Proc. Estonian Acad. Sci. Geol., 2004, **53**, 1, 28–41

Possibilities of stratigraphical interpretation of the Dividal Group in the Kilpisjärvi area (Finnish Lapland), based on lithogenetic characteristics

Enn Pirrus

Mining Institute of Tallinn Technical University, Kopli 82, 10412 Tallinn, Estonia; pirrus@starman.ee

Received 9 April 2003, in revised form 19 September 2003

Abstract. Lithological characteristics of the sedimentary rocks of the Dividal Group in the sub-Caledonian autochthonous complex outcropping in the Lapland area (Finland) are analysed. Based on lithogenetic features, the stratigraphic position of this problematic sedimentary body of Vendian–Cambrian age in the composite section of the East European craton was specified and new data which would help clarify the palaeogeography of that time in the northwestern rims of the craton were obtained.

Due to cleavage accompanying the orogeny, the authigenic minerals, such as pyrite, phosphates, glauconite, carbonates, etc., common in other regions, are not preserved in local rocks. The conditions have also been unfavourable for preservation of fossils and ichnofossils. At the same time, there is no rhythmical thin layering of claystones, characteristic of the Late Vendian in large areas of the East European craton.

Rare ichnofossils, including a few vertical pyrite-filled burrows of bioglyphs, as well as some indirect lithogenetical features, indicate that the Dividal Group probably corresponds to the Rovno Formation, the oldest stage of the East European Lower Cambrian. This interpretation is confirmed by fossils from the upper part of the same complex in the adjoining areas of Norway and Sweden, as well as in the Finnish inland territories, and by the chemical composition of clay rocks.

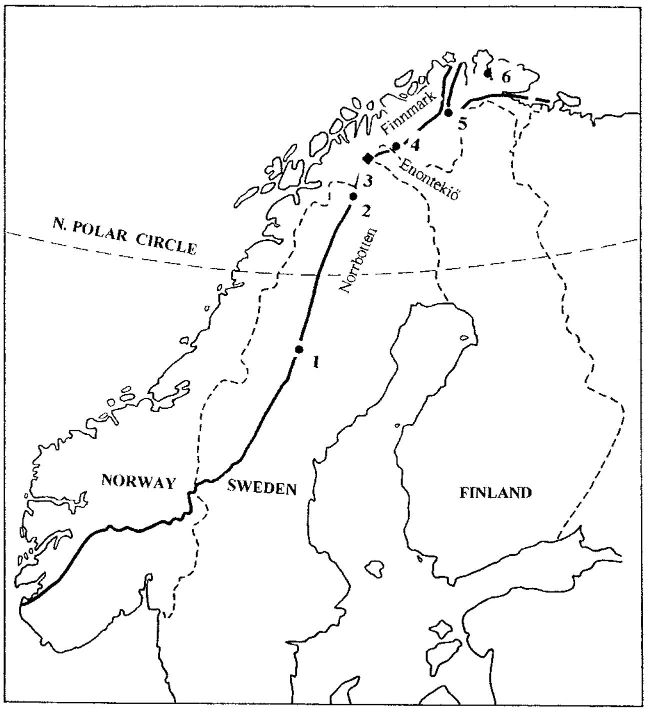
Key words: palaeogeography, Vendian, Lower Cambrian, Scandinavia, Finland.

INTRODUCTION

The lower boundary of the Cambrian has been a topic for wide international cooperation. Different aspects of the evolution of the western belt of the East European craton in the Late Proterozoic and Early Cambrian have been studied and new data obtained for defining the Cambrian–Precambrian boundary on that territory. A group of specialists from Scandinavia, Poland, and the former Soviet Union showed (Rozanov & Lydka 1987) that Lower Cambrian rocks were widespread in the vicinity of the Baltic Sea. The same has been established for the Vendian complex belonging to the Late Precambrian. The Vendian sediments are of more limited distribution, spreading generally in other regions surrounding the Fennoscandian shield, from the Norwegian Finnmark over the White Sea, Moscow, St. Petersburg, and East Baltic areas up to the Belarussian, Polish, and West Ukrainian depressions. The similarity of fossils and rocks suggests that large basins existed in that area, therefore it can be said that the palaeogeographical development of the region in the given time period has been established rather reliably (Rozanov & Lydka 1987). However, the development of the basins in the northwesternmost rim of the craton is somewhat unclear. In northern Scandinavia, the corresponding rocks are largely altered and buried under the Caledonian thrust sheet. Still, new occurrences of Cambrian fossils in the bottom of that structure have been recorded (Foyn & Glaessner 1979; Tynni 1980; Moczydlowska et al. 2001). This allows us to specify the stratigraphical dating of the heavily altered sedimentary rocks and trace the approximate position of the Vendian–Cambrian boundary. In this matter, the key interval is the so-called Dividal Group, consisting mainly of clayey rocks with the primary characteristics of sedimentary rocks preserved. The up to 200 m thick clayey rocks are widespread in northern Sweden, Lapland (Enontekiö, Finland), and Norway, containing rare fossils only in the uppermost part of the bed. This allows us to presume that the Upper Proterozoic (Vendian) and Cambrian boundary lies in the Dividal Group.

In summer 2002 the author had the opportunity, within the framework of the international LAPBIAT programme, to conduct a field study in the Kilpisjärvi (Lapland) region and investigate in more detail large outcrops of these rocks on the steep slopes of several mountain tundras (Saana, Malla, etc.; Figs. 1–3). Relying on his long-term experience in lithological study of a number of East European sections, the author conducted systematic research, in order to find lithogenetic characteristics indicative of specific conditions of the formation of Vendian and Cambrian sediments all over the East European craton.

Rhythmical thin bedding and low frequency or absence of marine indicator minerals, characteristic of the Upper Vendian clay rocks in all of Eastern Europe, suggests cool and possibly even near-freezing climate conditions or, furthermore, the existence of fresh water bodies (Pirrus 1992). These rocks are very poor in ichnofossils. Only the finest clays contain phytofossils of rich vendotaenid algae on some levels. Starting from the lowermost boundary of the Cambrian, the situation changes: marine glauconite, several forms of phosphates, and diagenetic pyrite (also in concretional nodules) appear in rocks. Ichnofossils of soft-bodied organisms appear in very variable numbers, as is typical of the Cambrian. The aim of the author was to find all those characteristics in the Dividal Group rocks in the vicinity of Kilpisjärvi, which would provide additional data for stratigraphical interpretation of the part of the section devoid of fossils and help create more general palaeogeographical reconstructions.



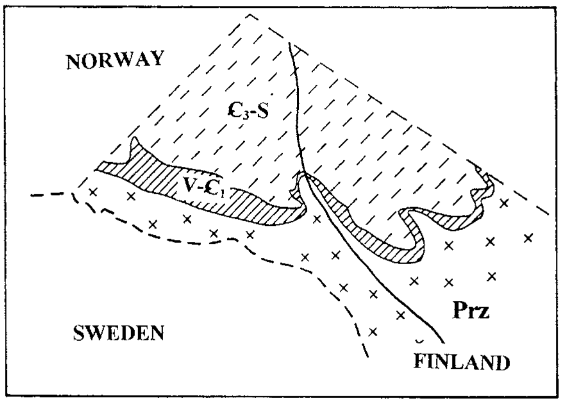


Fig. 1. The most important localities of the Dividal Group on the Scandinavian Peninsula (above): 1, Laisvall-Storuman; 2, Torneträsk; 3, Kilpisjärvi; 4, Avevagge; 5, Halkkavarre; 6, Finnmark. A schematic geological map of the Kilpisjärvi region (below). Striped area shows the outcrop of the Dividal Group.

GEOLOGICAL SETTING

The southeastern rim of the Caledonian thrust front is only a few kilometres wide in the northwestern corner of the Enontekiö county in Lapland (Fig. 1). A 50–150 m thick layer of the Dividal Group rocks lies on the levelled surface of the Archean bedrock (2.7 to 2.9 billion years). The Dividal Group consists predominantly of cleaved clay and siliciclastic rocks but has basal conglomerate in its lower part. This complex belongs to the pre-Caledonian autochthon (Lehtovaara 1988, 1995) and is only slightly deformed by the thrust in the upper part, exhibiting blocks of heavily tilted layering and flexures forming wavy folds. The Dividal Group is covered with different-aged allochthonous plate-like rock sheets belonging to the thrust. The sheets comprise rocks formed farther away and bearing signs of metamorphic phenomena: shales, quartzites, dolomites, gneisses, and amphibolites. According to tectonic analysis and isotope datings, the age of the rock sheets varies from Late Cambrian to Silurian (Lehtovaara 1988, 1995).

The unmetamorphosed Dividal Group rocks spread as a narrow, but several hundred kilometres long submeridian belt on the foot of the Scandes, not only in Finnish Lapland, but also in the adjoining Norwegian and Swedish territories, where they form a distinctive stratigraphical marker level in front of the thrust front (Fig. 1). The stratigraphy of the sequence has been studied in a number of isolated outcrops and the obtained palaeontological data suggest a comparatively wide stratigraphical range from younger Precambrian to earlier Lower Cambrian, i.e. the pre-trilobite level. In the Laisvall–Storuman region (northern Sweden), approximately 400 km south of the study area in Finland, the trilobite-bearing Lower Cambrian sequence has been convincingly proved by new palaeontological data obtained from the overlying rocks. However, the Dividal Group, which is lacking fossils, can be assigned to the pre-trilobite Cambrian only tentatively, even with doubt, due to the nearness of Vendian (?) rocks with glacial characteristics (Moczydlowska et al. 2001). Furthermore, the Dividal Group is represented here in a specific form, which is why its stratigraphic position is still uncertain. The sequence, however, is well distinguishable in Torneträsk, Sweden (Fig. 1), only about a hundred kilometres south from the study area in Finland. There, *Platysolenites antiquissimus* Eichw. has been found in the upper part of the Dividal Group (Foyn & Glaessner 1979). In the lower part of the section, which could be separated from the typical Dividal Group by a hiatus, the remains of algae – vendotaenids – may occur together with the medusoid *Kullingia* remains (Vidal & Moczydlowska 1996).

In Porojärvi (about 30 km northwest from Kilpisjärvi), Tynni (1980) found a pyritized fossil which he identified as *P. antiquissimus.* In the same layers somewhat lower than the previous find, he discovered a more problematic *Sabellidites cambriensis* Yan. In Norwegian sequences, north of Finland (Avevagge, Halkkavarre) numerous *P. antiquissimus* have been found, but only in the limited upper part of the Dividal Group (Hamar 1967; Foyn & Glaessner 1979). More fossiliferous sections occur farther in the north, on the territory of Finnmark where the index fossil of the upper part of the Lontova Stage (in the Baltic area), *P. spiralis*, has been found. In the central part of the section, *S. cambriensis* has been identified in an about 500 m thick complex. Ichnofossils and tillite layers, indicative of the

Vendian, occur in the lower part of the unit (Foyn & Glaessner 1979). This territory is certainly the best preserved sedimentation area of that period on the Baltica margin. Its further study would add important information to this research field. Finnmark, however, is rather far from the Finnish study area. Therefore, these layers can be considered only roughly analogous to the Dividal Group and have also different names.

At any rate, even these scarce palaeontological data are useful for the study of the Vendian–Cambrian transition in Finnish sections. Therefore, during field work, the author tried to discover lithogenetic elements which would allow association of this area with the general genesis of the East European craton.

METHOD

The research method used was very simple, relying on the field study of a large number of rock samples and their surfaces. Seven large and several smaller outcrops, located at the eastern side of the Pikku-Malla rock massive, on the southwestern, southern, and southeastern sides of the central Saanavuori Mountain, and on the northeastern shore of Lake Saanajärvi were studied (Fig. 2). About 10 000 rock samples were examined in the course of two weeks and a few samples were taken for laboratory analysis.

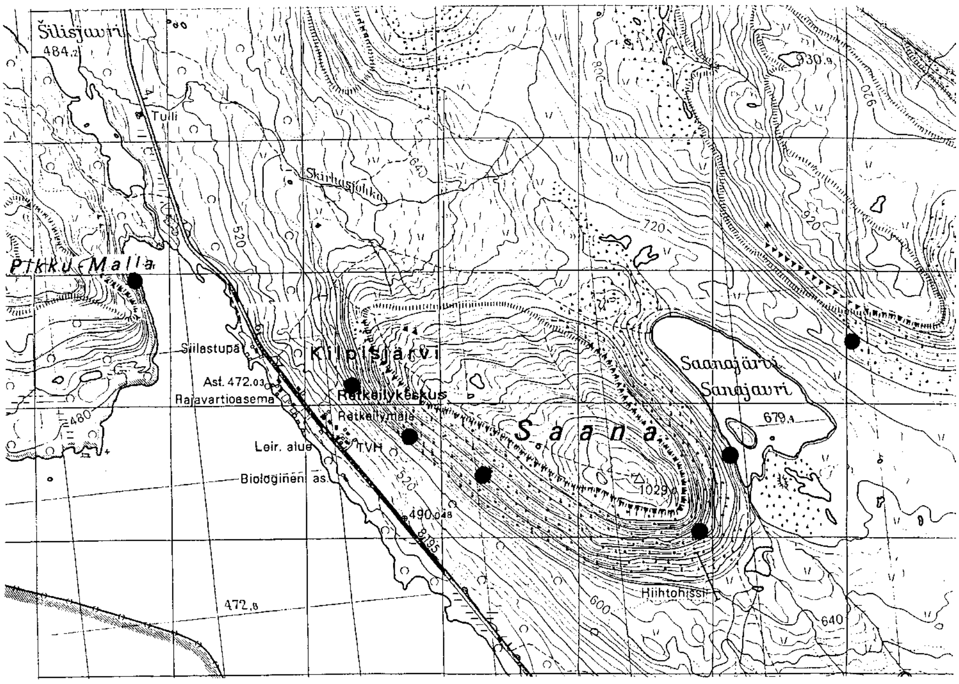


Fig. 2. Outcrops of the Dividal Group (black dots) studied in detail in 2002 in the vicinity of Kilpisjärvi and on the slopes of Saanavuori and Pikku-Malla.

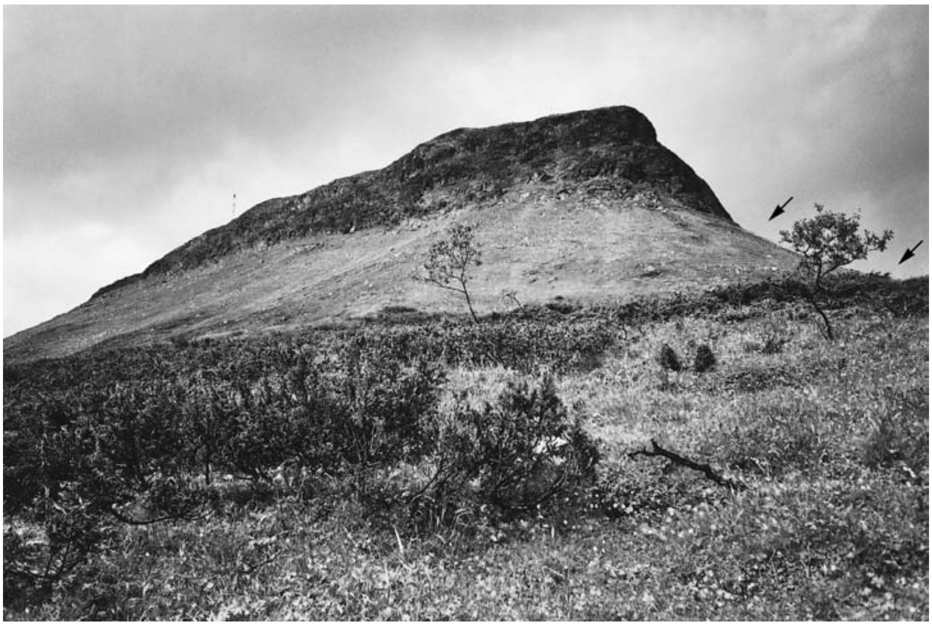


Fig. 3. Saanavuori – the central mountain on the northeastern shore of Kilpisjärvi with several outcrops of the Dividal Group in the talus zone of the slope (level is marked by small arrows).

RESULTS

Already the first observations showed that the sedimentary rocks belonging to the Dividal Group had after their formation undergone heavy dynamic (rather than thermal) stresses. Therefore, the entire section is well cleaved and interwoven by a number of irregularly oriented joint planes. These cut the preliminary layering and are covered by secondary dark oxide films which hinder both the formation of new surfaces and observation of the original layering in the outcrop wall. Signs of deformation: blocks tilted from their original position, folds of small amplitude, and other displacement features can be seen (Fig. 4). All the mentioned phenomena suggest a considerable influence of the nappe process even on the underlying autochthonous sedimentary rocks. The original clay material in those rocks is sericitized and the rock is occasionally impregnated by secondary quartz. This creates an impression that the percentage of true clay rocks in the section is insignificant; in steep rock walls mainly silt- and sandstones with a few intermediate clay layers seem to crop out. Clay-rich rocks usually disintegrate into splinters forming a loose talus in outcrops, which makes search for lithogenetic phenomena rather difficult. Sandstones in the sequence are also cemented with secondary quartz forming a hard non-porous rock, but primary rounded quartz particles can be seen as well. We should note that in the lower, Jerta

Fig. 4. A detail of an outcrop at Saanavuori showing smaller deformations of the bedding in the predominantly autochthonous sequence.

complex of the overlying thrust structure, sandstones have completely lost their primary granularity and turned into typical quartzites (so-called blue quartzites).

Despite the mentioned difficulties the study gave the following important results:

1. Unstable marine indicator minerals are almost totally absent in the cross-section of the Dividal Group. It may be assumed that pyrite and glauconite, which are widespread in siliciclastic rocks of Eastern Europe, could not survive the post-sedimentary conditions of this area. Furthermore, their occurrence would be abnormal. The single find from an outcrop near Saanajärvi may indirectly suggest that fossils could have been absent from the beginning (see 5 below). At the same time, it is difficult to explain the absence of phosphatic pebbles on the contact surfaces of sandstones, which is so characteristic of marine facies spreading on the platform. Since the phosphate (apatite) found in pebbles is a comparatively resistant mineral, it may be assumed that the sedimentary conditions of the Dividal Group rocks may have been similar to those of the Vendian in the inland areas of the East European craton, where phosphatic mineralization is almost non-existent.

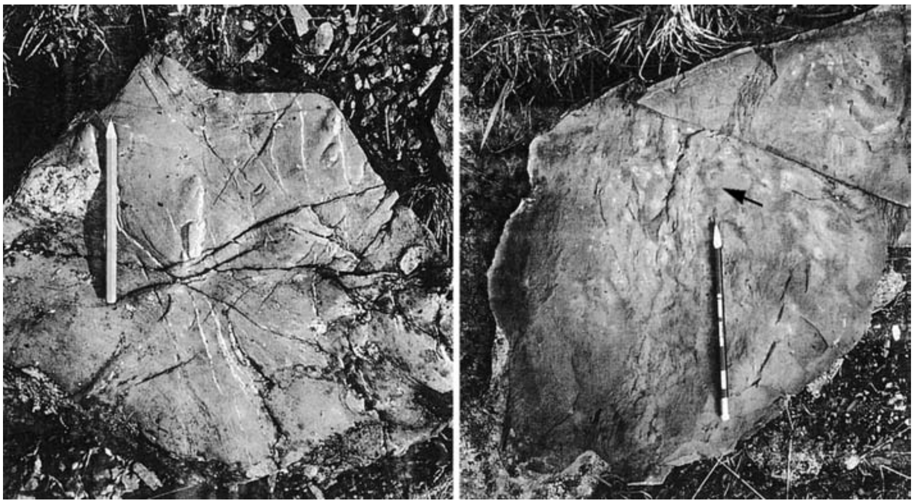
2. However, this conclusion seems to be contradicted by the fact that vertical rhythmical thin lamination, which in normal sections of the East European craton can be seen in most of the upper Vendian claystone sequences, is almost lacking in the Dividal Group. It is hard to believe that constant microheterotrophicity, indicative of climatic conditions, would simply have disappeared due to cleavage

of claystone. Most probably it was originally lacking in fine clay sediment. Rather irregular smooth silty surfaces on some samples support this assumption. Let us note for comparison that the original thin bedding of rocks is sometimes preserved despite heavy metamorphism. Such rocks can be seen in mylonite shales spread in thrust formations on top of Saanavuori.

3. Accumulations of concretional matter, as well as nodules, and other mineralogical heterogenic phenomena are totally absent. This suggests suppression of typical marine diagenetic processes during the accumulation period of the Dividal Group sand- and claystones. Most of the diagenetic concretions (sulphides, carbonates) are unstable in late metagenetic processes. However, their bedding defects, or pseudo-morphological replacement phenomena, could have survived in the sedimentary rock, yet no such phenomena were discovered.

4. In three outcrops (in the central part of the southwestern slope of Saanavuori, on the southeastern slope of Saanavuori, and on Saanajärvi (Fig. 2.), interesting reddish-brown and violet clay varieties containing 5–22 mm patches, secondarily reduced into greenish-grey colour, were found. These resemble the Vendian and Cambrian claystones of the East European craton, where primary haematite pigmentation suggests the absence of organic matter reducer during the early diagenesis of sediments. The appearance of a similar phenomenon as an evident relict in the Dividal Group rocks of Lapland is remarkable, because during the local post-diagenetic deep changes (sericitization and chloritization of sedimentary rocks), the reduction, which is probably caused not by organic matter, but by other reductive fluids, encompasses the entire rock massive. The content of Fe is 7.6–8.5% in originally preserved reddish relicts, and 6.0–7.1% in green reduced patches and predominantly greyish shale. Thus, partial outflow of iron compounds is characteristic of the geochemical background of local lithogenesis.

5. A specific feature of the given rock sequence is the almost total absence of trace fossils of organisms – the bioglyphs – even on contact planes of sandstones and clays, where they could have been best fixed. Despite careful search, such bioglyphs, even problematic ones, were not found. Still, they are constantly abundant and diverse in similar facies of the East European pre-trilobite Lower Cambrian. True, the observation of horizontally extensive bedding planes in the Dividal Group rocks is difficult due to their heavy fracturing. Considering the great number of observations, very few ichnofossils were found in these rocks. No vertical erosion tunnels filled with siltstone were discovered. In some places wale-like horizontal furrows were seen on rock surfaces, but these were mostly just small fractures in microfolds of the layers. Some of the furrows were lens-like in cross-section, but their organic origin could not be stated with certainty. Lehtovaara (1988) has also found similar problematic forms on some surfaces. The forms, even if occurring together, are of very variable sizes, which makes their systematic-taxonomical identification impossible and causes more doubts (Fig. 5a). The only exception was a single fossil from the outcrop on Saanajärvi's eastern shore, where brownish shale was pierced by a cylindric burrow 12 mm long and 3 mm in diameter, filled with fine crystal pyrite (Fig. 5b). This form – surrounded on the layer surface by a goethitic oxidation belt – leaves no doubt about its organic



(a) (b)

Fig. 5. Problematic ichnofossils (a), including a solitary vertical burrow tunnel (b) filled with pyrite (indicated by an arrow), are very rare.

origin, although it is impossible to determine its taxonomical position. The study of that horizon yielded more similar finds, but only in the form of presumable tunnel fragments. The passage filled with pyrite is a very important finding. Firstly, its vertical position in the sediment shows that this form probably belongs to the Cambrian, because such trace fossils are not known in the underlying Vendian. Secondly, the find suggests that marine conditions must have governed the sedimentary environment, so that, as a result of sulphate reduction, enough pyrite could be formed to fill the tunnel. Thirdly, the fossil shows that it is quite possible to find sulphidic formations, which were originally formed in rocks subjected to such metamorphism.

If those beds are indeed of Cambrian age, then why do they contain so few ichnofossils? By the beginning of the Cambrian, the biota was already significantly developed and differentiated, so that it could have occupied a wide range of facies in the basins. The answer is evidently hidden in ecology. It is possible that fairly cool climate, or even post-glacial fresh-water conditions, dominated this area and hindered wide distribution of bottom organisms in the sedimentary basin.

6. Considering the above arguments, we searched for possible evidence (signs) of organic matter of plants. Commonly in the East European sequence, Vendian rocks in some stages are rich in films of fossilized sapropelic organic matter and in remains of ribbon-shaped membranes of vendotaenid algae. The distribution of vendotaenids was not limited by fresh or cold water – they were fairly adjusted to such conditions. It could be expected that at least some signs of organic matter had preserved in these strongly lithified sedimentary rocks. Some barely visible ribbon-like formations were found on a few layer surfaces at the bottom of the

Pikku-Malla outcrop, although secondary oxide coating on rock surfaces limited the search considerably. The size of the finds corresponds to that of *Vendotaenidiae* or *Sabellidites* fragments, but this identification is highly speculative and gives no reliable data about the nature of organic matter. As these fossils are very poorly preserved and similar ones were not found in other outcrops, they could be regarded as a “game of nature” as well.

DISCUSSION

Due to metamorphosis processes in sediments, lithogenetic study of the Dividal Group in the outcrops surrounding Kilpisjärvi contributed only little to the comparison of these rocks with the normal sequence of the East European craton. It can only be presumed that the local cross-section most probably corresponds to the Vendian–Cambrian boundary interval, where the characteristic features of the Vendian (such as the rhythm of cool-climate clay rocks) are no longer, and marine features of the Lower Cambrian (primarily bioturbation) are not yet clearly fixed in the sediments.

The section could primarily be correlated with the Rovno Stage on the East European craton, which shows greatest similarity with the Dividal Group rocks. Occurrences of fossils seem to support this reasoning. Poorly preserved *Sabellidites* and *Platysolenites* specimens were identified by Tynni (1980) about 30 km northwest of Kilpisjärvi, in the surroundings of Halti, where they most likely belong to the upper part of the Dividal Group sequence. These fossils are indicative of the lower part of the Lontova Stage or, possibly, of the highest beds of the Rovno Stage, and thus speak in favour of the above correlation. The lack of ichnofossils in the Kilpisjärvi Dividal Group rocks is another heavy argument: rapid development of those organisms in the Lontova Sea would most certainly have left more traces in the sediments. Better preserved fossils, including *Platysolenites spiralis* Posti, dated to late Lontova age, originate from Finnmark (Fig. 1), where the section in the Lower Cambrian part seems to be the most complete. Reliable fossils of Lontova age, although no *P. spiralis*, have been recovered 100 km south of Kilpisjärvi – in Dorrovarre (Norway) and Torneträsk (Sweden). In the lower part of the latter section, remains of vendotaenid algae characteristic of the Vendian, have been found (Vidal & Moczydlowska 1996). All this shows that the thrust plates of the Caledonides cut the autochthonously preserved Upper Proterozoic and Lower Cambrian deposits at several levels. Thus, similar interpretations are also possible for Kilpisjärvi, especially when considering the notable variation in the thickness (50–200 m) of the local Dividal Group sequence. On the other hand, sections of northern Norway may suggest that in the southern areas, including Finnish Lapland, considerable lowerings accompanied the transgression of the Rovno-time Cambrian Sea, as can be seen on a wide territory in the border areas of the craton (Rozanov & Lydka 1987).

The above discussion is insufficiently grounded and, unfortunately, lithogenetic study provided no reliable data. However, the observations do not contradict our hypothesis either. During the Rovno Age, the conditions characteristic of the Cambrian Sea strengthened in the western part of the East European craton: bioglyphs were not well developed yet, the undeveloped marine water circulation did not yet favour the fixation of phosphate into the sediments, diagenetical prerequisites for the formation of pyrite-glauconite were lacking, and fine rhythmical clay textures of the fading cool Vendian Sea were only episodically represented in sediments. All these features can be observed in the Dividal Group in the Kilpisjärvi region despite cleavage of rocks (dynamometagenesis). The mineral composition of the main components in rocks adds no information: total sericitization and regenerational displacement of quartz in the final lithification process mask the primary characteristics of rock formation. The comparison of the chemical compositions of Vendian and pre-trilobite Cambrian claystones from the Kilpisjärvi Dividal Group with those from the inner territories (Estonia) of the craton is more informative (Table 1).

As can be seen from Table 1, the main components of claystones in both above-mentioned regions are rather well comparable. Although the quartz content of clay shales of the Dividal Group is slightly higher (secondary silicification?), the $SiO_2 : Al_2O_3$ ratio in both cases is similar to the original illitic composition of the clay mineral. The amount of Al_2O_3 is slightly larger in Estonian Vendian clays with notable admixture of kaolinite. A greater difference can be noted in the distribution of alkaline compounds. Estonian clays are rich in Ca and K, but somewhat poorer in Na. These differences are most likely reflected in the initial matter which forms the clay component: it is more mature and thus richer in K-feldspar in the

Table 1. Comparison of the chemical composition (%) of coeval claystones

	Dividal Group (Finland)		Kotlin Formation (Vendian, Estonia)	Lontova Formation (Lower Cambrian, Estonia)
	Fluctuation	Average	Average (19 samples)	Average (26 samples)
SiO_2	57–68	62.50	58.44	60.00
TiO_2	1.37–1.50	1.43	0.97	0.84
Al_2O_3	15.5–15.9	15.70	21.40	17.90
Fe_2O_3	6.13–9.39	7.76	5.53	6.44
MnO	0.02–0.04	0.03	0.05	0.04
MgO	1.16–2.25	1.71	1.78	2.28
CaO	0.33–0.59	0.46	0.71	0.66
Na_2O	0.91–1.04	0.97	0.32	0.37
K_2O	2.73–3.00	2.86	4.06	5.17
L.O.I	3.06–3.65	3.35	6.33	5.47
Total		96.77	99.59	99.17

Finnish data from Lehtovaara (1995), Estonian data by E. Pirrus (unpublished results of 1975–1989).

craton's inner region, and contains less stable plagioclases on the marginal region on the Scandinavian side. Difference in the L.O.I. is natural – the silicates of a layered structure in shales which have undergone dynamic deformation are more dehydratized. In conclusion, the chemical data show that clay sediments formed in sedimentary basins of that time are similar in the entire northwestern part of the East European craton, including the marginal area buried under the Caledonides.

CONCLUSIONS

Based on the above results, we can daw the following conclusions:

1. In sedimentary rocks of the Dividal Group of Finnish Lapland no lithogenetic features characteristic of the primary sedimentation are preserved, probably due to the Caledonian orogeny. This has unified the rock composition and destroyed authigenic indicator minerals, and only few fossils are preserved in an identifiable state.

2. Analysis of indirect factors, especially the occurrences of a few ichnofossils, and comparison with the sequence of the East European plate allow us to assume that the most probable accumulation time of that sedimentary level in the vicinity of Kilpisjärvi is the Rovno Age. By that time the transgressive sea environment was not yet entirely developed, but the sedimentation environment of the Late Proterozoic had already faded.

3. Direct palaeogeographic reconstructions between the accumulation areas of the region and the inner platform areas are rather difficult, due to the central uplift area of the Fennoscandian Shield between them.

4. Further, more detailed palaeogeographical studies would contribute to determining the development of the Fennoscandian region during the Phanerozoic. All stratigraphically important fossil occurrences in this area should be carefully recorded and located on general charts of the craton. Fairly perfect Vendian and Lower Cambrian sections of Finnmark in North Norway would serve for this purpose, because a basin-like connection with the main part of the craton could have existed here. Mineralogy of the rocks at Kilpisjärvi, however, gives little trustworthy information for this work.

ACKNOWLEDGEMENTS

The research was conducted within the framework of the international programme LAPBIAT under the IHP Access to Research Infrastructures of the European Union. The author thanks his colleague Dr. Ülo Sõstra for initiating and leading the project, and all the workers at the Kilpisjärvi biological station (University of Helsinki) for creating excellent conditions for field work. The author also thanks Ms. Helle Pohl for the linguistic aid and Dr. Dimitri Kaljo and Dr. Kaisa Mens for the improvements in the manuscript.

REFERENCES

Foyn, S. & Glaessner, M. F. 1979. *Platysolenites*, other animal fossils, and the Precambrian–Cambrian transition in Norway. *Norsk Geol. Tidsskr.*, **59**, 25–46.

Hamar, G. 1967. *Platysolenites antiquissimus* Eichw. (Vermes) from the Lower Cambrian of northern Norway. *Nor. Geol. Unders.*, **249**, 87–95.

Lehtovaara, J. J. 1988. The palaeosedimentology of the autochthon of the Finnish Caledonides. *Geol. Surv. Finland Spec. Pap.*, **5**, 255–264.

Lehtovaara, J. J. 1995. *Kilpisjärven ja Haltin karta-alueiden kallioperä. Suomen geologinen kartta 1 : 100 000*. Geologian tutkimuskeskus, Espoo, 1–64.

Moczydlowska, M., Jensen, S., Ebbestad, J. O. R., Budd, G. E. & Marti-Mus, M. 2001. Biochronology of the autochthonous Lower Cambrian in the Laisvall-Storuman area, Swedish Caledonides. *Geol. Mag.*, **138**, 435–453.

Pirrus, E. 1992. Freshening of the Late Vendian basin on the East European Craton. *Proc. Estonian Acad. Sci. Geol.*, **41**, 115–123.

Rozanov, A. Yu. & Lydka, K. (eds.). 1987. *Palaeogeography and Lithology of the Vendian and Cambrian of the Western East-European Platform*. Publ. House Wydawnictwa Geol., Warsaw.

Tynni, R. 1980. Fossiileja Porojärven alueella kaledonialaisen ylityöntölaatan alaisilla Ala-Kambrissa sedimenteissa. *Geologi*, **32**, 17–24.

Vidal, G. & Moczydlowska, M. 1996. Vendian–Lower Cambrian acritarch biostratigraphy of the central Caledonian fold belt in Scandinavia and the palaeogeography of the Iapetus–Tornquist seaway. *Norsk Geol. Tidsskr.*, **76**, 147–168.

Soome Lapimaa Kilpisjärvi ümbruse Dividal-rühma kivimikompleksi stratigraafilise interpretatsiooni võimalustest litogeneetiliste tunnuste alusel

Enn Pirrus

On analüüsitud Soome Lapimaal Kilpisjärvi ümbruses paljanduva Kaledoniidide-aluse autohtoonse kompleksi Dividal-rühma settekivimite litoloogilisi iseärasusi. Uuringu eesmärk oli püüe täpsustada litogeneetiliste tunnuste abil selle problemaatilise Vendi-Kambriumi vanusega settekeha stratigraafilist asendit Ida-Euroopa platvormi koondläbilõikes ja sel teel saada uusi pidepunkte selleaegse paleogeograafia selgitamiseks platvormi loodepiirdel.

Selgus, et Kaledoonia orogeneesiga kaasnenud kildastumise tõttu ei ole siinsetes kivimites säilinud teistele piirkondadele iseloomulikke autigeenseid mineraale püriiti, fosfaate, glaukoniiti, karbonaate jt. Ebasoodne on siinne olustik olnud ka fossiilide ja nende elutegevuse jälgede fikseerimiseks. Samas ei ilmne savikiltades Hilis-Vendile omast savikivimite rütmilist peenkihitatust, mis osutaks selleaegsetele omapärastele ja suurel alal jälgitavatele jahedatele kliimatingimustele.

Harvad elujäljed, sealhulgas üksikud mudaorganismide püriidiga täitunud vertikaalkäigud, aga ka mitmed kaudsemad tunnused lubavad oletada Dividal-kompleksi kivimite tõenäolist kujunemist Ida-Euroopa Alam-Kambriumi vanima, Rovno lademe formeerumise ajal. Sellise interpretatsiooniga on kooskõlas sama kompleksi ülaosast pärinevad paleontoloogilised leiud, mis on saadud Rootsi ja Norra külgnevatelt aladelt ning ka veidi kaugemalt Soome alalt. Savikivimite keemiliste iseärasuste võrdlus ei tekita samuti vastuväiteid.

Edasises uurimistöös, mis soodustaks paleogeograafilise arenguloo mõistmist platvormi loodeserval, tuleks hoolikalt registreerida ja teadaoleva koondläbilõikega seostada kõik uued paleontoloogilised leiud ja samas igakülgselt uurida klimaatiliselt karmis Norra Finnmargis asuvaid täielikke läbilõikeid, sest siitkaudu võis kulgeda Kaledoonia-eelsete epikontinentaalsete basseinide ühendus ookeaniga.