U-Pb zircon age of a dolerite dyke from near Hamningberg, Varanger Peninsula, North Norway, and its regional significance

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A dolerite dyke cutting very low-grade metasedimentary rocks of the Løkvikfjellet Group near Hamningberg, NE Varanger Peninsula, Finnmark, has yielded a U-Pb zircon upper intercept age of $567.1\ ^{+30}/_{-23}$ Ma. This ENE-WSW-trending dyke, and others of comparable field character, petrography and geochemistry in this northeastern part of Varanger, have previously given Late Devonian/Early Carboniferous, K-Ar whole-rock ages. Accepting 567 Ma as the approximate age of intrusion, the K-Ar dates are considered to reflect a thermal resetting associated with either a late-Scandian pulse or a slightly later, regional crustal extension and rifting event known from borehole data in the Barents Sea. A Late Devonian thermal overprint has also affected comparable dolerite dykes on the nearby Rybachi Peninsula of Northwest Russia.

The Late Vendian age of the Hamningberg dyke is in good accord with regional geological development, involving a Late Vendian, Baikalian deformation and metamorphism affecting rocks on Rybachi and probably also NE Varanger, characterised by a NW-SE (to c.N-S) fold axial trend and cleavage strike. The Hamningberg dyke and related dykes in this NE Varanger/Rybachi region cut the folds and cleavage at high angles, and probably penetrated along extensional master fractures at a late stage in the Baikalian deformation episode. It is suggested that many of the dykes in the Båtsfjorden, Kongsfjorden and Berlevåg swarms in the north and northwest of the Varanger Peninsula may also be of Vendian (to possibly Cambrian) age; these dykes were subsequently affected to varying degrees by Caledonian deformation and metamorphism.

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Introduction

Varanger Peninsula in Finnmark, northern Norway, is underlain by weakly metamorphosed sedimentary rocks of Neoproterozoic to Early Cambrian age. In terms of Caledonide tectonostratigraphy (Roberts & Gee 1985), the peninsula exposes the transition from autochthonous formations lying unconformably upon Palaeoproterozoic crystalline rocks, through the weakly folded sequences of the Parautochthon, into more penetratively folded and cleaved successions of the Lower Allochthon in westernmost areas. In addition to the Caledonian structures, it has been suggested that folds and cleavage of Late Vendian age (the Baikalian deformation of NW Russia) may be represented in the northeasternmost parts of Varanger Peninsula (Roberts 1993, 1996). A complex, polyphase, NW-SE-trending fault zone, the Trollfjorden-Komagelva Fault Zone (TKFZ), divides the peninsula into two halves — the Tanafjorden-Varangerfjorden Region (TVR) to the southwest, and the Barents Sea Region (BSR) to the northeast (Siedlecka & Siedlecki 1967) (Fig.1).

The chronostratigraphy of the successions on the peninsula has been based largely on diverse faunal evidence – acritarchs (Vidal 1981, Vidal & Siedlecka 1983), stromatolites (Bertrand-Sarfati & Siedlecka 1980) and Ediacaran fossils (Farmer et al. 1992) – but there are also Rb-Sr whole-rock isochron ages for two formations in the TVR (Sturt et al. 1975). Indirect evidence which also has a bearing on the relative ages of parts of the lithostratigraphical successions has come from a K-Ar dating investigation of mafic dykes (Beckinsale et al. 1976). From these K-Ar determinations, three age groups were defined: (A) Ages of c.360 Ma for comparatively unaltered dolerite dykes from the eastern parts of Varanger Peninsula, in both the BSR and the TVR; (B) Ages of c.650 Ma for weakly cleaved metadolerites from the Båtsfjorden area of the BSR; (C) A group of ages ranging from 945 to 1945 Ma, from schistose metadolerites in the Kongsfjorden area of the BSR. All K-Ar ages given here, and in the subsequent discussion, are recalculated according to Dalrymple (1979). A palaeomagnetic study of one of the group A dykes in the easternmost part of the TVR yielded data which suggested a probable Vendian to Cambrian age (Torsvik et al. 1995), rather than the Late Devonian age indicated by the K-Ar analyses of Beckinsale et al. (1976). Results of a similar study on dolerite dykes from the BSR were not definitive, but also tended to favour a latest Neoproterozoic to Early Palaeozoic age (Knutsen 1995). Finally, there is an unpublished Sm-Nd date of 550 Ma, noted in Andersen & Sundvoll (1995), for a mafic dyke from the Kongsfjord area (locality not given).

In view of these discrepancies in age, there is clearly a need for a more precise isotopic dating of many of these mafic dykes. As the ^{40}Ar-^{39}Ar and Rb-Sr methods had been

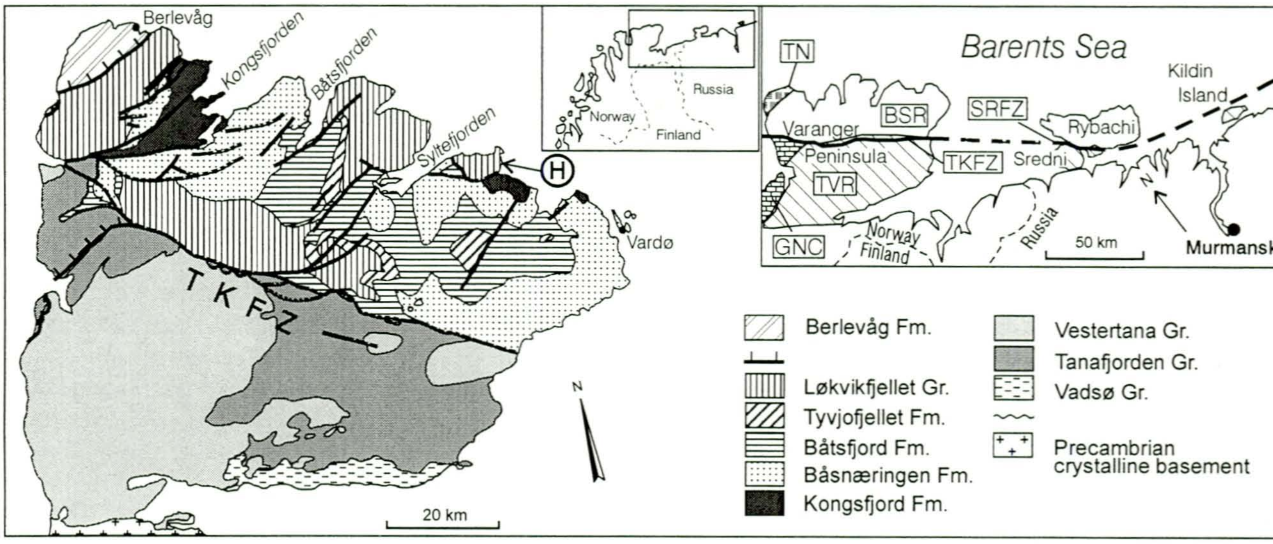

Fig. 1. Simplified geological map of the Varanger Peninsula, showing the location of the Hamningberg dolerite dyke (circled H). BSR - Barents Sea Region; TVR - Tanafjorden-Varangerfjorden Region; GNC - Gaissa Nappe Complex; TN - Tanahorn Nappe; TKFZ - Trollfjorden-Komagelva Fault Zone; SRFZ - Sredni-Rybachi Fault Zone.

tried without much success (Roberts et al. 1995 and unpublished data), we delivered a 3.5 kg sample of dolerite from a dyke near Hamningberg (Fig.1) to NGU's mineral separation laboratory, in the hope that baddeleyite or some few zircons could be recovered. A limited number of zircons were, in fact, found. In this paper we present the results of U-Pb analyses of zircon fractions extracted from this dyke.

Aspects of regional geology

The geology of Varanger Peninsula has been described in many publications over the past 20 years. Reviews or accounts of various kinds include those of Siedlecka (1975, 1985), Johnson et al. (1978), Rice et al. (1989a), Siedlecka & Roberts (1992) and Karpuz et al. (1993). Lithostratigraphic correlations with successions occurring on the Rybachi and Sredni Peninsulas in nearby Northwest Russia can be found in Siedlecka (1975) and Siedlecka et al. (1995a,b).

On Varanger, the *Barents Sea Region* is dominated by two principal, epizone-grade lithostratigraphic mega-units, the 9 km-thick Barents Sea Group and the unconformably overlying 5.7 km-thick Løkvikfjellet Group (Siedlecka & Siedlecki 1971, Siedlecki & Levell 1978) (Fig.1). In the extreme northwest of the region, the Løkvikfjellet Group is overthrust by the Tanahorn Nappe (Siedlecka & Roberts 1992) which comprises a mixed phyllite-metasandstone succession, the Berlevåg Formation (Levell & Roberts 1977). The Barents Sea Group shows a shallowing-upward succession of 4 formations commencing with submarine-fan turbidites of the Kongsfjord Formation (Siedlecka 1972, Pickering 1981). The age of this group, based on microfossils, is Late Riphean (Vidal & Siedlecka 1983). The terrigenous Løkvikfjellet Group has been divided into 5 formations and it is the oldest unit, the Sandfjorden Formation, which occurs in the Hamningberg area (Fig.1) (Siedlecka 1984). Microfossils recovered from the Løkvikfjellet Group yielded a less definitive, Vendian age; and Vidal & Siedlecka (1983) speculated that the highest formations could be as young as Late Vendian.

An attempt to date the prominent cleavage in Kongsfjord Formation pelites south of Hamningberg by the Rb-Sr method yielded a whole-rock isochron age of 520±47 Ma (Taylor & Pickering 1981), interpreted by these authors as dating a folding and cleavage event at ca.520 Ma. Rice et al. (1989) questioned this interpretation, arguing for a Scandian age for the metamorphism in the BSR.

The *Tanafjorden-Varangerfjorden Region* is underlain by a 4 km-thick succession comprising three groups, the Vadsø, Tanafjorden and Vestertana Groups, which range in age from Late Riphean to Early Cambrian. Tillites marking the Varangerian Ice Age occur in the basal parts of the Vestertana Group (Edwards 1984). In general, most of the rocks of the TVR are in diagenesis grade, forming part of the Caledonian Autochthon and Parautochthon, but in the west metamorphic grade increases to upper anchizone in and immediately beneath the Gaissa Nappe Complex (Rice et al. 1989b). The youngest fossiliferous rocks in this allochthonous unit are found on the Digermul Peninsula, and are of Tremadoc age. In one small area immediately southwest of the Trollfjorden-Komagelva Fault Zone, rocks of the upper part of the Vadsø Group are lying unconformably upon a formation of the Barents Sea Group (Rice 1994), a relationship which marks an important link between the TVR and the BSR.

The metadolerite dykes of groups B and C (p.95) occur as swarms in the Båtsfjorden and Kongsfjorden areas of the BSR, respectively, trending mainly ENE-WSW to NE-SW (Roberts 1972, Rice & Reiz 1994). A swarm of dykes of similar trend also occurs in the northern parts of the Berlevåg

Fig. 2. The Hamningberg dyke, cutting medium-bedded sandstones of the Sandfjorden Formation, Løkvikfjell Group; looking approximately east-northeast.

Formation in the Tanahorn Nappe. Group A dykes, on the other hand, are few in number and occur in comparative isolation in the eastern parts of the Barents Sea Region; and also in eastern coastal tracts of the Tanafjorden-Varangerfjorden Region (Roberts 1972, 1975, Beckinsale et al. 1976) where they generally trend between NE-SW (BSR) and N-S (TVR).

Dolerite dykes also occur in the northwestern part of Rybachi Peninsula, along the northern coast of the Kola Peninsula, just 60 km southeast of Varanger Peninsula. The dykes there are comparable in petrography, geochemistry and weathering colours to those of group A on Varanger and they also trend NE-SW, cutting NW-SE-trending folds and an associated penetrative cleavage almost at right-angles (Roberts & Onstott 1995). $^{40}Ar/^{39}Ar$ laser microprobe analyses of pyroxenes and feldspars from these dykes yielded only Mid Ordovician-Silurian and Late Devonian overprint dates, whereas palaeomagnetic data acquired from these same dykes have suggested a Vendian to Cambrian age of intrusion (Torsvik et al. 1995).

The Hamningberg dolerite dyke

The sample is from a 13.5 m-thick dyke located just southeast of the former fishing settlement and whaling station of Hamningberg, in the northeastern part of the Barents Sea Region on Varanger Peninsula (grid.ref. 1125 2695, 1:50,000 map-sheet Syltefjord 2436-2). The sample was taken from the central part of the dyke along a road-cut. The dolerite dyke trends between NE-SW and ENE-WSW and dips at c.70° to the NNW. It cuts very low-grade, thick-bedded sandstones of the Sandfjorden Formation (Siedlecka 1984) of the Løkvikfjellet Group (Fig. 2) which dip at c.40° to the SE. Thin, silty pelite intercalations carry a weakly developed, steep, ESE-dipping, spaced cleavage which is axial planar to the open, upright, ca. N-S-trending folds which characterise this part of the BSR (Siedlecki 1980). Rotating the bedding back to the horizontal would indicate that the dyke originally dipped steeply to the SSE-SE.

The dark brown to almost black, medium- to coarse-grained dolerite shows orange-brown colours on weathered surfaces. A feature of the dyke, best seen along its margins, is that it displays well developed, pseudohexagonal, columnar jointing (Fig.3). The mineralogy of the dyke is dominated by plagioclase (An_{44-60}) and clinopyroxene (pigeonite, with some augite in outer marginal zones). Lath-shaped plagioclase exhibits minor sericitisation, and the clinopyroxene is typically twinned. There are minor amounts (<1%) of a primary yellow-green amphibole and secondary chlorite; and magnetite is the opaque phase. A subophitic texture prevails, but there are also glomerophyric clots of plagioclase + clinopyroxene and just clinopyroxene.

Fig. 3. Pseudohexagonal, columnar jointing in the Hamningberg dyke. The photo was taken looking NNW, perpendicular to the structurally lower margin of the dyke.

Analytical methods and results

U-Pb zircon analytical methods

Zircon separates were cleaned in successive solutions of 2N HNO_3, 3N HCl and distilled H_2O to remove contaminant sulphides and surface impurities. Zircon concentrates thus treated were then handpicked into three 3-grain fractions on the basis of morphological similarity, employing visual discriminants such as size, form, colour, clarity and aspect ratio. In each case the zircon grains appeared to be magmatic in origin (as judged by aspect ratio and preservation of crystal terminations and crystal edges) with no macroscopic evidence of magmatic resorption or mechanical rounding as might be observed if these zircons were xenocrystic. We note, however, that there are no independent data to confirm whether or not these zircons are co-genetic with the melt that crystallised to form the dyke.

The handpicked fractions were air abraded in a device similar to that described by Krogh (1982). Zircon dissolution and ion-exchange procedures were comparable to those described by Krogh (1973) and Parrish et al. (1987). A mixed ^{205}Pb-^{233}U-^{235}U tracer was employed. Pb was loaded on W filaments and U was loaded to Re filaments and analysed on the Finnigan MAT 261 multicollector mass spectrometer at Brown University. Pb was analysed in static multicollector mode employing Faraday cup collection of masses 208, 207, 206 and 205, while simultaneously collecting mass 204 in a secondary electron multiplier. Uranium was analysed in static multicollector mode employing Faraday collectors only. Additional analytical details are given in the footnotes to Table 1.

Data and age interpretation

Three zircon fractions from sample HMBG were analysed. The data are shown in Table 1 and graphically displayed in Fig.4. U-Pb systematics are normally discordant for the three fractions. A best-fit discordia trajectory through these data defines an upper intercept of 567.1 $^{+30}/_{-23}$ Ma and a lower intercept of 392 $^{+25}/_{-36}$ Ma; and with a mean square of weighted deviate of 17. The rather large intercept uncertainties are *not* due to the inherent quality of the analytical data. The uncertainties are the result of apparently non-simple isotopic systematics (a combination of Pb loss and variable but small amounts of inheritance?) coupled with the low angle of the discordia trajectory to concordia, a problem that befalls all geologically young zircons that are discordant due to Pb loss relatively shortly after crystallisation.

If we assume that these zircons crystallised from the same melt as the dyke, the upper and lower intercepts place some important constraints on the emplacement age. We interpret the upper discordia intercept of 567 Ma to give the approximate crystallisation age of the dyke within the numerical uncertainties expressed above. The lower intercept is interpreted to reflect a Devonian isotopic disturbance related, most likely, to a Caledonian (late Scandian; possibly Early Devonian) tectonothermal event; or, given the errors for the intercept, conceivably to the initial, Late Devonian stages of a regional, Devono-Carboniferous rifting and crustal extension which affected wide areas of the southern Barents Sea and probably also the coastal areas of northern Finnmark and the Kola Peninsula.

Discussion

The U-Pb zircon crystallisation age for the Hamningberg dyke differs appreciably from the Late Devonian/Early Carboniferous (c.360 Ma) K-Ar date of Beckinsale et al. (1976). On most modern time-scales an age of 567 Ma falls in the Late Vendian, taking the Vendian-Cambrian boundary at

Fraction properties°	Amount analysed (grains)	Concentration+ (ppm)		Pb isotopic composition#				Radiogenic ratios@		Age and uncertainty ** (Ma)		
		Pb	U	206/208	206/207	206/204	206Pb*/238U	207Pb*/235U	207Pb*/206Pb*	206Pb*/238U	207Pb*/235U	207Pb*/206Pb*
ar=3:1, pale brown	3	73.5	835.2	7.207	15.629	2,473	0.0854 (0.29%)	0.6882 (0.35%)	0.05842 (0.18%)	528.5 (± 1.5)	531.7 (± 1.8)	545.8 (± 1.0)
ar=2:1, pale yellow	3	82.3	996.9	9.266	15.930	2,940	0.0852 (0.29%)	0.6823 (0.34%)	0.05809 (0.17%)	527.1 (± 1.5)	528.2 (± 1.8)	533.2 (± 0.9)
ar=3:1, pale brown	3	64.3	855.3	14.433	16.350	3,515	0.0773 (0.23%)	0.6111 (0.26%)	0.05721 (0.11%)	481.1 (± 1.1)	484.3 (± 1.3)	499.5 (± 0.6)

f Zircons mechanically abraded for 6 - 12 hours; ar= aspect ratio prior to abrasion; colour as observed with grains in alcohol.
+Concentration is total Pb and includes blank Pb, common Pb in zircon, and radiogenic Pb. Total procedural blanks are ~2 picograms for U and ~10 picograms for Pb.
Because weights of grains are estimated and a mixed U-Pb tracer was employed, uncertainty in estimates of grain weight affects only concentration data, not calculated U-Pb or Pb/Pb ages.
#Measured isotopic ratios prior to correction for mass fractionation of ~0.11% per atomic mass unit based on replicate analyses of NIST SRM 981 and 982 and adjusted for small amount of 206Pb in tracer.
@Number in parentheses is percent uncertainty in the calculated ratio, stated at the 2-sigma level.
**Decay constants: 238U = 1.5513 E-10/yr.; 235U = 9.8485 E-10/yr. Atom ratio 238U/235U = 137.88. Uncertainty in the calculated ages is stated at the two-sigma level and estimated from combined uncertainties in calibrations of mixed 205Pb - 233U - 235U tracer, measurement of isotopic ratios of Pb and U, common and laboratory blank Pb isotopic ratios, Pb and U mass fractionation corrections, and reproducibility in measurement of NIST Pb and U standards.

Table 1. Zircon data, Hamningberg dyke

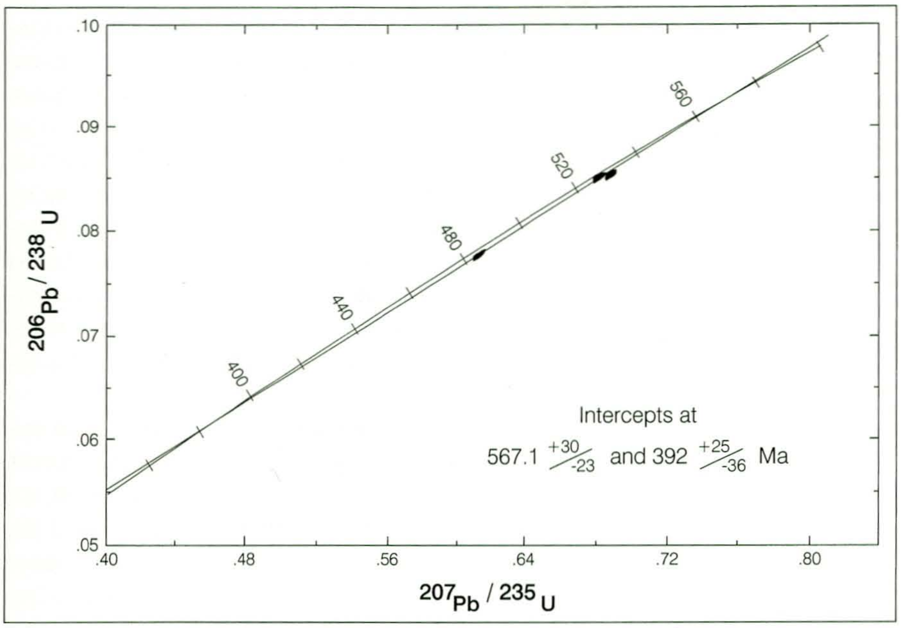

Fig. 4. U-Pb concordia diagram for the three zircon analyses from the Hamningberg dyke. The data are presented in Table 1.

545 Ma (Tucker & McKerrow 1995). As a consequence of this, it is necessary to reassess certain aspects of the geological history of the region.

Although in general field appearance the dated dyke seems to be unmetamorphosed, and as such should postdate the spaced cleavage seen in silty pelite interbeds, a definitive mutual relationship cannot be demonstrated at this locality. Some 2 km to the southeast, however, near Finvik, a similar NE-SW trending, unmetamorphosed dolerite dyke with a comparable K-Ar age cuts an ESE-dipping cleavage which is axial planar to mesoscopic and mappable c.N-S folds. The host rocks here are part of the Kongsfjord Formation. The indications are, therefore, that the earliest folding, cleavage and very low-grade metamorphism in this particular area of Varanger Peninsula are pre-567 Ma, i.e. pre-Caledonian. In this regard, the Rb-Sr date of 520$\pm$47 Ma for the cleavage in Kongsfjord Formation pelites reported by Taylor & Pickering (1981) takes on renewed interest. Accepting the error of $\pm$47 Ma, a maximum age for the cleavage would thus be put at 567 Ma. What we clearly need is a more accurate dating of this cleavage-forming event, perhaps by the ^{40}Ar-^{39}Ar method (a ^{40}Ar-^{39}Ar cleavage dating project has, in fact, just commenced, on Rybachi Peninsula, with the possibility of future extension onto the Varanger Peninsula).

On the Rybachi Peninsula (Fig.1), the turbiditic Upper Riphean succession is quite pervasively folded and cleaved along a consistent NW-SE trend (Negrutsa 1971, Roberts 1995, Roberts & Karpuz 1995). These structures were generated during the *Baikalian* deformation, an event recognised also southeast of Kola in the Timans. Biostratigraphic and radiometric dating evidence on Rybachi, and on the nearby Sredni Peninsula, have constrained this deformation and low-grade metamorphic event to c.580-560 Ma (Roberts 1995). As noted earlier, there are NE-SW trending dolerite dykes on Rybachi which clearly cut across the NW-SE folds and cleavage, at high angles. Based on ^{40}Ar-^{39}Ar mineral data, the dykes are evidently older than Mid Ordovician; and are more likely to have intruded at some stage during the Vendian-Cambrian time interval judging from the results of the paleomagnetic investigations (Torsvik et al. 1995).

It has been argued that the Baikalian structures occurring on Rybachi and Sredni can also be recognised in the eastern parts of Varanger Peninsula, especially in the eastern BSR (Roberts 1995, 1996). This is, in fact, an idea first presented almost a century ago (Ramsay 1899, Tchernyschev 1901), i.e., that the 'Timanian mountain chain' could be followed from the Timans along the northern coastline of the Kola Peninsula, and possibly into the Varanger Peninsula in northeastern Norway, following the same trasé as the pre-existing Riphean to Vendian rift basin along the northern and northeastern margins of the Russian Platform.

As the arguments for an extension of Baikalian folds and cleavage into NE Varanger are thus quite strong, then the U-Pb zircon age presented here should be viewed in a more regional context. Considering the group A dolerites, they occur almost exclusively in the northeastern parts of Varanger Peninsula, and trend between NE-SW and c.N-S. The only exception is a dyke which intrudes the rocks of the Tanahorn Nappe in the northwestern BSR. The dolerites occurring in NW Rybachi also fall into this same category. If the ca.567 Ma zircon age can also be applied generally to this group of mafic dykes (but they need not all be of *precisely* the same age), then it is tempting to interpret these particular dykes as having intruded either in the terminal stages of, or shortly after the peak of the Baikalian tectonothermal event. As the dykes strike at high angles to, and clearly transect the Baikalian folds and cleavage, they can be readily envisaged as having been emplaced along major 'ac' tensional fractures or faults which developed in association with the regional folds. It is in such an extensional situation, antithetic to the cleavage- and fold-generating compressive stress, that one would expect rising mafic magma to have met least resistance to penetration of the uppermost crust.

The 567 Ma age for the Hamningberg dyke thus fits quite neatly into this general story, whereby the dyke emplacement would appear to have occurred during the later stages of the Baikalian tectonothermal event. The U-Pb age also falls within the 'age range' for these group A dolerite dykes which is indicated by palaeomagnetic data, some of which are yet unpublished (Knutsen, Torsvik & Roberts, in prep.). Another piece of evidence which provides indirect support for this general reinterpretation of the structural development of NE Varanger Peninsula is that of Rb-Sr dating of illite fractions from formations in the central and eastern parts of the Tanafjorden-Varangerfjorden Region (Gorokhov et al. 1996). Data from the Nyborg and Stappogiedde Formations of the Vestertana Group indicate an age of burial diagenesis in these very low-grade rocks of ca.560 ± 10 Ma. This was interpreted to relate in some way to a regional compaction of the succession arising from the effects of the approaching Baikalian deformation front to the northeast (Gorokhov et al. 1996).

The U-Pb dating reported here naturally questions the validity, or rather the interpretation of the K-Ar ages (Late Devonian-Early Carboniferous) of the group A dykes of Beckinsale et al. (1976). The ^{40}Ar-^{39}Ar laser microprobe analytical data reported by Roberts & Onstott (1995) from the Rybachi dykes also indicated a Late Devonian 'age', but in this case the data clearly showed that the dyke emplacement age was older than Mid Ordovician. These authors did, in fact, interpret the ca.376 Ma isochron age to relate to a thermal resetting event associated with the Late Devonian to Carboniferous rifting which is known to have occurred extensively in the southern parts of the Barents Sea. It does, therefore, seem more reasonable that the K-Ar dates derived for the group A dykes are likely to be a reflection of a weak thermal input arising from the regional, Devono-Carboniferous, crustal extension.

The K-Ar dates of the group C dykes of Beckinsale et al.(1976) are known to be highly suspect in view of the extremely low potassium contents; and some of the ages reported exceed the biostratigraphic age of the metasediments. However, a recent unpublished Sm-Nd date for one of these dykes points to an age of ca.550 Ma (Andersen & Sundvoll 1995). Group B dykes, on the other hand, do appear to have K-Ar ages which, geologically speaking, are not unreasonable. Although ca.650 Ma was said to be «a probable true age», the dates reported do in fact range from ca.660 to ca.550 Ma, with an error bar of ± 19 Ma (Beckinsale et al.1976). These dates, taken at face value, thus overlap with the U-Pb zircon age of the Hamningberg dyke. This may mean that many, though not necessarily all of the dykes in the ENE-WSW-trending Båtsfjord swarm may be of a comparable Late Vendian age. Since they intrude rocks of the Vendian Løkvikfjellet Group, this is indeed likely. Some dyke intrusion may have extended into Cambrian time, but the very oldest of the K-Ar dates of group B may be the most questionable in view of the biostratigraphic constraint.

Although dyke/fold relationships are not the subject of this contribution, it can be noted that a fold-related spaced cleavage is oriented subparallel to the ENE-WSW-striking dykes in the Båtsfjord district. In several cases it can be seen that the regional cleavage bends into perfect parallelism with the dyke margin, and the dykes, especially the thinner ones, are weakly cleaved. The preferred interpretation here is that the dykes are pre-cleavage/folding. This cleavage and these folds can be traced southwestwards into the Kongsfjord area where they are more intensively developed and metamorphic grade is slightly higher (Roberts 1972).

In the Kongsfjord area, metadolerite dykes (group C) are also profuse, with folds and axial planar cleavage subparalleling the now strongly schistose, ENE-WSW-trending dykes (Roberts 1972, 1975, Rice & Reiz 1994). Although Roberts (1972) initially favoured a syn-tectonic emplacement age, subsequent geochemical data (Roberts 1975), additional field studies, and more recently a detailed investigation by Rice & Reiz (1994), has steered interpretation in favour of a pre-cleavage/folding origin for the majority of these dykes (but see Siedlecka & Roberts 1992). Moreover, the situation in the western BSR is such that the folds and penetrative cleavage there – from the Berlevåg area eastwards via Kongsfjorden to Båtsfjord – are almost certainly Caledonian (Roberts 1996), and probably Scandian. Thus, the majority of the dykes also in the Kongfjord and Berlevåg swarms could well be of Late Vendian to Cambrian age, and relate to a tensional/transtensional scenario situated close to the junction of the Iapetus Ocean and Varanger-Timan rift basin (Siedlecka 1975, Roberts & Gale 1978, Rice & Reiz 1994). Whereas the Rybachi and NE Varanger dykes appear to represent magma emplaced in a tensional situation associated with the tail-end of a compressional fold belt, the swarm-like character of the broadly coeval dykes further to the northwest, and also in the higher nappes, may rather be indicative of the more regional, upper crustal extension which is known to have affected the Baltoscandian margin in the Neoproterozoic rifting phase prior to Iapetus opening (Roberts & Gale 1978, Gayer et al. 1985, Kumpulainen & Nystuen 1985).

Conclusions

A 13.5 m-thick dolerite dyke cutting the lower part of the Løkvikfjellet Group near Hamningberg in NE Varanger Peninsula, has yielded a U-Pb zircon crystallisation age of $567.1\ ^{+30}/_{-23}$ Ma. It is argued that dykes of comparable field character, petrography and chemistry occurring in this northeastern part of Varanger Peninsula and in northwestern Rybachi Peninsula, NW Russia, which have previously given K-Ar or ^{40}Ar-^{39}Ar, Late Devonian to Early Carboniferous dates, may be of broadly the same age, i.e. Late Vendian. The Devono-Carboniferous dates probably signify a thermal re-setting associated with either late-Scandian cooling or a slightly later, regional crustal extension and rifting event.

Taking into account the regional geological development, which involves a Late Vendian, Baikalian deformation and low-grade metamorphic event on Rybachi and Sredni, and probably also in NE Varanger, then the 567 Ma dyke age can be seen as relating either to a very late-stage Baikalian event, or an immediately post-Baikalian emplacement. Following the regional development of NW-SE trending folds and cleavage, mafic magma is envisaged as having penetrated along extensional master fractures and faults trending c.NE-SW, i.e., almost perpendicular to the Baikalian fold axes.

Dykes occurring in a swarm in the Båtsfjord district may be of approximately the same age as the Hamningberg dyke. Similarly, the dyke swarms in the Kongsfjord and Berlevåg areas are here suggested to be of broadly the same age. In contrast to the Hamningberg dyke and the dykes on Rybachi, however, these dyke swarms were probably intruded in a more regionally extensile regime and were also subsequently affected by penetrative Caledonian deformation and metamorphism.

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