however, has also recorded smaller specimens. According to Samuelsson (1997), the stratigraphic range of *T. laminaratum* is restricted to the Neoproterozoic (Upper Riphean to Vendian), according to Timofeev (1966) its living range extends to slightly later, to early Cambrian. In Finland the species has previously been recorded in the Riphean, i.e. Mesoproterozoic Muhos formation. The specimens recorded there were larger, 100–129  $\mu\text{m}$  in size (Tynni & Uutela 1984).

Three taxa have a stratigraphical range from **Mesoproterozoic to Cambrian** or even younger strata. Rather loose cell clusters of *Synsphaeridium* spp. (121 specimens, > 40%, Plate I, Fig. A1) are common only in DC1 at a depth of 46.80 m, at other levels they are rare. The size of a single cell is ca. 5  $\mu\text{m}$ . Genus *Synsphaeridium* Eisenack, 1965 appeared in the Mesoproterozoic and disappeared in the Carboniferous Period (Hagenfeldt

1989a). In Finland, *Synsphaeridium* species have been previously recorded at Muhos (Tynni & Uutela 1984) and at Hailuoto (Tynni & Donner 1980), but also in the Neoproterozoic (Vendian) strata of the Saarijärvi impact crater at Taivalkoski (Tynni & Uutela 1985) as well as in the Cambrian deposits of the Söderfjärden crater (Tynni 1978, 1982a, Hagenfeldt 1989a).

In the genus *Symplassosphaeridium* Timofeev, 1959 cells are clustered together more tightly forming a more regular spheroid than cells in the genus *Synsphaeridium*. Often these two genera are combined together into *Synsphaeridium* (cf. Samuelsson 1997). In DC2 two *Symplassosphaeridium* specimens have a diameter of ca. 20 µm, such small specimens have also been found at Muhos (Tynni & Uutela 1984). The specimens found at Hailuoto are notably larger in size (Tynni & Donner 1980). Both genera *Synsphaeridium* and *Symplassosphaeridium* have a long stratigraphic range, which makes them biostratigraphically less valuable (Hofmann & Jackson 1994). However, they are more common in pre-Varangerian deposits than in younger strata (Samuelsson 1997).

Small (diameter 10–15 µm, height of velum 2–3 µm), slightly granulated cells with equatorial velum specimens of genus *Granomarginata* Naumova, 1961 are common (56 specimens, 33%) in DC1 at a depth of 144.70 m, and the genus is also recorded as rare at depths of 46.00 to 80.55 m. *Granomarginata* specimens in the present material resemble Cambrian *Granomarginata squamea* Volkova, 1968, but they are almost twice as large. Rather similar *Granomarginata* sp. recorded at Muhos were also larger in size (Tynni & Uutela 1984). Cambrian species of genus *Granomarginata* are often recorded in the Baltic area (Naumova 1960, Volkova 1968, Moczydlowska 1991), in Russia its range is from Mesoproterozoic to Silurian (Chibrikova 1972, Lopukin 1974).

Assemblage yields also fragments of psilate threads of filamentous cyanobacteria, which are attributed to the genus *Siphonophycus* Schopf, 1968, emended Knoll, Swett & Mark, 1991, narrow to *Siphonophycus rugosum* (Maithy, 1975) Hofmann & Jackson, 1994 (width 6.5–13 µm) and wide to *Siphonophycus kestron* Schopf, 1968

(width 14–20 µm), subdivision according to Hofmann and Jackson (1994). *S. rugosum* is common in both drill cores in the upper part of the deposit, while *S. kestron* is rare throughout the deposit (Plate I, Fig. A4). The length of fragments is usually less than 50 µm. In Finland, *Siphonophycus* threads (width 8–13 µm) have been recorded at Muhos (Tynni & Uutela 1984). *Siphonophycus* threads are common in benthic mat communities (Hofmann & Jackson 1994).

Two fragments of narrow pseudo-septate threads (width 20 µm, height of septa 5 µm), attributed to genus *Oscillatoriopsis* Schopf, 1968 were found in DC1 at a depth of 96.40 m (Plate I, Fig. A3). They resemble Neoproterozoic (Vendian) *Oscillatoriopsis constricta* Tynni & Donner, 1980 described at Hailuoto (Tynni & Donner 1980), although they are still narrower (12 µm) and also partly constricted. Samuelsson (1997) has also recorded narrow *Oscillatoriopsis* specimens in the early Neoproterozoic deposits in the Kola Peninsula, Russia. *Oscillatoriopsis magna* Tynni & Donner, 1980 recorded at Hailuoto are markedly wider (80–100 µm, Tynni & Donner 1980). Both genera *Siphonophycus* and *Oscillatoriopsis* are well known from Neoproterozoic occurrences worldwide, but they are not stratigraphically significant (Hofmann & Jackson 1994).

Five acritarch species are attributed to **Cambrian**. The small granulated *Filisphaeridium tornatum* (Volkova, 1968) Sarjeant & Stancliffe, 1994 species is common only in DC1 at a depth of 144.70 m (34%), it is rare elsewhere in the deposit. In DC2 only one specimen is found at a depth of 106.5 m.

Genus *Tasmanites* Newton, 1875, emended Schopf, Wilson & Bentall, 1994 is attributed to green algae (Phrasinophyceae). Pores of thick-walled *Tasmanites volkovae* Kirjanov, 1974 are characteristically visible (Plate I, Fig. B5), while *T. tenellus* Volkova, 1968 is thin-walled and the pores are irregularly situated in the cell (Plate I, Fig. B7). In the present material most of the *Tasmanites* specimens are mechanically broken. A total number of 69 cells or cell fragments of *T. volkovae* are found in DC1 and two in DC2. DC1 yields twelve *T. tenellus* specimens. One fragment of *Ski-*

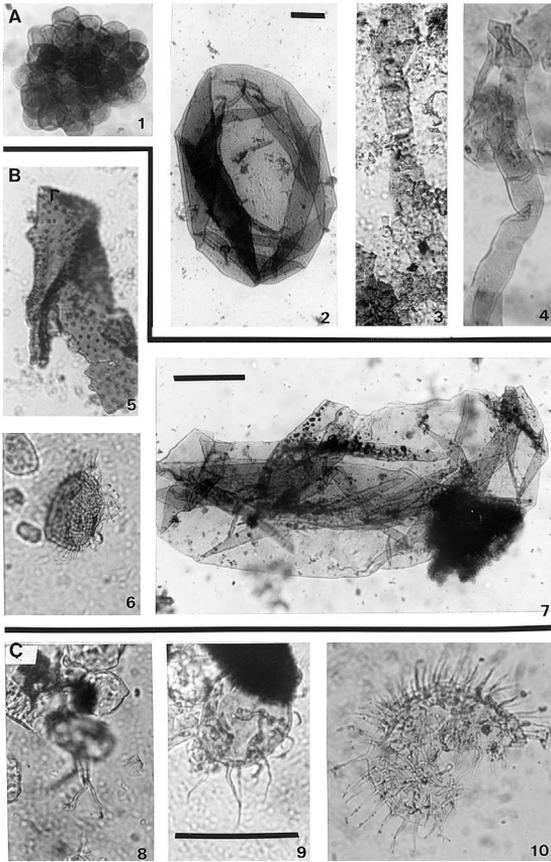


Plate I. Selected acritarchs in the Karikkoselkä impact crater. Proterozoic species: A1 *Synsphaeridium* sp., A2. *Chuaria circularis*, A3. *Oscillatoropsis* cf. *constricta*, A4. *Siphonophycus kestron*. Cambrian species: B5. *Tasmanites volkovae*, B6. *Filisphaeridium molliculum*, B7. *Tasmanites tenellus*. Ordovician species: C8. *Diexallophasis striatum*, C9. *Baltisphaeridium hirsutoides*, C10. *Baltisphaeridium annelieae*. Bars equal 50  $\mu\text{m}$ . Bar in Figure C9 is the same as in Figures A1, A3, A4, B5, B6, C8 and C10.

*agia compressa* (Volkova, 1968) Downie, 1982 is found at a depth of 60.20 m in DC1. Two specimens of *Filisphaeridium molliculum* (Moczydlowska & Vidal, 1988) Sarjeant & Stancliffe, 1994 are found in DC1 at a depth of 73.65 m (Plate I, Fig. B6).

The living range of *F. molliculum* and *T. tenellus* is restricted to early Cambrian, while *F. tornatum*, *Sk. compressa* and *T. volkovae* are early to middle Cambrian species (Hagenfeldt 1989a, b, Moczydlowska 1991, and references herein). In the present material, none of the recorded species is

restricted to middle Cambrian alone.

**Ordovician** acritarchs are very rare in the assemblage (less than 1% of the total specimens) and most of them are mechanically broken. Three thick-walled bright yellow cell fragments of genus *Leiosphaeridia* are similar to those recorded in Ordovician Rapla material (Uutela & Tynni 1991). These *Leiosphaeridia* fragments are recorded at a depth of 34.15 m in DC1 and at depths of 73.25 m and 90.90 m in DC2.

Two whole specimens and two fragments of *Baltisphaeridium hirsutoides* Eisenack, (1931) 1958 are found in DC1 at depths of 34.05 m, 73.65 m and 85.65 m, and in DC2 at a depth of 106.50 m (Plate I, Fig. C9). Other *Baltisphaeridium* species in the assemblage are *B. microspinosum* (Eisenack, 1954) Downie, 1959 at a depth of 46.00 m, *B. parvigranosum* Loeblich & Tappan, 1978 at a depth of 51.30 m and *B. annelieae* Kjellström, 1976 emended Bockelie & Kjellström, 1979 at a depth of 130.85 m in DC1 (Plate I, Fig. C10).

*B. hirsutoides* and *B. microspinosum* are typical Ordovician and early Silurian species in the Baltic area (Uutela & Tynni 1991, and references herein). *B. parvigranosum* is recorded in middle Ordovician deposits in Estonia (Uutela & Tynni 1991), in Sweden (Górka 1987) and in the U.S.A. (Loeblich & Tappan 1978), but also in late Ordovician deposits in Estonia (Uutela & Tynni 1991). In Estonia *B. annelieae* has been recorded previously from middle (Kunda Regional Stage in Estonian stratigraphy) to late Ordovician (Kukruse Regional Stage) deposits (Uutela & Tynni 1991), and in Sweden and central Europe in middle Ordovician (Kjellström 1976, Bockelie & Kjellström 1979, Górka 1979, 1987, Tynni 1982a, Turner 1984) as well as in late Ordovician deposits in the U.S.A. (Jacobson 1978). Half of *Diexallophasis striatum* (Uutela & Tynni, 1991) Sarjeant & Stancliffe, 1994 in DC1 is found at a depth of 34.05 m and the other half at a depth of 113.05 m (Plate I, Fig. C8). Previously it has been recorded only in the late Ordovician Keila Regional Stage at Rapla, Estonia (Uutela & Tynni 1991), being extremely rare there.

In DC2 the uppermost sample of till (depth 13.80 m) yields well preserved Quaternary pollen

of *Pinus*, *Picea*, *Alnus* and *Betula*, which dominates, and spores of *Lycopodium* and *Sphagnum*.

## DISCUSSION

Based on the acritarch results, the age of the Karikkoselkä impact event is impossible to estimate. The significant feature of the sedimentary deposit is the mixture of acritarch assemblages throughout the deposit reaching almost to the lowermost samples. The presence of *Diexallophasis striatum* gives the impact event its maximum age, i.e. it took place during the Keila Regional Stage (middle Caradocian in British Series, late Ordovician 458–449 Ma) or later. Quaternary pollen without acritarchs in the uppermost till sample indicates that, at the minimum, the impact event occurred prior to the Fennoscandian Ice Age, i.e. till was formed after the impact event.

Palaeomagnetic data gives three different ages for the impact of which the oldest, late Palaeoproterozoic (1760–1650 Ma) is according to Pesonen et al. (1999) less likely. Early Palaeozoic acritarchs in the deposits filling the crater would also rule out this age. The second age interpretation, i.e. late Neoproterozoic to early Cambrian (560–530 Ma), is not supported by the present material because of the presence of Ordovician acritarchs. The palaeomagnetic data suggesting an age of 260–230 Ma (late Permian to early Triassic) is neither excluded nor supported by the microfossil results, but this is the most consistent. Northern Scandinavia was situated at 45° on the northern hemisphere and was dry desert during the Permian (Lottes & Rowley 1990, Nie et al. 1990). The nearest location with Triassic (Rhaetian, upper Triassic) microfossils is in Scania, southern Sweden (cf. Guy-Olsson 1981), but the assemblage is completely different from the present material. If the land area was covered with some kind of vegetation, no pollen or spores are preserved. If the Karikkoselkä area was covered with seawater or fresh waters, no acritarchs or green algae are preserved.

Based on the acritarch results, the pre-impact Karikkoselkä area was covered with Meso- and/

or Neoproterozoic deposits overlain by early Palaeozoic (early and/or middle Cambrian and early to late Ordovician) deposits. Sedimentary deposits in the crater consist of mudstone and siltstone, which are typical of Proterozoic and Cambrian sedimentary deposits in the Baltic area. Ordovician deposits consist of marl and limestone.

The acritarch results suggest that the Baltic Sea covered the Karikkoselkä area during Neoproterozoic and the early Cambrian. Absolute evidence of Mesoproterozoic deposits is lacking. Although none of the species in the present material have a living range restricted only to the middle Cambrian, it is likely that the sea also covered the Karikkoselkä area at the beginning of the middle Cambrian. This point of view is supported by the early middle Cambrian (Kibartai Regional Stage) acritarchs found at Söderfjärden (Hagenfeldt 1989b) and Lappajärvi, in western Finland (Uutela 1998). During the late middle Cambrian both Söderfjärden and Lappajärvi seem to have been dry land, obviously also the Karikkoselkä area.

Early Palaeozoic sea covered central Finland during the middle Ordovician, using terminology for Estonian regional stages, from Lasnamägi Regional Stage, when *B. parvigranosum* appeared, to the late Ordovician Kukruse Regional Stage, when *B. annelieae* disappeared. Absolute evidence of early Ordovician deposits is lacking. Because both *B. hirsutoides* and *B. microspinosum* have a living range from early Ordovician to early Silurian, an early Ordovician age is neither excluded nor supported. Lindström (1979) estimated an early Ordovician transgression to have covered central and eastern Finland, while Thorslund (1960) estimated it to have covered the whole of Scandinavia with the exception of the northeastern part of Finland. Röömusoks (1960), Jaanusson (1963) and Männil (1966) proposed narrower boundaries for the transgression. Hiatus and/or hiati are possible in the succession. It is possible that there is a hiatus between the late Ordovician Kukruse to Keila regional stages, i.e. in the Haljala Regional Stage (see Männil 1966). So far, *Diexallophasis striatum* is recorded only at the end of Keila Regional Stage, late Ordovician (Uutela & Tynni 1991).



Table 2. Occurrence and distribution of acritarch specimens in DC2. Legend: Neopr. = Neoproterozoic. A = Siphonophycus kestron, B = S. rugosum, C = Filisphaeridium tornatum, D = Tasmanites volkovae, E = Baltisphaeridium hirsutoides, F = Leiosphaeridia sp.

Depth m	Proterozoic - Tertiary <i>Leiosphaeridia</i> spp $\phi$ $\mu$ m										Neopr		Cambrian		Ordovician		$\Sigma$
	<10	11-	21-	41-	61-	81-	101-	151-	>200	$\Sigma$	A	B	C	D	E	F	
13.80										0							0
29.90			3	5						8		+					8
33.60	1	20	61	30	4	3	3			122	+						122
38.75		4	60	18						82		+					82
39.70	1	2	2	10						15							15
43.60			5	1						6							6
44.75										0							0
49.60		1	1	1						3							3
53.70		2	6	6						14	+						14
55.00	11	28	20	15	2					76							76
57.50										0							0
60.00										0							0
63.45			4	4	1					9							9
65.85	1	6	6	2						15							15
67.10			2	3						5							5
73.25	1	9	2	1						13						1	14
78.90	5	9								14							14
86.10										0							0
90.90										0						1	1
96.60		1								1							1
100.70										0							0
106.50										0					1		1
112.70				4	3	17	33	1	4	63			1	2			66
120.35										0							0
123.40	1	4	6	2	1					14							14
129.20										0							0
130.70										0							0
$\Sigma$	21	86	178	102	11	20	36	1	4	460	+	+	1	2	1	2	466

## CONCLUSIONS

1. Brecciated and redeposited sedimentary rocks of the Karikkoselkä impact crater yield a mixed assemblage with Proterozoic and early Palaeozoic (Cambrian and Ordovician) cyanobacteria, green algae and acritarchs.
2. The microfossil results of this study neither support nor exclude the most likely age of the impact event (260–230 Ma, late Permian to early Triassic). The results contradict two other

possible palaeomagnetic datings, i.e. late Neoproterozoic to early Cambrian (560–530 Ma) and Proterozoic (1760–1650 Ma).

3. The microfossil assemblage gives new information on pre-impact sedimentary rocks covering central Finland.

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