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Rutile-bearing eclogites in Western Norway

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REPORT

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Rutile-bearing eclogites in Western Norway

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Summary:

The eclogite province of W.Norway is subdivided into 8 geographic regions. The three southernmost of these regions - Holsnøy, Dalsfjord and Førdefjord, are surrounded by large areas without known eclogites, while the regions from Nordfjord and northwards form parts of a large eclogite province. The rutile content is generally 1-2%; 3-4% rutile or more occur within some eclogites in the Holsnøy (Hordaland), Dalsfjord and Førdefjord (both Sogn og Fjordane) regions. Occurrences of high-Ti eclogites are less common, but not absent, in the northern regions.

The investigations in 1992 and even more in 1993 were focused on the Dalsfjord and Førdefjord regions which were considered to have the best potential for economic rutile deposits. The investigations in the northern regions in W.Norway (1992) have given significant additional information, but have not revealed rutile mineralizations of economic interest comparable to those known from the Førdefjord and Dalsfjord regions. Because of the need to obtain economically interesting data quickly, continued investigations in the northern regions were postponed, and practically all energy was focused on the Dalsfjord region in 1993, with the main objects at Saurdal and Orkheia in the Fjaler and Hyllestad commune, respectively.

This report summarizes available geologic information concerning rutile in eclogites in W.Norway. It also includes information (not confidential when open-file reports are referred to) additional to that obtained with DuPont's participation.

Keywords:	Berggrunnsgeologi	Titan
Rutil	Fagrapport	

Contents: *page:*

Figures:

Appendix:

1. Introduction

Rutile in eclogites in the Førdefjord and Dalsfjord regions of W. Norway was the subject of economic-geological investigations by NGU and Norwegian companies during the late 70s and early 80s. In 1988 NGU renewed its interest in rutile and started investigations in recently discovered eclogite terrains at Holsnøy and Gulen. Some interest was also paid to the Engebøfjellet and Fureviknipa eclogites in the Førdefjord region.

NGU's investigations were originally planned to terminate by the end of 1991 with a report summarizing the results (Korneliusssen et al., 1992). However, since DuPont showed interest in continued rutile-investigations in W.Norway, a collaboration project between DuPont and NGU was established, and a new series of field investigations was carried out in 1992 and 1993.

This report summarizes available geologic information concerning rutile in eclogites in W. Norway. It includes information in addition to that obtained with DuPont's participation, which is available in open-file reports. When no special reference is made, the information is confidential according to the Agreement between DuPont and NGU.

The investigations in 1992, and even more in 1993, were focused on the Dalsfjord and Førdefjord regions which were considered to have the best potential for economic rutile deposits. The investigations in the northern regions in W. Norway (1992) have given significant additional information, but have not revealed rutile mineralizations of economic interest comparable to those known from the Førdefjord and Dalsfjord regions. This does not mean that there is no chance for eclogite deposits of economic interest in those regions, but the time and resources needed to find them will be considerable. Because of the need to obtain economically interesting data quickly, continued investigations in the northern regions were postponed, and practically all energy was focused on the Dalsfjord region in 1993.

2. Major characteristics of rutile-bearing eclogites in W. Norway

Eclogite protoliths: Most eclogites in W. Norway occur as lenses within gneisses and lack clear indications of the nature of their protoliths. Others are clearly eclogitized intrusions either with obvious intrusive relationships to the surrounding rocks, or with relict gabbroic textures. Large volumes of eclogite in the Førdefjord region are believed to be of volcanic origin. These meta-volcanic rocks are intruded by eclogitized dykes. A comparable situation occurs in the Averøy area (Kristiansund region) where basic host-rocks to stratabound sulfides (volcanogenic Cu-Zn deposits) were intruded by Ti-rich dykes before eclogitization.

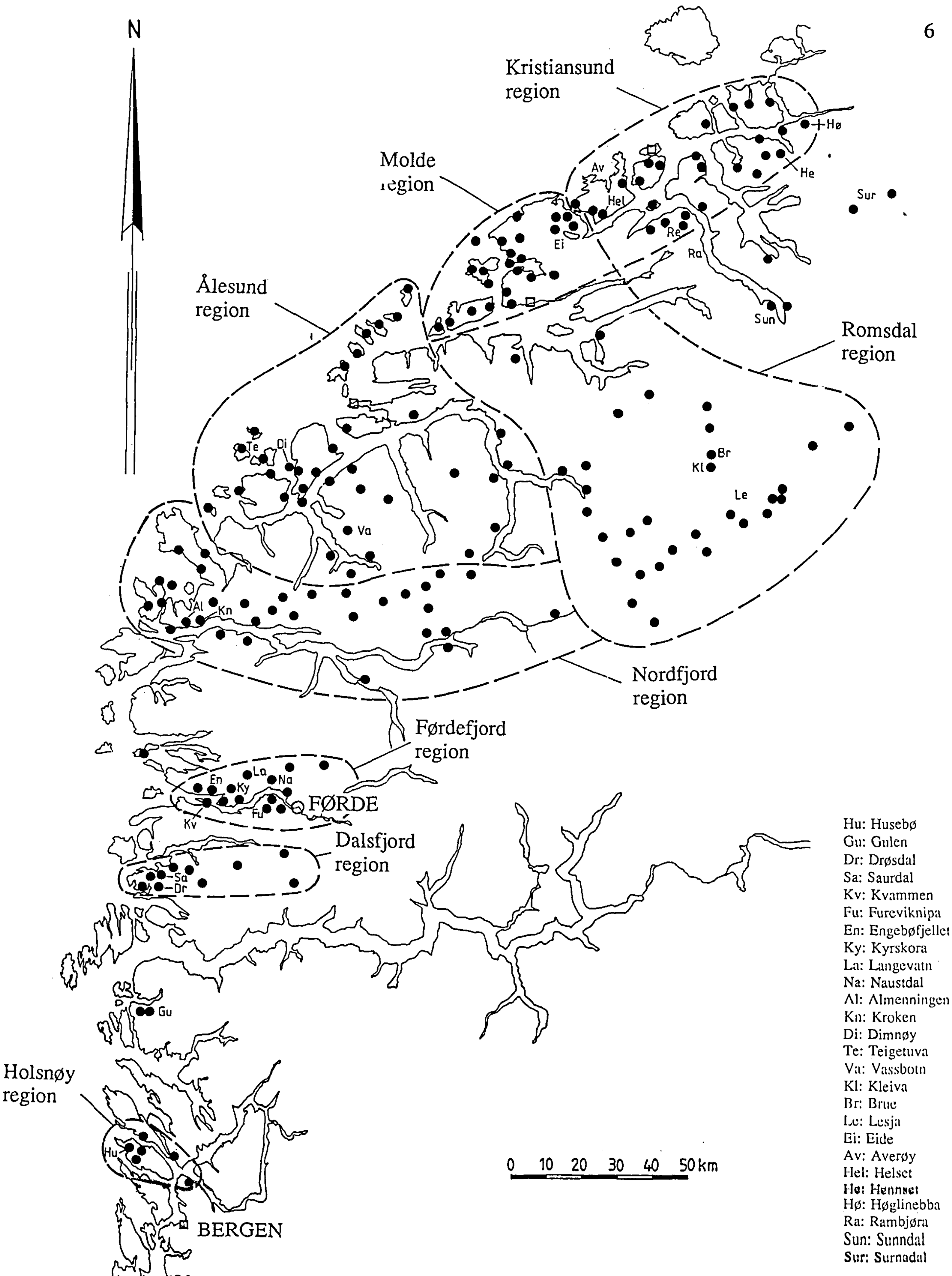


Fig.1: General overview of the eclogite province of Western Norway.

Eclogitization and retrogression: It is generally accepted that the Basal Gneiss Region in W. Norway was metamorphosed under eclogite facies conditions around 400 Ma with the highest P,T-conditions in the northwest, i.e. the western parts of the Nordfjord, Ålesund and Molde regions (Krogh, 1977a,b; see also the discussion of P,T-relations in Griffin, 1987). The eclogitization of basic rocks is incomplete. Gabbros showing gradual transitions into eclogites occur in many places from Holsnøy in the south to the northernmost parts of the Kristiansund region. Gradational variations from gabbro to eclogite are described from Nordøyane SW of Molde (Mørk, 1985a and b; 1986), from the Surnadal area (Tørudbakken, 1981), from the Gjemnes and Halsa districts (Appendix 2.7 in Korneliussen, 1992), from the Gulen district (Korneliussen, 1989) and from the Gjølanger-Flekke area in the Dalsfjord region where gabbroic to anorthositic rocks show gradual transitions to eclogite (Cuthbert, 1985; see also Chapt. 3.2 in the present report). Eclogitization of basic rocks along shear zones is well documented at Holsnøy by Austrheim & Griffin (1985) and Austrheim (1987, 1991).

Large areas within the west Norwegian eclogite province do not show signs of eclogitization of basic rocks; this may be either because they never underwent eclogite facies metamorphic conditions or because extensive retrogression has obliterated the signs of eclogite. The probability is that the Basal Gneiss Region of W. Norway reached eclogitefacies conditions 400 m.y. ago, and then underwent a period of major tectonic events that positioned geologic units in a complex pattern of nappes that have experienced different metamorphic and defomational histories.

The mineral reactions during the eclogitization process are cmplex. *In this context an important observation is that ilmenite from the mafic protolith reacts with feldspar and form garnet and rutile.* The titanium remaining when the iron from ilmenite goes into garnet, forms rutile. Another factor that will increase the proportion of Ti as free rutile in eclogite facies rocks is the very low solubility of Ti in chain silicates i.e. pyroxenes (and amphiboles) at high P. The Ti-content in basaltic and gabbroic pyroxenes (Ti-augites) protoliths, however, may be very high. Ti in the igneous pyroxenes is incorporated by the Ti-tshermak substitution: $(Mg^{2+})^{VI}(2Si^{4+})^{IV}$ <=> $(Ti^{4+})^{VI}(2Al^{3+})^{IV}$. The Ti-tschermak molecule (component) is dominated by tetrahedral Al, and this results in a large unit cell which is very unfavorable for hosting Ti in the cell structure at high P. Therefore, Ti is released from pyroxenes during eclogitization of gabbroic rocks.

The rutile-forming reactions are usually incomplete, leading to rutile intergrown with ilmenite in various proportions. Occasionally sphene occurs as rims around rutile/ilmenite within partly decomposed feldspars. See the photographs in Appendix 3.55 in Korneliussen (1992).

During retrogression the omphacitic clinopyroxene of the eclogite mineral paragenesis breaks down to symplectitic aggregates of plagioclase and diopside, +/- hornblende that may replace diopside. During this alteration rutile may break down to ilmenite, but normally it is unaffected. Such symplectitic aggregates are shown in a variety of photomicrographs in Korneliussen (1992). During more extensive retrogression garnet tends to break down to hornblende. At that stage rutile is altered to ilmenite and occasionally also to sphene. In the completely amphibolitized eclogites sphene+ilmenite are the characteristic Ti-bearing minerals. Such retrograde formation of ilmenite or ilmenite+sphene tends to occur along cracks or shear zones within eclogite bodies as well as along the margins of the bodies.

Sphene: Sphene has been found as narrow rims around grains of rutile/ilmenite in major rutile deposits such as Husebø, Vassbotn, Saurdal, and Engebøfjellet. See the photographs in Appendixes 3.6.3, 3.19 and 3.55. in Korneliussen (1992). The amount of sphene within these deposits is, however, minor relative rutile/ilmenite. Microscopy of thin-sections from many scattered eclogites within the eclogite province of W. Norway shows that sphene is a fairly common mineral, especially in the northern and eastern regions where retrogression is extensive.

Chloritization may or may not lead to the formation of sphene. At Saurdal chloritization is accompanied by a significant CaO-loss from 7-8% CaO in the eclogite to 1-2% CaO in the chlorite schist that is the end-product of this metamorphic and metasomatic process (based on X-MET analyses of old drill-cores). Apparently there is not enough CaO available in the chloritized rock to form sphene.

Size and form of eclogite bodies: Eclogites in W. Norway usually form bodies or lenses less than 200m long surrounded by gneisses. Big eclogites of more than 1 km in length occur mainly in the Dalsfjord and Førdefjord regions and in the Ulsteinvik, Eide and Averøy areas in the Ålesund, Molde and Kristiansund regions, respectively. Some scattered occurrences of big eclogites occur elsewhere.

At Holsnøy eclogites may occur along distinct fractures or shear zones in the form of cm- to dm-thick bands, as eclogite breccias with 1 to 10(+) m-large eclogite fragments within non-eclogitized granulites, or as completely eclogitized rocks over several hundred meters in length.

In the partly eclogitized gabbros in the Molde and Kristiansund regions eclogitization has occurred either at the margin or along shear zones within the gabbro bodies. Such eclogite zones are from a few decimeters to a few hundred meters in thickness.

Rutile contents in W.Norwegian eclogites are generally 1-3% but 3-5% rutile is fairly common within eclogites in the Førdefjord, Dalsfjord and Holsnøy regions. The eclogites richest in rutile, and also of significant size, are those at Engebøfjellet and Fureviknipa in the Førdefjord region, at Saurdal and Orkheia in the Dalsfjord region, and at Husebø in the Holsnøy region. Some eclogite localities in the Kristiansund and Romsdal regions (see Appendix 2.7-2.8 in Korneliussen 1992) have TiO_2-contents as high as 3-6%, at least locally. Unfortunately, the proportion of ilmenite to rutile is high (see Appendix 2 in this report) and sphene may be present.

Rutile occurs in aggregates or as disseminated individual grains. The individual rutile grains are usually in the range 0.1 - 1.0 mm. In general, rutile from the southernmost regions, i.e. Holsnøy and Dalsfjord, is more coarse-grained than further north, but there are big local variations.

TiO_2 (rutile) vs. TiO_2 (total): Electron microprobe analyses of silicate minerals from eclogites in the Førdefjord and Holsnøy regions have shown that garnet and clinopyroxene have approximately 0.1% TiO_2, amphibole 0.2-0.4% TiO_2 and micas 0.4-0.8% TiO_2 (Korneliussen & Foslie, 1985, Korneliussen et al., 1990). However, since garnet, clinopyroxene and low-Ti amphiboles are the dominant minerals in most eclogites, titanium in silicates can be neglected for practical purposes at least at the reconnaissance stage of investigation.

An analytical procedure that determines the amount of rutile as the difference between total TiO_2 (XRF-analysis) and HCl-dissolved TiO_2 (ICP-analysis) has been established at NGU. The TiO_2 analysed by ICP gives the titanium in ilmenite. Titanium in silicates, including sphene, is assumed to be close to zero and therefore is negligible in these calculations. 500-600 samples have been analysed at NGU since 1990 by this method and have given reliable results.

According to such rutile analyses approx. 90% of the titanium in the Engebøfjellet, Drøsdal and Orkheia eclogites is in rutile (see Figs. 24, 26 and 29). In all the other eclogites where several analyses are available TiO_2 (rutile) vs. TiO_2 (total) varies wildly, though 60-80% of the titanium as rutile is most common.

In summary: The eclogite province of W. Norway has been subdivided into 8 geographic regions. The three southernmost of these regions - Holsnøy, Dalsfjord and Førdefjord, are surrounded by large areas without known eclogites, while the regions from Nordfjord and northwards form parts of a large eclogite province.

In general, eclogites in the northwestern parts of the gneiss region of W. Norway, i.e. the western parts of the Nordfjord, Ålesund and Molde regions, have been formed at the highest P,T-conditions, but significant variations occur due to major tectonic events after the eclogitization period at c. 400 Ma. The details of such inhomogenities in the regional P,T-pattern remain to be investigated.

Eclogite protoliths are Proterozoic (?) basaltic volcanic rocks and a variety of Proterozoic intrusions that belong to ultramafic-mafic and mafic-intermediate (gabbro-anorthositic) suites.

The rutile contents are generally 1-3%; 4-5% rutile or more occurs within some eclogites in the Holsnøy, Dalsfjord and Førdefjord regions. Occurrences of high-Ti eclogites are less common, but not absent, in the northern regions. The northern regions are, however, much less carefully investigated with respect to titanium in eclogite, and other Ti-rich occurrences are therefore likely to exist.

Sphene is fairly common. It occurs in very small amounts as rims surrounding rutile/ilmenite grains in major rutile deposits such as Husebø, Saurdal, Engebøfjellet and Vassbotn. Sphene is frequently found in thin-sections of the most retrograded eclogites, i.e. mainly in the eastern parts of the Kristiansund, Romsdal and Nordfjord regions. It is less frequent in the western and southern terrains.

Table 1: Average content of rutile, TiO_2, Fe_2O_3 and P_2O_5 in major rutile deposits.

Deposit	Rutile (% rutile vs. TiO_2)	TiO_2	Fe_2O_3	P_2O_5	n	Comments
Husebø (Holsnøy region)	2.13 (59%) *3.20*[1]	3.62	14.31	0.07	263	Drill-dust samples. [1] Rutile-enriched part of the eclogite (Korneliussen & Furuhaug 1991a)
Saurdal (Dalsfjord region)	1.40[2] (39%)	3.58	20.18	0.25	107	[2] Drill-dust sample series
Orkheia (Dalsfjord region)	1.59[3] (82%) *2.32*[4] (87%)	1.93 2.67	14.46 15.97	n.a. n.a.	33 34	[3] Western Part, drill-dust samples [4] Eastern Part, drill-dust samples
Fureviknipa (Førdefjord region)	2.10 (63%) *2.90*[5]	3.31	19.95	1.45	66	Drill-dust samples [5] Rutile-enriched part
Engebøfjellet (Førdefjord region)	1.70 (95%) *3.50*[6]	1.79	12.71	0.09	51	Drill-dust samples. [6] Rutile-enriched part (Korneliussen & Furuhaug 1991b)
Vassbotn (Ålesund region)	1.60 (66%)	2.42	18.84	0.08	12	Chip-samples.

a.

b.

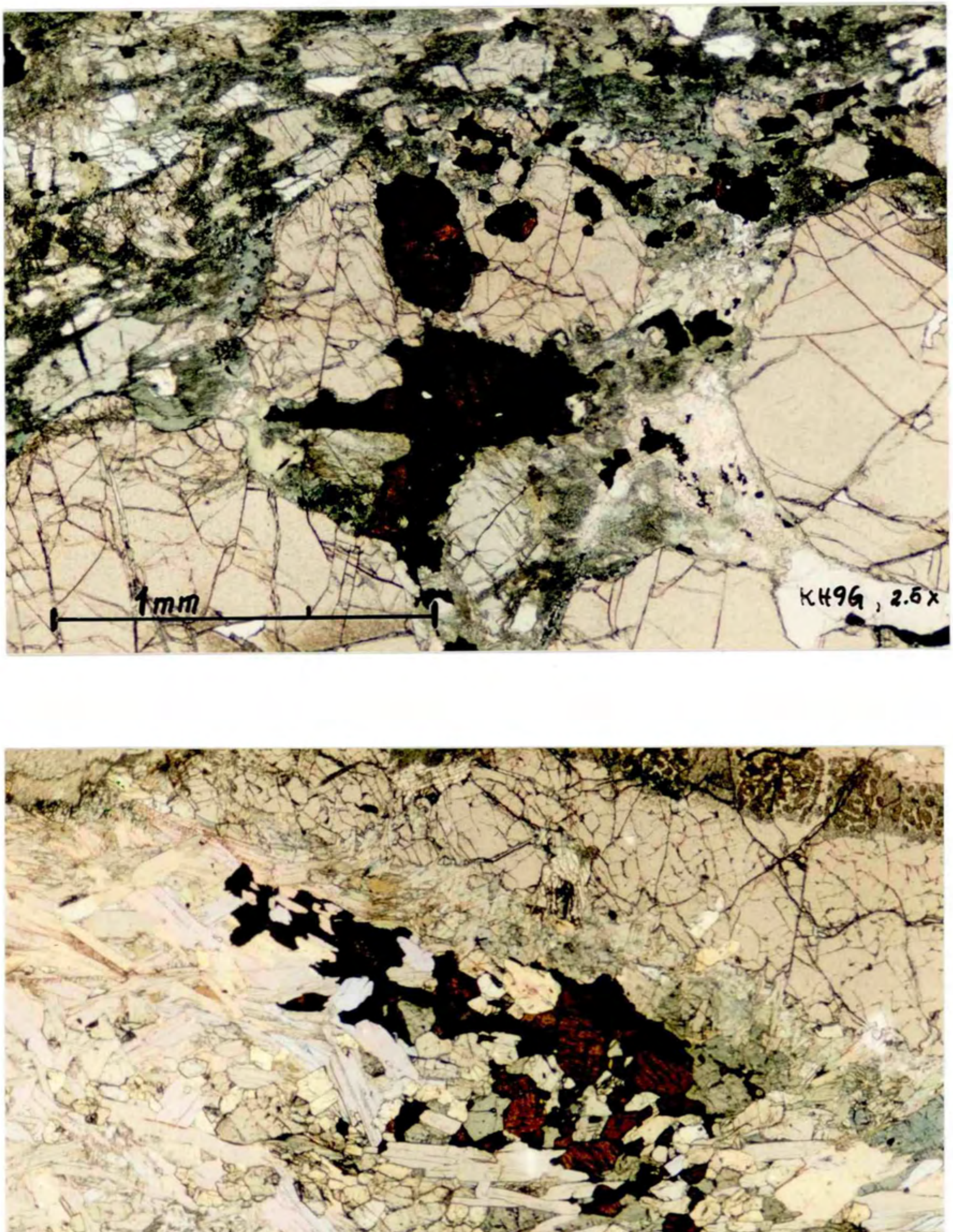
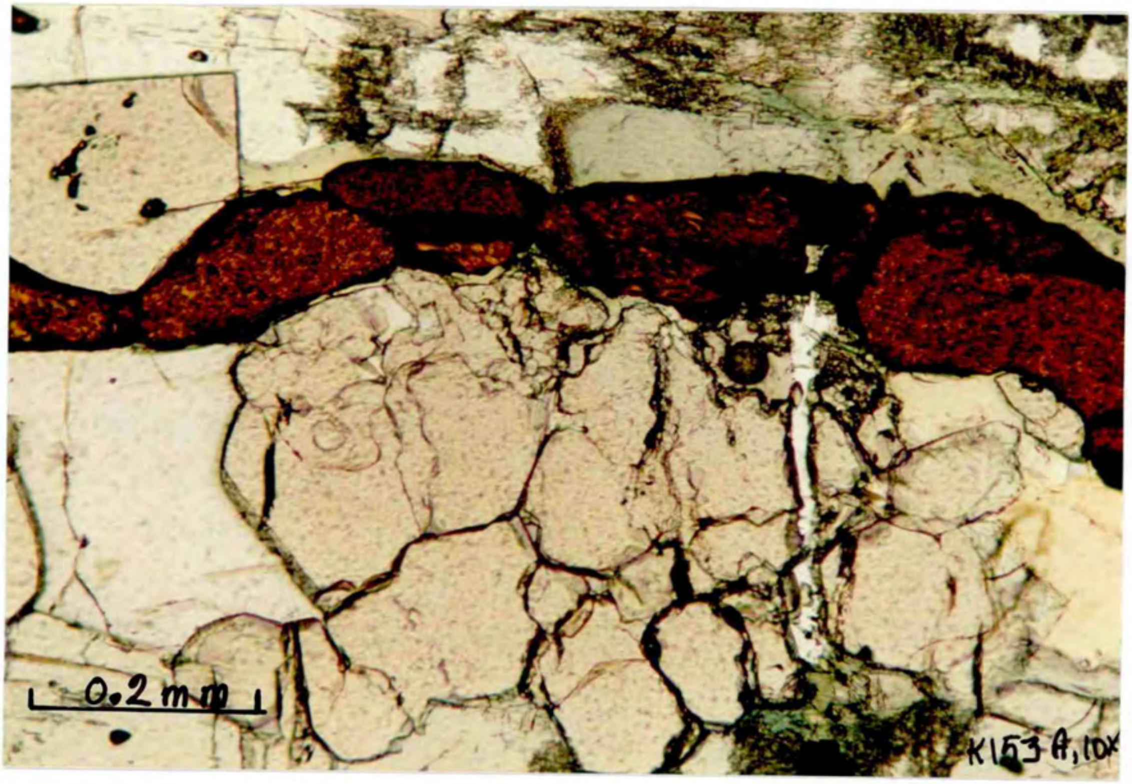


Fig. 2a-b: Photomicrographs of rutile (brownish) and ilmenite (black) aggregates in (a) the Husebø eclogite at Holsnøy and (b) the Saurdal eclogite from the Dalsfjord region.



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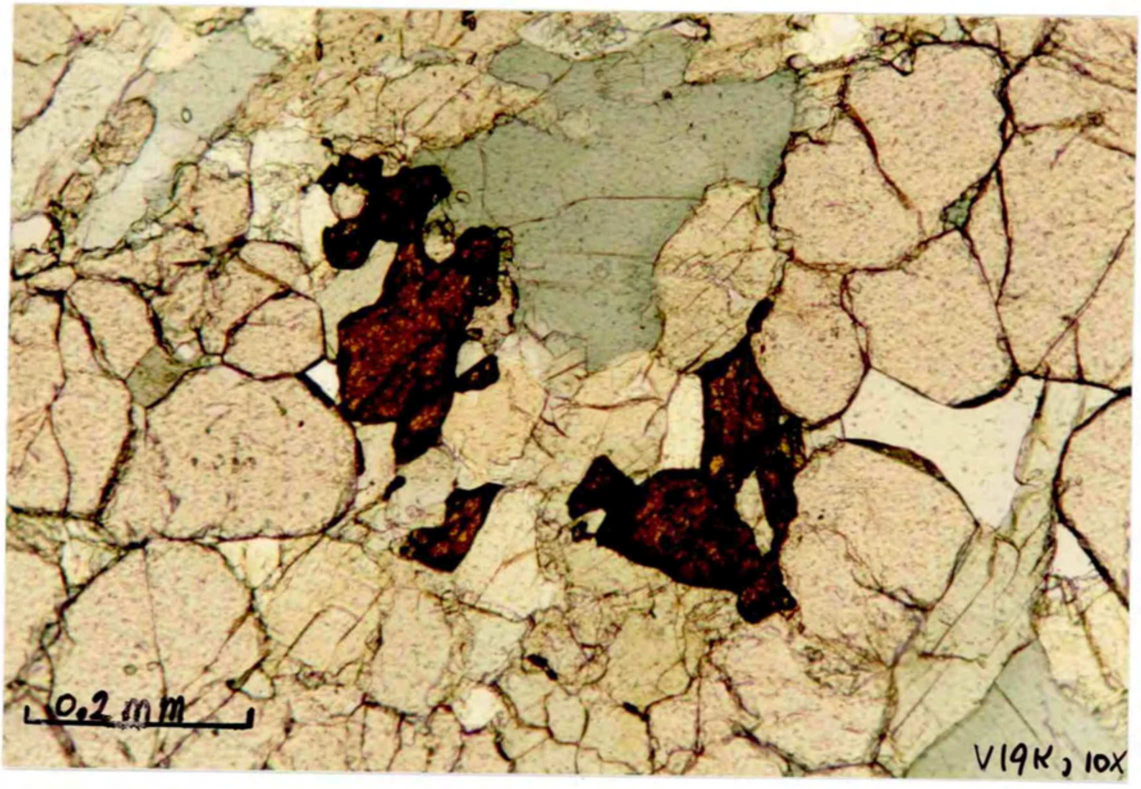
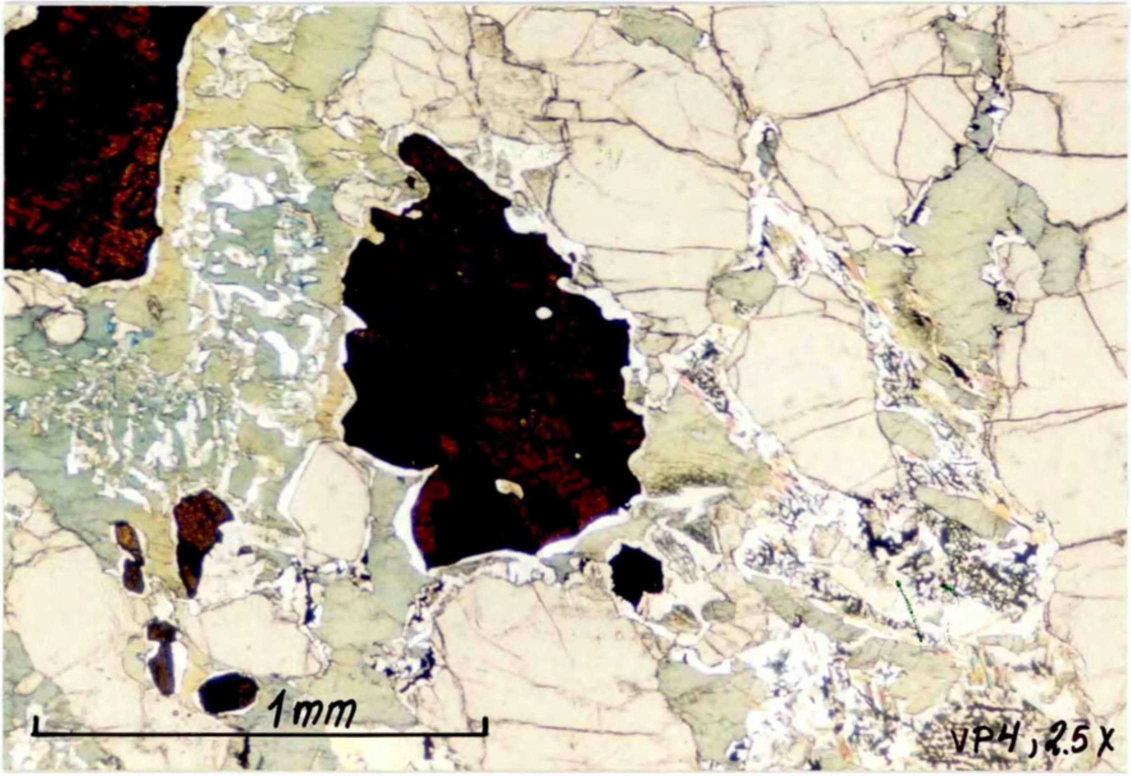


d.

Fig. 2c-d: Photomicrographs of rutile (brownish) from (c) the Orkheia eclogite, Dalsfjord region and (d) Engebøfjellet eclogite, Førdefjord region.



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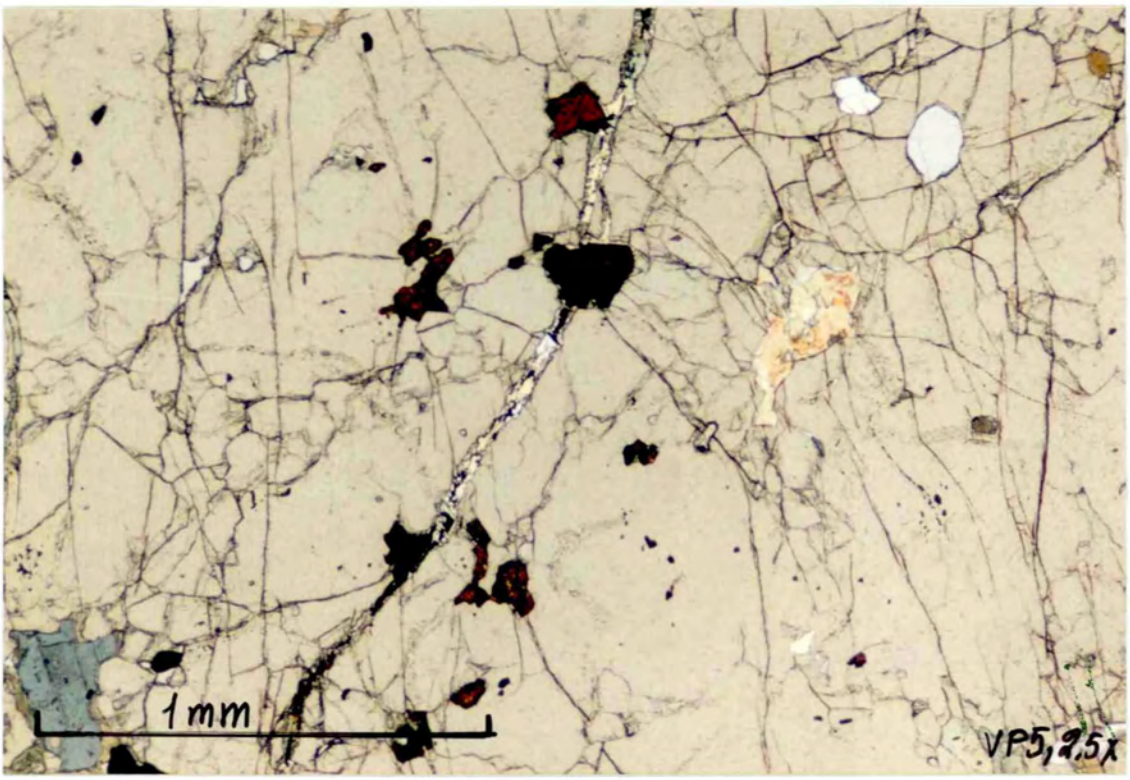


f.

Fig. 2e-f: Photomicrographs of rutile (brownish) and ilmenite (black) from the Vassbotn eclogite near Volda, Ålesund region. The oxides in the Vassbotn eclogite tend to occur in two associations: as big grains of rutile/ilmenite interstitial to garnet (upper photo) and as inclusions of small grains within garnet (lower photo).

2.1. Holsnøy region (see Korneliussen et al. 1990, 1991)

Ti-rich rocks associated with a large Proterozoic anorthosite complex (c. 1000 m.y.) in the Bergen region of W. Norway have, in the northern parts of Holsnøy, been metamorphosed to eclogites along Caledonian (c. 400 Ma) shear zones. Anorthositic rocks are dominant in the region. They vary from pure anorthosite through gabbroic anorthosite to leucogabbro. These rocks are normally very low in titanium, but may occasionally contain minor Ti-enriched layers or segregations and Ti-enriched dykes of garnet-pyroxenitic composition. Dykes and larger bodies of jotunite rocks frequently intrude the anorthosite. The jotunite rocks contain large amounts of low-grade ilmenite mineralization/dissemination. Other rocks in the area are gabbros, spinel-lherzolites, mangerites, garnet-pyroxenites and banded granulites. These rocks have crystallized at approximately 1000 Ma in the following order: anorthosite, gabbro, Ti-rich garnet-pyroxenite, jotunite, Fe-Ti-P-rich garnet-pyroxenite, and mangerite (Austrheim, 1990). They were metamorphosed under granulite facies conditions during or shortly after the time of crystallization and experienced high-pressure Caledonian metamorphism (c. 400 Ma) with eclogitization in shear zones (see Austrheim & Griffin, 1985; Austrheim, 1987 and 1990; Austrheim & Mørk, 1988; Jamtveit et al., 1990).

One fairly large deposit occurs at Husebø within eclogitized jotunite, covering an area of about 100.000 m^2. The average TiO_2-content based on surface samples is 3.6% TiO_2, but higher contents do occur within parts of the deposit. Approximatly 60% of the titanium is in the form of rutile and 40% in ilmenite. The rutile-TiO_2- relations in 263 drill-dust samples are shown in Fig.3. Other mineralizations at Holsnøy may have higher rutile-contents than Husebø, but are too small to have economic interest. Holsnøy rutile mineralizations are the most coarse-grained known in Norway, but tend to be intergrown with ilmenite (Fig. 2a). Ilmenite from Husebø and other deposits at Holsnøy have a low MgO-content (≤1% MgO). The region is close to Bergen and is fairly densely populated. The environmental conflict caused by rutile mining would be large.

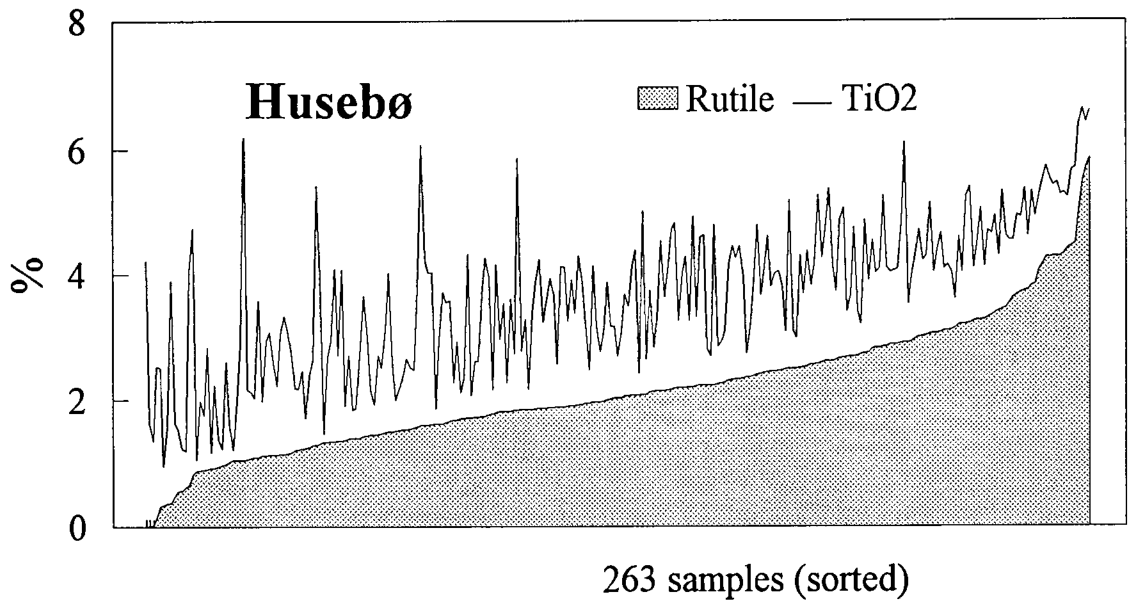


Fig. 3: Rutile vs. TiO_2 for the Husebø eclogite, Holsnøy. The samples are sorted with increasing rutile content. The complete analyses are given in Korneliussen and Furuhaug (1991a).

2.2. The Dalsfjord region (see Chapt. 3 for more detailed information)

This region contains a variety of gneisses, and basic, ultrabasic and Fe-Ti oxide-rich rocks; the basic rocks are frequently eclogitized. Massive bands and impregnations of magnetite-ilmenite occur within gabbroic, partly eclogitized rocks. Some of these were mined for magnetite at the beginning of the century. The largest of these deposits is at Saurdal where up to 0.5 m thick bands of massive magnetite-ilmenite occur along an E-W trending 800 m-long zone along the southern margin of an eclogitized gabbro. The 1993 investigations in the DuPont/NGU project were concentrated on the Dalsfjord region, mainly focusing on rutile-bearing eclogites in the Gjølanger-Saurdal area and westwards towards Drøsdal/Orkheia/Seljevoll.

2.3. The Førdefjord region (see Chapt. 4 for more detailed information)

Eclogites in the Førdefjord region frequently occur as several kilometer-long folded and boudinaged layers with thicknesses in the range of 10 meter to a few hundred meters. Some of the larger boudins are fairly massive eclogite bodies covering areas of more than 100,000 m^2 (e.g. Engebøfjellet). The TiO_2-content is generally 1-3%, but contents of 4-5% TiO_2 or more are not uncommon. The high Ti-contents are often, but not always, associated with fairly massive parts of the eclogites.

2.4. The Nordfjord region

Known eclogite localities in the Nordfjord region are shown in Fig.4. In general, these eclogites are small bodies that are believed to represent eclogitized basic dykes. A characteristic feature of this region is an abundance of anorthosites, commonly forming concordant layers tens to hundreds of meters thick and many kilometers long. A regional association of ultramafic rocks, anorthosites and mangerites raises the possibility that these rocks could be part of a disrupted layered complex (Mørk and Krogh, 1987). Since Ti-rich rocks commonly are associated with anorthosites elsewhere, for example at Holsnøy, the anorthosites of Nordfjord might also be spatially associated with Ti-rich rocks that include eclogites.

Only three samples of Nordfjord eclogites have been analysed for rutile (Appendix 2a). Their rutile and TiO_2-contents are shown in Fig.5. Sample KN4.92 is from the Almenningen eclogite, while sample KN3A.92 and KN3B.92 are from the Kroken eclogite. Both localities are situated on the northern side of outer Nordfjord. The TiO_2-content is less than 2%. A dominant part of the titanium in the rock resides in rutile (Fig.5). Microscopy shows that a significant portion of the rutile/imenite minerals occur as distinct grains (Fig.6a) that may be easily separable by beneficiation. Therefore a high rutile recovery can be expected for these eclogites.

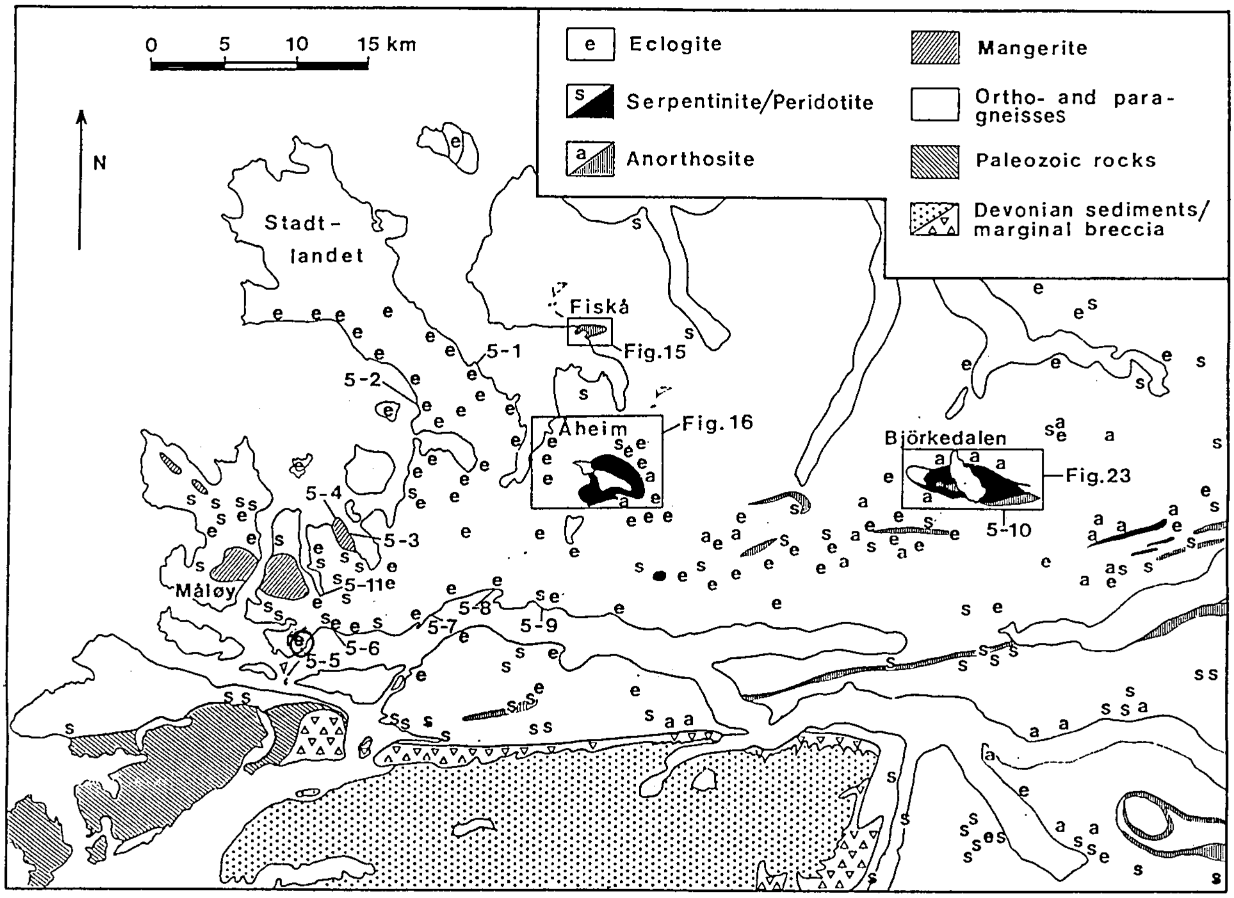


Fig.4: Eclogite in the Nordfjord region (after Griffin & Mørk, 1981). 5-1, 5-2, etc. refer to excursion localities that are described in detail by Griffin & Mørk. Figs. 15, 16 and 17 refer to other maps in the same publication.

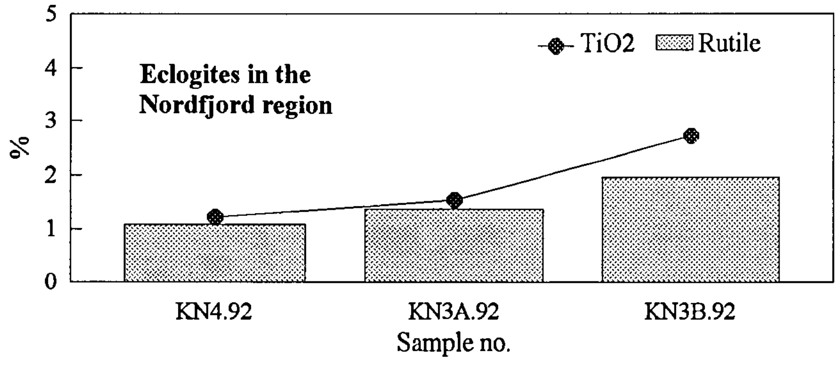
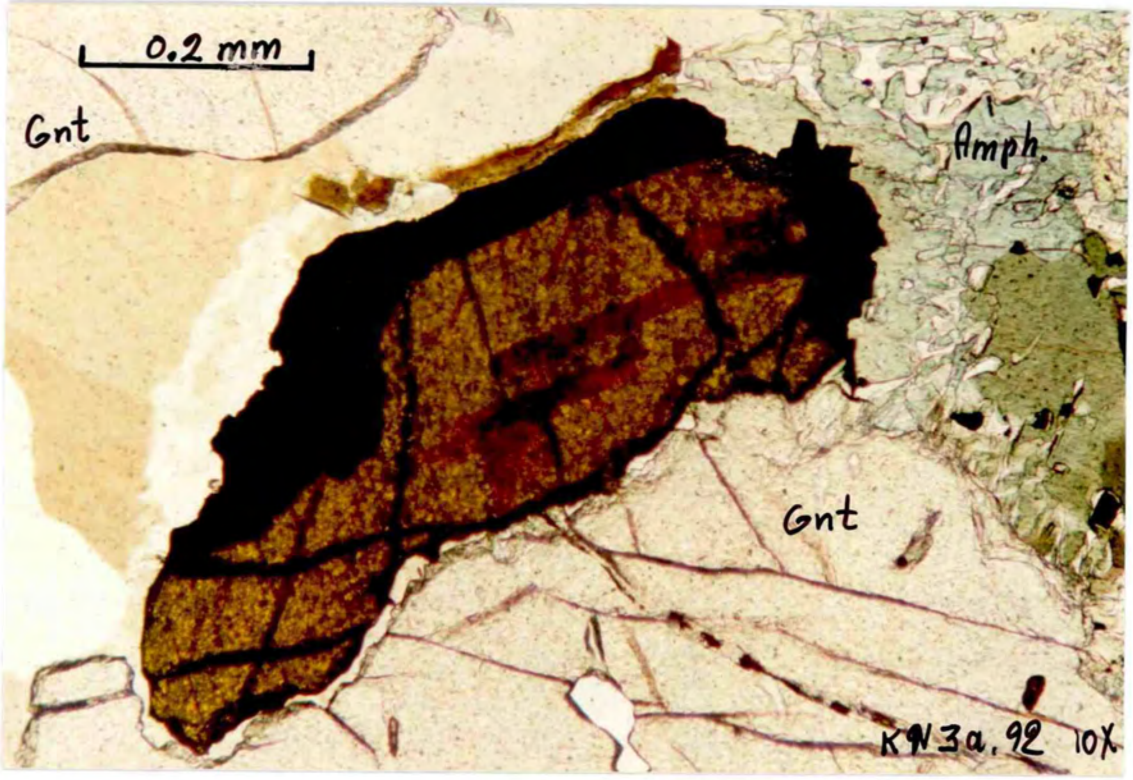
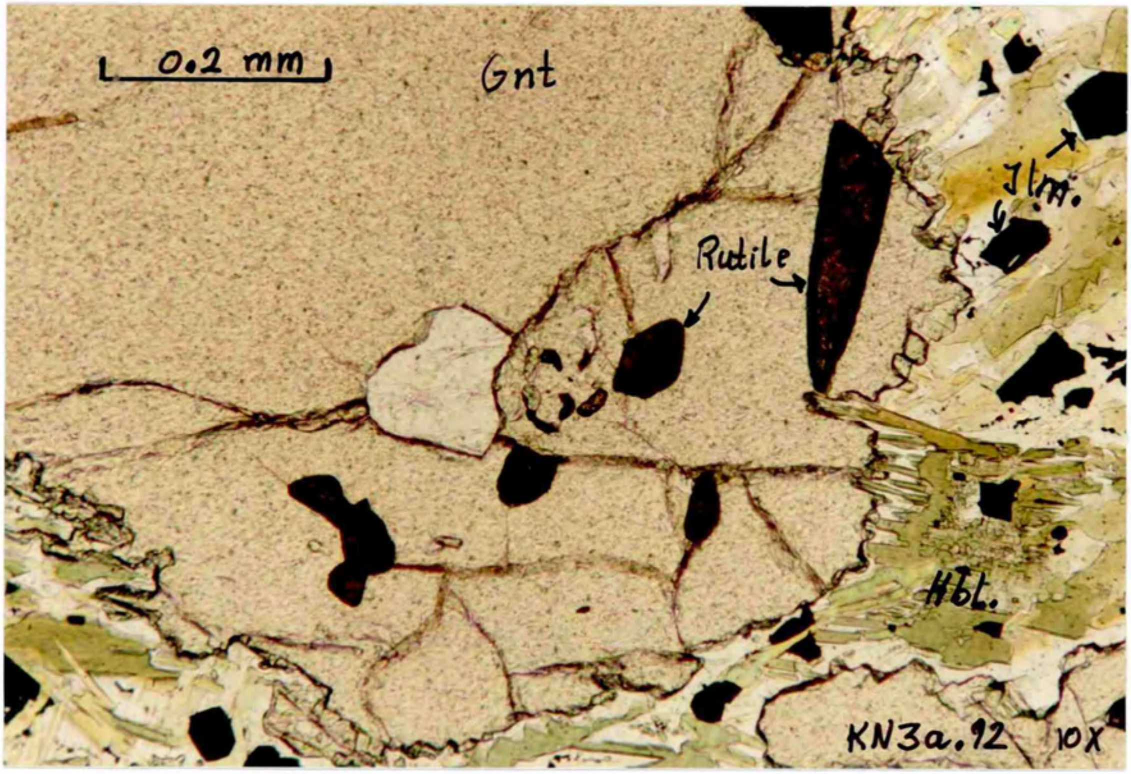


Fig. 5: Rutile vs. TiO_2 for three analysed samples from Almenningen (KN4.92) and Kroken (KN3a-b.92). The complete analyses are given in Appendix 2a.



a.



b.

Fig.6: Rutile (brownish) and ilmenite (black) from the Kroken eclogite, Nordfjord region. The upper photo shows a big rutile/ilmenite grain interstitial to garnet. The lower photo shows small rutile grains enclosed in garnet and ilmenite grains within hornblende (alteration product after omphacite). In this case the garnet has protected the rutile from being altered to ilmenite during the amphibolite facies retrogression of the eclogite, while rutile within omphacite was altered to ilmenite presumably simultaneous with the omphacite-to-hornblende alteration.

2.5. The Ålesund region

One big eclogite in the Ulsteinvik area forms a sheet of approximately 25 km^2, but is only about 300 m thick (Grønlie et al., 1972). The chemical composition is transitional alkali olivine basalt and olivine tholeiite (Mysen & Heier, 1972). The metamorphic peak has been estimated at ca 800°C, 18 kb by Griffin et al. (1982). The Ulsteinvik and other eclogites in the area tend to be fairly retrograded and low in TiO_2. An exception is an eclogite at Aurvåg (loc. K104.93; Appendix 1) that shows X-MET TiO_2-values varying between 2-3% and 15% (mainly ilmenite) over a 2-3m thick zone in a 200-300 m long eclogite body that contains approx. 2% TiO_2 in average.

In the Volda district east of Ulsteinvik, a number of relatively small eclogites are known, and some of these are believed to be eclogitized remnants of Proterozoic layered intrusions (cf. Erambert, 1985). Decimeter-thick layers within mafic and ultramafic eclogitized layered rocks have occasionally a few percent rutile (samples given to A. Korneliussen by M. Erambert in 1990).

At Vassbotn a few kilometers north of the town of Volda a fairly large and extremely garnet-rich eclogite outcrops on a mountain slope. The TiO_2-content is 2-3%, mainly in the form of rutile (Fig.7). Stokke Industri is investigating this deposit for possible garnet production. The mineralogical features of the Vassbotn eclogite are comparable to those of Ti-rich layers in layered, eclogitized mafic intrusions elsewhere in the Volda district (Muriel Erambert, pers. comm. 1994).

The garnet potential of another garnet-rich eclogite, Teigetuva at Nerlandsøy (see Appendix 2.5 in Korneliussen, 1992), is also being investigated by Stokke Industri.

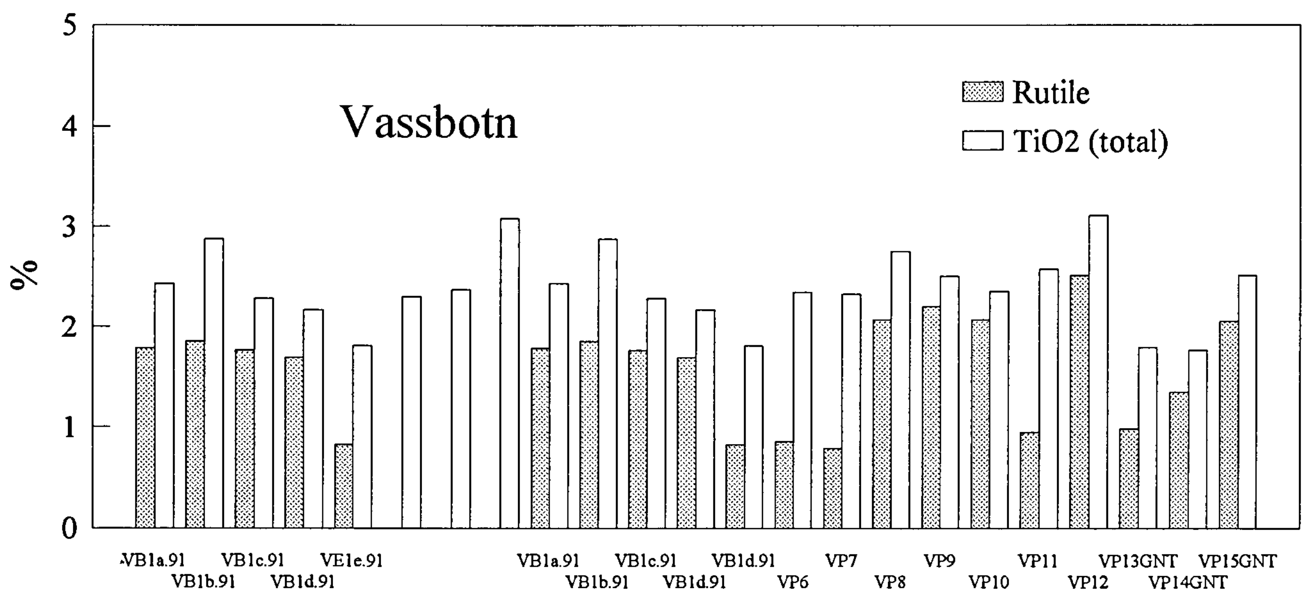


Fig.7: Rutile vs. TiO_2 for the Vassbotn eclogite, Volda. The complete analyses are given in Appendix 2.b.

a.

b.

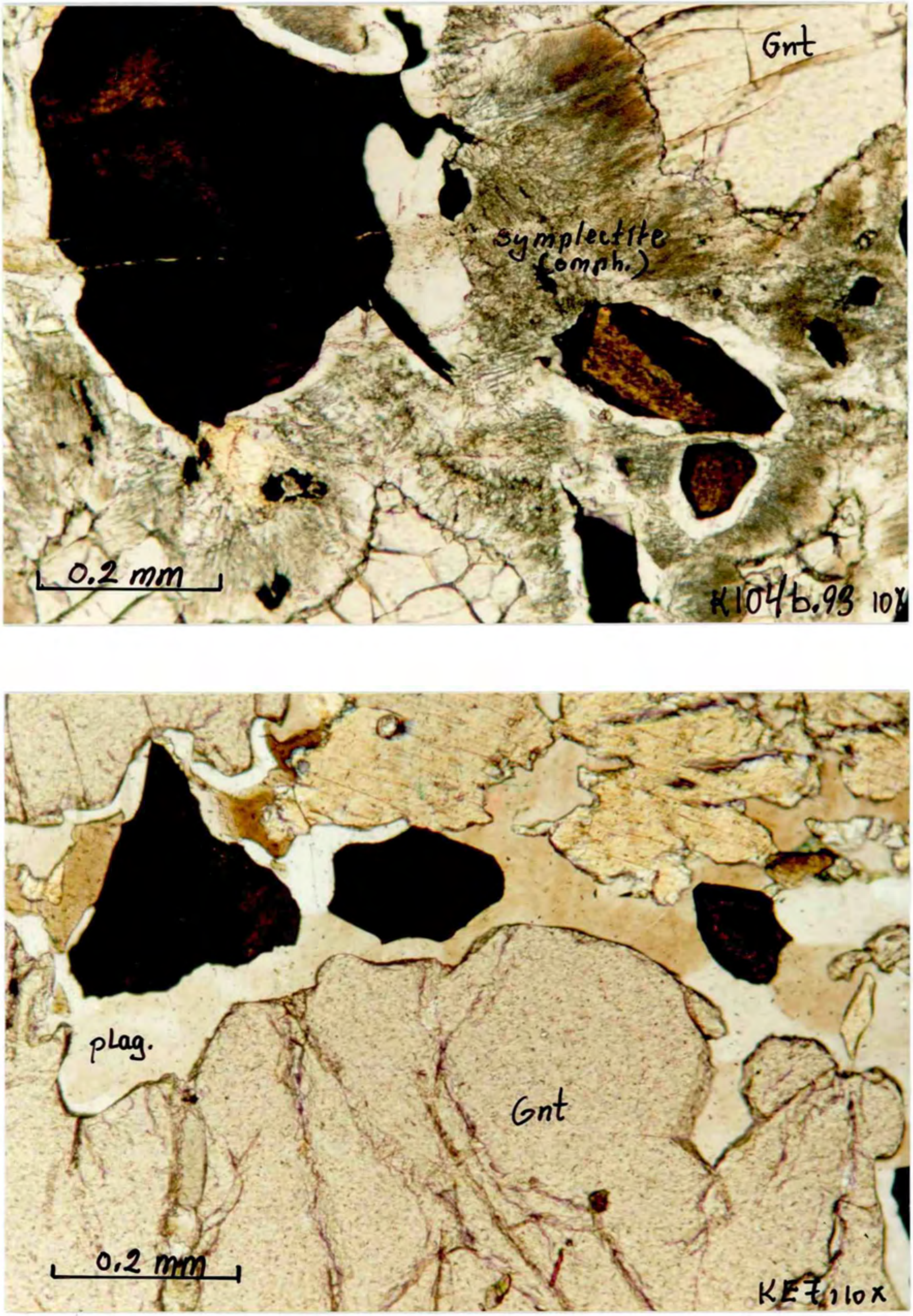


Fig. 8: Rutile/ilmenite within altered omphacite (symplectitic) from the Aurvåg eclogite, Ålesund region (sample K104b.93; upper photo) and rutile/ilmenite within plagioclase in an garnet-amphibolitic to eclogitic rock from the Eide area, Molde region (sample KE7.92; see Korneliussen 1992).

2.6. The Molde region

A large number of eclogites occur north and northeast of Molde in the Fræna and Eide districts. The Eide area and its eclogites are described by Reksten (1985). Most of these eclogites are small with TiO_2-contents of 1-3% (based on a few analysed localities). At Eide a large volume of garnet-amphibolite/eclogite is associated with indisputable metasedimentary rocks including carbonates. The protoliths for these eclogites are presumably of volcanic origin; they continue northeastwards on the island Averøy (Kristiansund region) where the same basic rock units are the host-rocks for stratabound massive sulfide deposits.

As shown in Fig.9 and Appendix 2 the analysed eclogites have 1-2% TiO_2 of which less than 1% TiO_2 occurs in rutile. Certainly the eclogite protoliths have not been of Ti-rich types, and the eclogite metamorphism has partitioned only 40-60% of the titanium into rutile. The rutile/ilmenite is not intergrown with garnet and might, for that reason, be fairly easy to concentrate (?). Ti-rich dykes at Averøy (see Chapt. 2.7) indicate that Ti-rich eclogites occur in the region, and the possibility for major rutile/eclogite deposits cannot be excluded.

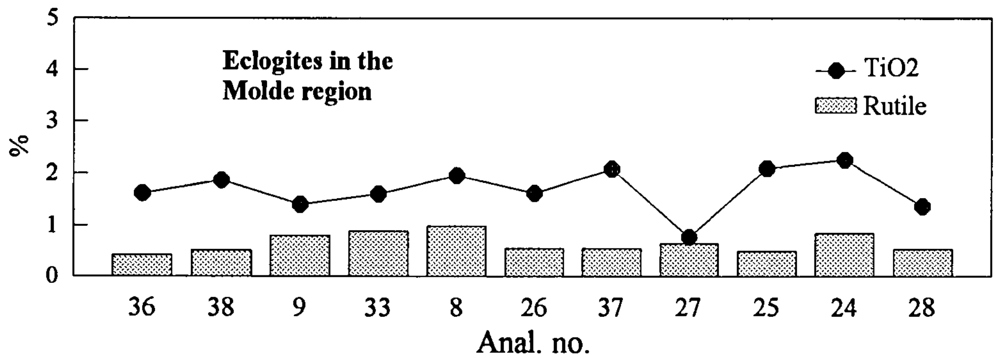


Fig. 9: Rutile vs. TiO_2 for miscellaneous eclogites in the Molde region. The complete analyses are given in Appendix 2.

2.7. The Kristiansund region

At Averøy large volumes of low-TiO_2 (1-2%) basic rocks of volcanic origin are metamorphosed into garnet-amphibolites and eclogites. At Helset the dominant low-TiO_2 eclogite is intruded by dm-thick dykes (eclogitized) with 3-9% TiO_2. Thin-sections show that ilmenite is more abundant than rutile. This dyke-situation has some similarity to the Førdefjord area where large volumes of basic volcanic (?) rocks with some scattered Ti-rich dykes and plutons have been eclogitized.

Further northeast on the islands Frei and Tustna the eclogites tend to occur as fairly small, boudinaged, low-TiO_2 bodies within gneisses.

In the Gjemnes and Halsa districts further east, the eclogitization has been less complete; a number of gabbroic intrusions show gradual transition into eclogite. TiO_2-contents are generally 1-2%, though contents of 3-4% occur occasionally.

As shown in Fig.10 and Appendix 2 the TiO_2-content in eclogites in the Kristiansund region varies between 1% and 4% TiO_2, with a highly variably rutile/ilmenite ratio.

The eastern parts of the Kristiansund region that contain Fe-Ti-rich amphibolites and metagabbros should be investigated in order to find eclogitized portions of these rocks. Eclogites in these areas have experienced significant retrogression in general, but there are probably large local variations. Fairly high ilmenite/rutile ratios and the fact that sphene is a common mineral cast doubt on the potential of these areas even if high-Ti eclogites do occur. Some continued investigations should, however, be done to obtain more precise information.

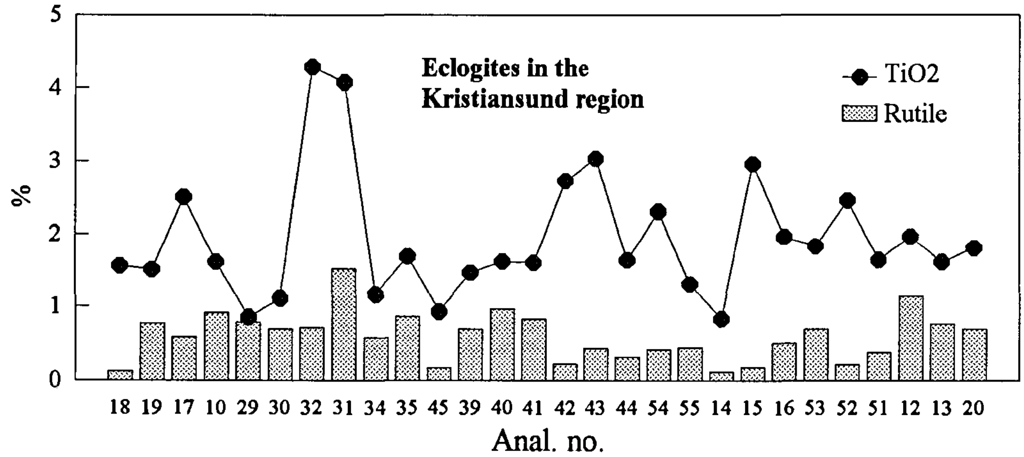


Fig. 10: Rutile vs. TiO_2 for miscellaneous eclogites in the Kristiansund region. The complete analyses are given in Appendix 2.

2.8. The Romsdal region

Eclogites in the Romsdal region are rather scarce and have scattered occurrences (Fig.1), presumably due to lesser amounts of favorable basic protoliths. Eclogites in the Lesja district tend to be fairly titanium-rich (3-4% TiO_2). Many of the eclogite bodies are small, but some may be large (covering areas of more than 100,000 m^2). However, the rutile portion of the titanium (Fig.11, Appendix 2) is low, and microscopy shows extensive retrogression that causes rutile alteration to ilmenite and also to sphene.

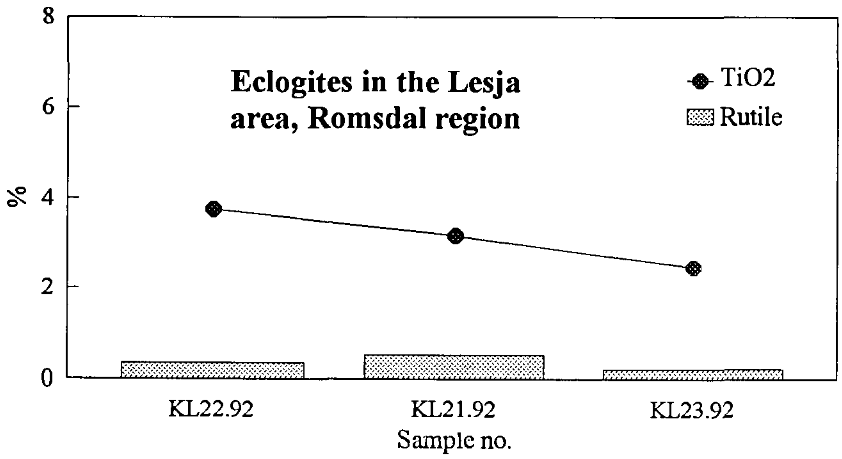


Fig. 11: Rutile vs. TiO_2 for eclogites at Lesja, Romsdal region. The complete analyses are given in Appendix 2.

2.9. Other localities

In the Rausand district large volumes of vanadium-bearing magnetite-ilmenite ore are associated with amphibolites surrounded by a variety of gneisses (see Sanetra, 1985). A possibility that remains to be tested is that such magnetite-ilmenite ores have been the protoliths for Fe-Ti rich eclogites elsewhere in the region, perhaps resulting in large volumes of rutile-rich eclogites.

At Dalsfjell in the Gulen area between the Holsnøy and Dalsfjord regions a large gabbro has been incompletely eclogitized. The TiO_2-contents are in the range 1-4% with 50-80% of the titanium as rutile (Korneliussen, 1989). The largest eclogites in this area occur at Slengesol, Nordal and Kjelby (also called Kjellbju) where the eclogitized areas are up to 3-400 m long and ≥100 m wide.

3. Eclogites in the Dalsfjord region (Figs. 12-14)

3.1. General geology

Rutile-bearing eclogites in the Dalsfjord region were investigated by NGU in 1978-79 (Korneliussen 1980, 1981, 1985). The central part of this region, at Hellevik-Gjølanger-Flekke, was investigated by S.Cuthbert in a doctoral thesis (1985). This region contains a variety of gneisses, and basic, ultrabasic and Fe-Ti oxide-rich rocks; the basic rocks are frequently eclogitized. Many eclogites had demonstrably low-pressure igneous protoliths and/or show intrusive relationships with the gneisses, indicating a crustal, eclogite-facies metamorphism of all lithologies. Relics of early granulite-facies assemblages occur in most lithologies (Cuthbert 1985). Associated eclogites have been metasomatically altered but retain some tholeiitic characteristics. The Flekke unit rocks have affinities with some layered basic intrusions typical of mid-Proterozoic anorthosite suites. Mineral chemistry and parageneses of a variety of lithologies indicate an early (presumably Proterozoic) granulite-facies event at 7-13 kb, and 750-1000°C, followed by metamorphism to high-pressure eclogite-facies conditions at 597+/-30°C, and decompression during exhumation to below 6 kb. Such a P-T path is incorporated into a continental collision model for the Scandinavian Caledonides involving transient "subduction" of the Basal Gneiss Complex in a Himalayan-style collision zone (Cuthbert, 1985).

Massive bands and impregnations of magnetite-ilmenite occur within gabbroic, partly eclogitized rocks in the western parts of the Dalsfjord region, in the Saurdal-Gjølanger and Sellevoll areas. Some of these were mined for magnetite at the beginning of the century. The largest of these deposits is at Saurdal where up to 0.5 m thick bands of massive magnetite-ilmenite occur along an E-W trending 800 m-long zone along the southern margin of an eclogitized gabbro. A mica-rich variety of the neighbouring eclogite has recently been quarried for block-stone for ornamental purposes.

The 1993-investigations in the DuPont/NGU project have concentrated on the Dalsfjord region, mainly focusing on the Gjølanger-Saurdal area and westwards towards Drøsdal/Orkheia/Seljevoll.

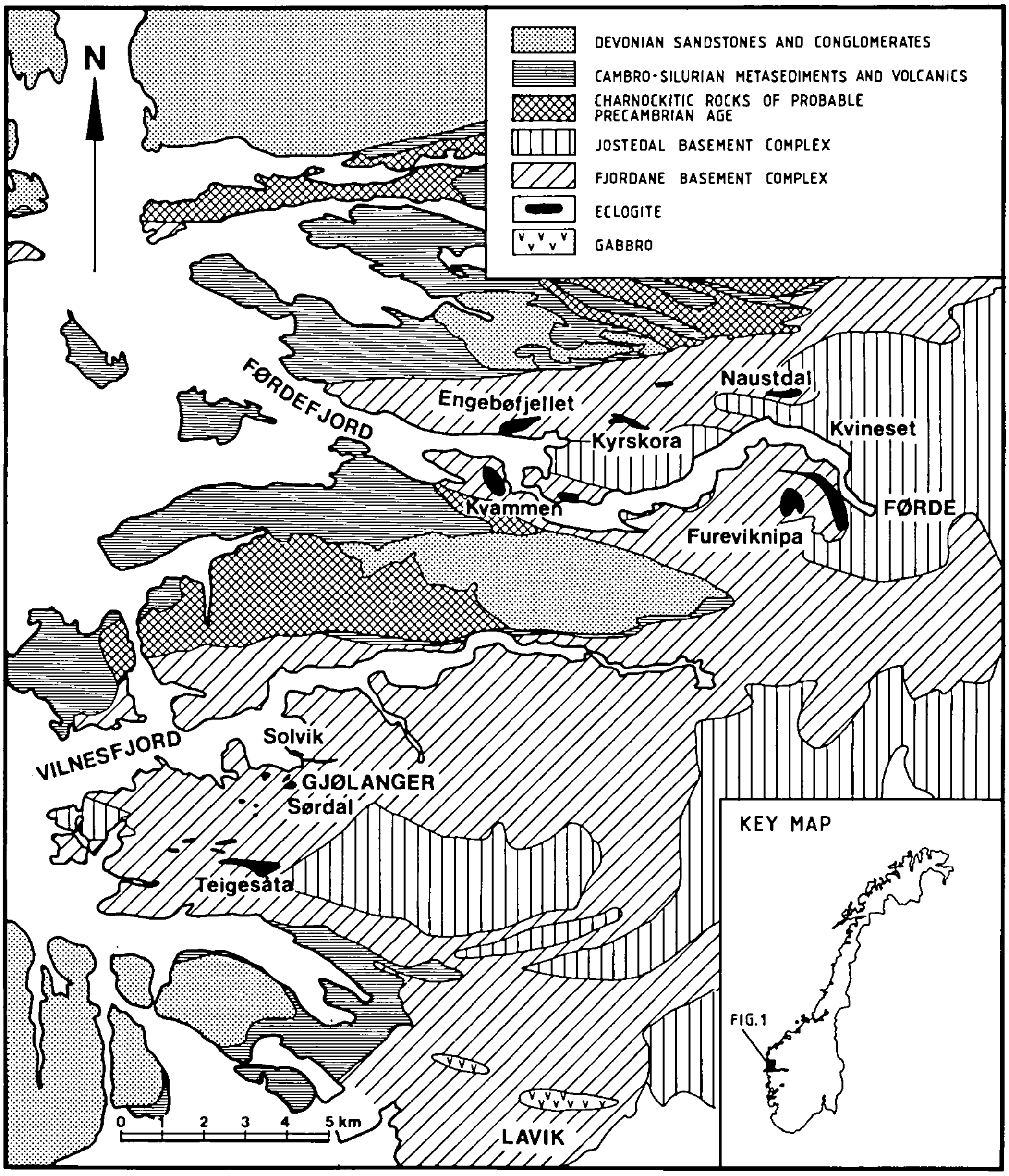


Fig.12: Regional geological map showing major eclogites in the Førdefjord and Dalsfjord regions (from Korneliussen and Foslie, 1985)

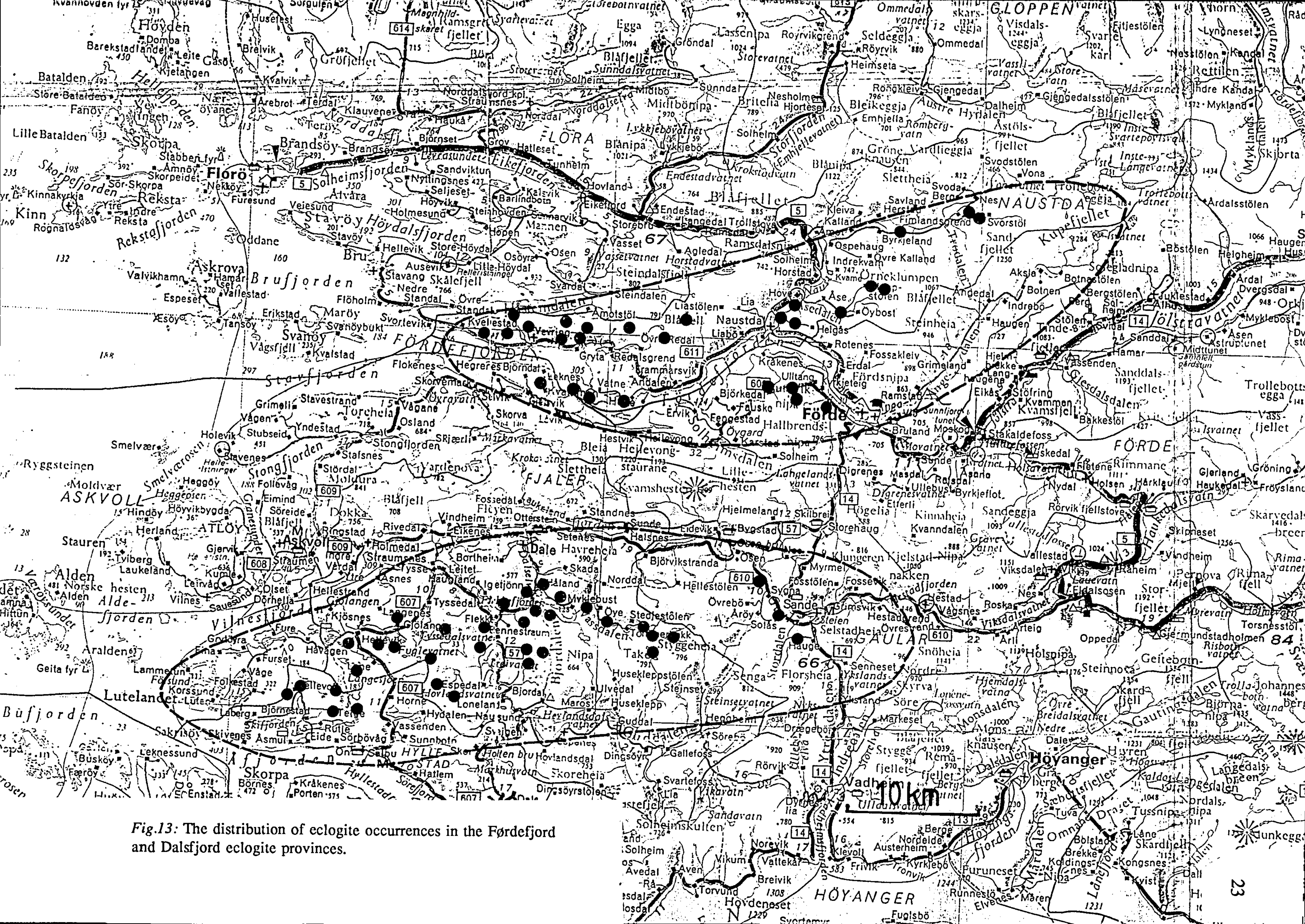


Fig.13: The distribution of eclogite occurrences in the Førdefjord and Dalsfjord eclogite provinces.

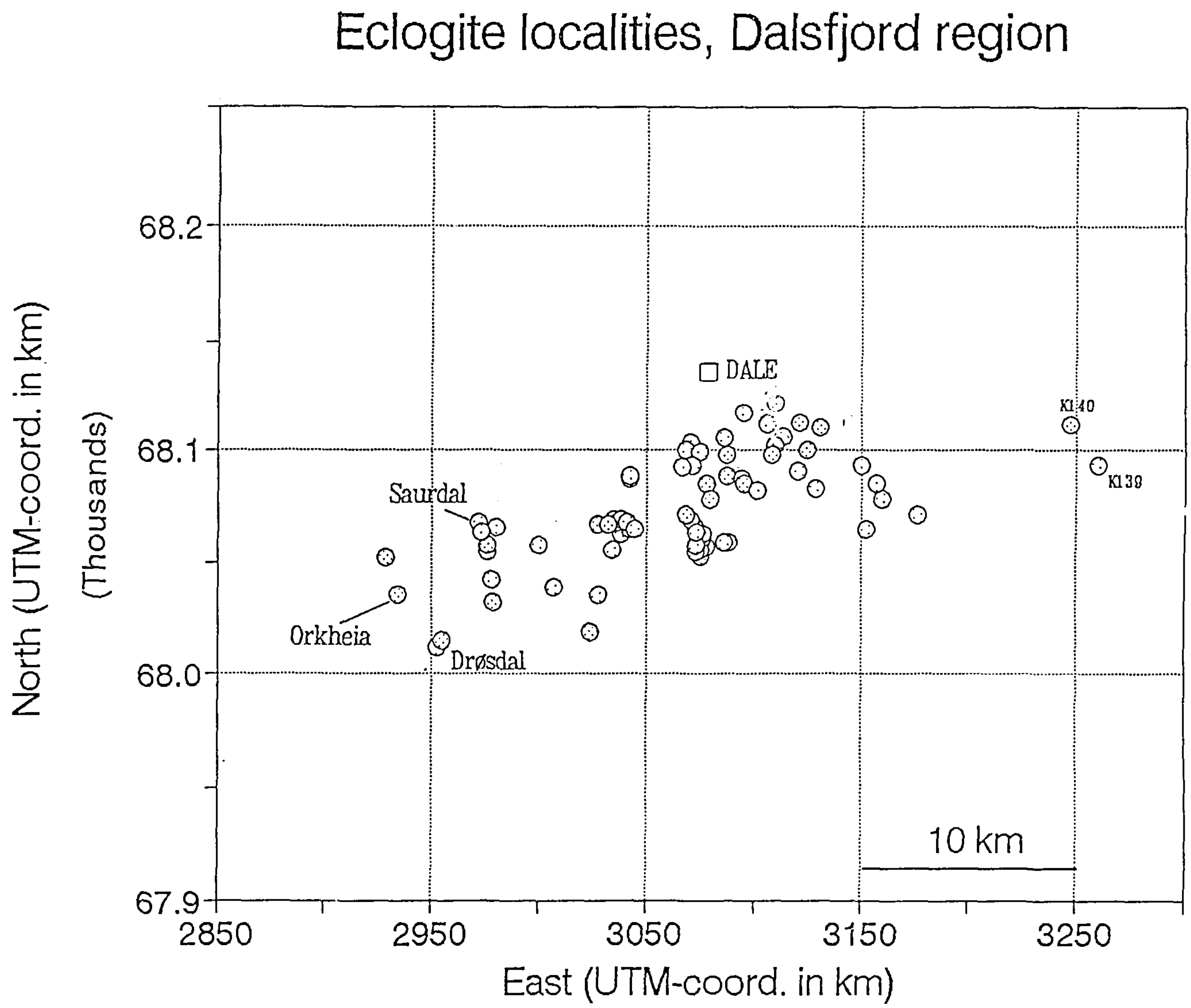
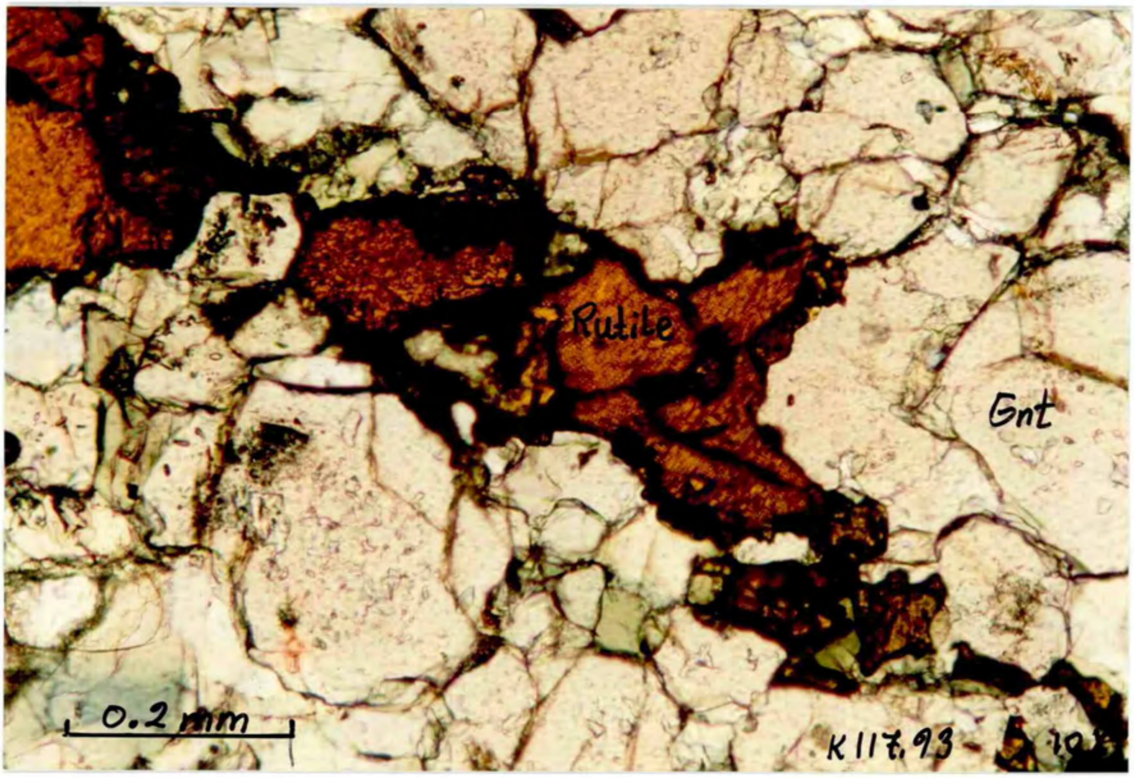


Fig.14: Eclogite occurrences in the Dalsfjord region that are described in more detail in Appendix 1.

a.


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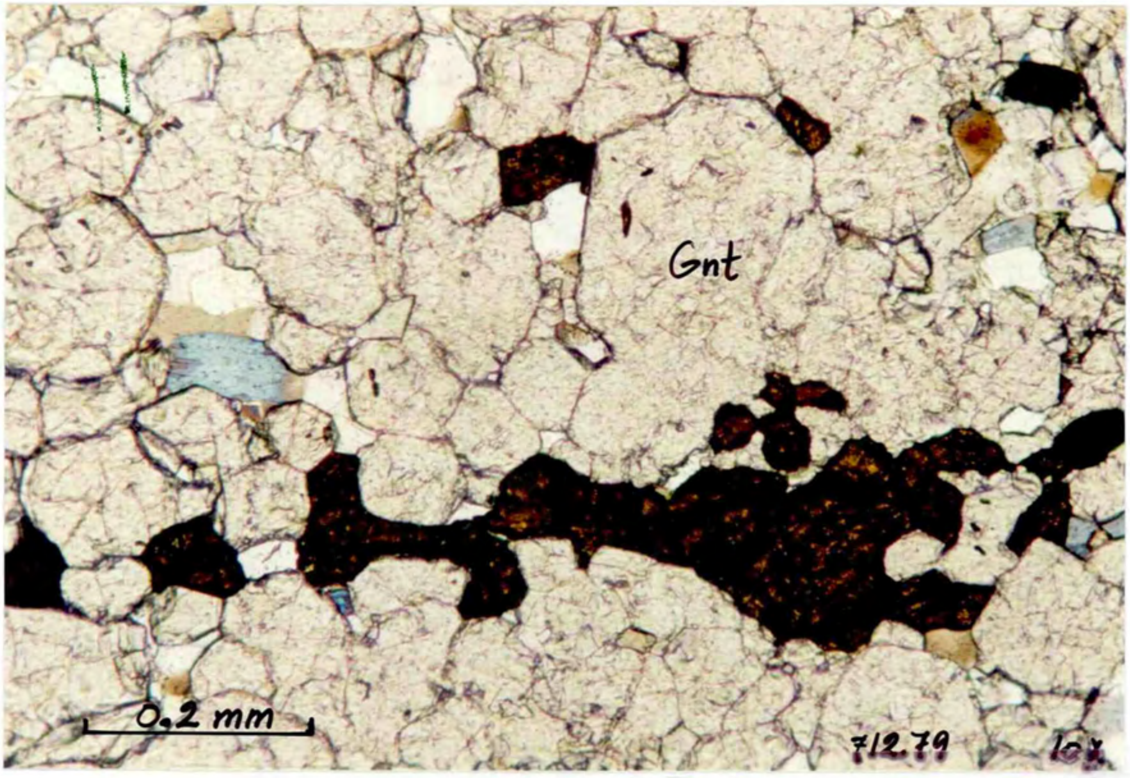
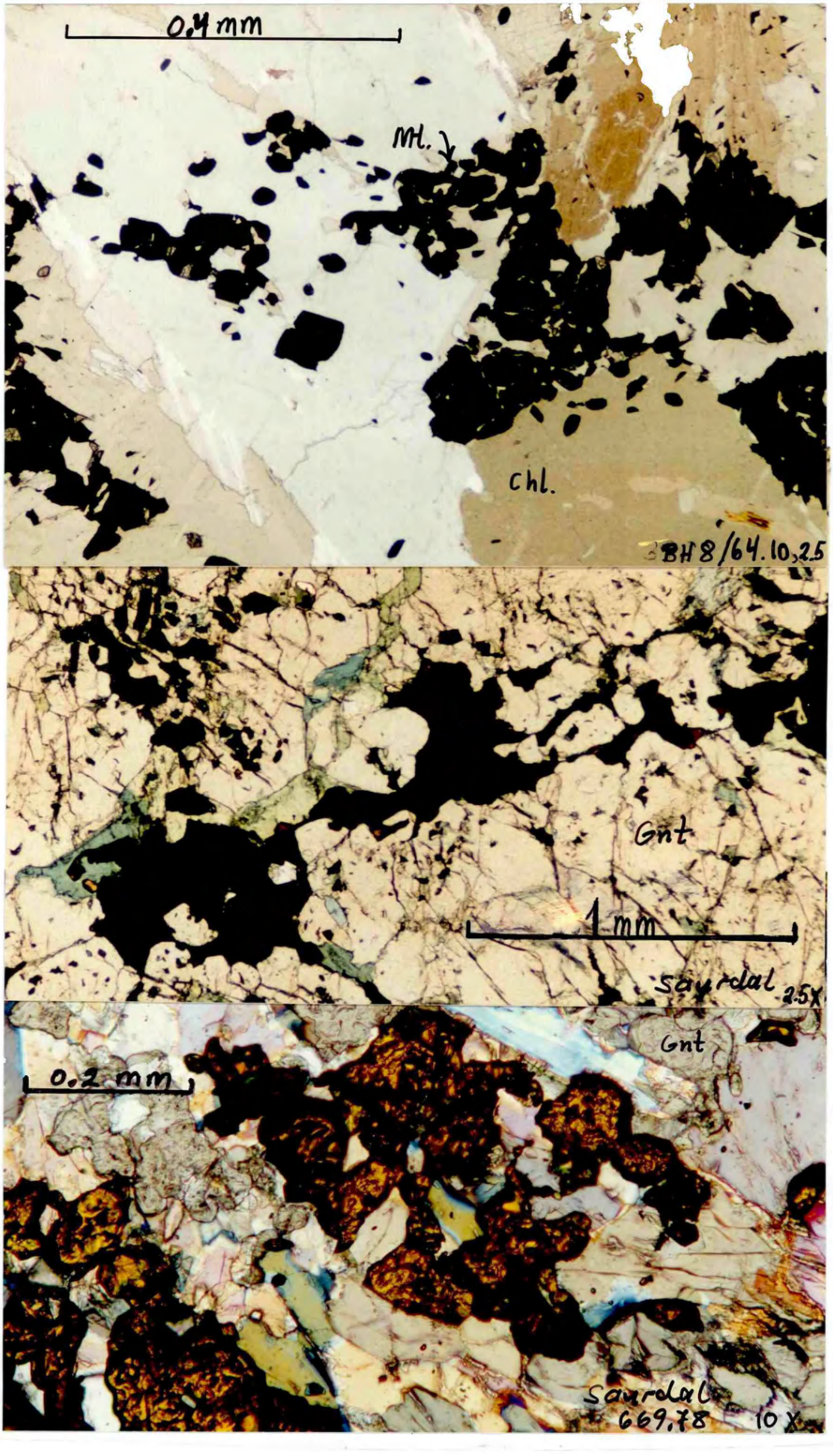


Fig.16: Microphotograps of rutile in garnet-rich eclogites from Rakneberg (see Appendix 1) between Flekke and Dale (sample K117.93; upper photo) and Solvik, Gjølanger area (sample 712.79; lower photo).



a. b. c.

Fig.17: Miscellaneous microphotograps, Saurdal eclogite. (a) Secondary magnetite and chlorite from a chlorite schistthat might be a product of extensive greenschist-facies retrogression of eclogite. (b) Intergrown rutile and ilmenite (dominates) in a garnet- and iron-rich variety of the Saurdal eclogite. (c) Rutile in a variety of the Saurdal eclogite that has an intermediate content of garnet and iron.

3.2. The Saurdal eclogite

General geology

The geology of the Saurdal area (and Gjølanger-Flekke as well) is characterized by basic rocks that range from coarse, practically undeformed gabbros with preserved primary minerals through several variations of sheared and metamorphosed gabbros including eclogite. These basic rocks are frequently intruded by a low-K tonalitic rock that is deformed together with the metabasic rocks. Cuthbert (1985) has divided this central part of the Gjølanger-Flekke area with its various basic and intrusive acidic rocks into two units called the Flekke and the Gjølanger unit respectively. The area to the north consists predominantly of paragneisses (Cuthbert's Vardeheia unit) and to the south predominatly of orthogneisses (The Jostedal Complex).

Previous investigatons

At the beginning of this century gabbroic rocks in the Dalsfjord region experienced prospecting and small-scale mining for magnetite. The deposits, however, were found to be small and, due to magnetite/ilmenite intergrowths, the magnetite concentrates generated had a fairly high and unwanted Ti-content. Consequently the prospecting/mining activities terminated after a few years.

The Saurdal magnetite is fairly V-rich. The company Rausand Gruber A/S, a mining company operating a vanadiferous magnetite-ilmenite deposit near Kristiansund, carried out a drilling program for V-bearing magnetite at Saurdal in 1956. They drilled eight drill-holes at Saurdal in four profiles approx. 150 m apart, and one drill-hole east of Solvik at the Gjølanger bay. This investigation did not, however, identify any significant volume of ore.

In NGU's investgations of rutile-bearing eclogites in the region in 1978-79, the eclogite at the northern side of the Saurdal magnetite-ilmenite ore-zone (called the Saurdal eclogite) was identified as rutile-bearing, but not regarded as being of economic interest. (Korneliussen, 1980).

Several years ago a small company from Larvik started to quarry a white-mica rich eclogite variety at Saurdal for block-stone. Due to cracks in the rock they had problems in taking out sufficiently large blocks; mainly for this reason the mining has now stopped.

This investigation

1991: Four sets of chip-samples were taken in the block-stone quarry; they contained 2.81% rutile on average.

1992: (a) X-MET analyses were done directly on the rock surface over the eclogite body (Garson, 1993). (b) The drill-cores from 1956 were relogged at Løkken, including X-MET analyses on the cores (Garson, 1993, Korneliussen, 1992).

1993: (a) Dh8 from Rausand Gruber's 1956-investigation was analysed in 10 m-sections for rutile and major elements. (b) 107 drill-dust samples were taken to obtain additional information on the rutile distribution over the eclogite body. (c) A ground-magnetic survey over the Saurdal eclogite was carried out westwards to investigate the continuation of the Saurdal rocks in this direction.

Ore geology

Cumulate magnetite-ilmenite layers and impregnations occur within the metagabbroic rocks. At Saurdal such oxide enrichments were subject to small-scale mining for magnetite at the beginning of this century. The ore occurs as irregular, less than one m-thick layers and lenses of massive to semi-massive magnetite/ilmenite within a 30-40 m-thick E-W trending zone of chloritic schist along the southern margin of the Saurdal eclogite body. This ore-zone can be followed for approx. 800 m. After a 300 m break it is again found 300 m further to the west. This is consistant with the results of a ground-magnetic survey done by NGU in 1993 (see below). This western area is heavily covered by soil and vegetation, and drilling is needed to obtain reliable information on the character of the ore.

The nine drill-holes drilled in 1956 by Rausand Gruber, in total 1400 m, are available at NGU's core-storage at Løkken. Eight of these drill-holes (Dh1 to 8) are from four profiles approx. 150 m apart at Saurdal, and one (Dh9) was drilled east of Solvik at the Gjølanger bay. See Garson (1993) and Korneliussen (1992) for more details on the drill-holes, based on inspection of the cores at Løkken in the autumn 1992. The 1956-investigation did not identify any significant volumes of magnetite-ilmenite ore. However, impregnations of Ti-oxides occur in eclogitic rocks on the northern side of the Mt-Ilm ore-zone. Garson (1993) estimated, based on X-MET field analyses and analytical data from the Dh8, that the Saurdal eclogite contains at least 250 million tons of rutile-bearing rocks with 4-5% TiO_2. Thus the Saurdal eclogite could represent a significant rutile deposit lying on the northern side of the massive magnetite-ilmenite ore.

The Saurdal magnetite contains from 0.14% to 0.75% V and from 0.12% to 2.37% Cr, based on Rausand Gruber's analyses of magnetite concentrates made from the drill-cores (Geis 1979). Of these holes Dh8 is the only one that gives a good (207m) section through rutile-mineralized eclogite. Dh8 is directed northwards, cutting the eastern part of the Saurdal eclogite at depth. Dh1 to 7 are directed southwards (see Garson, 1993) and cut dm-thick zones of magnetite-ilmenite ore surrounded by eclogite that has been variably altered to a chloritic schist.

Metamorphic effects

The original magmatic magnetite-ilmenite ore has been significantly affected by the Caledonian metamorphism.

(a) Eclogitization. The region experienced Caledonian high-pressure metamorphism in which miscellaneous basic rocks were transformed into eclogite. However, the eclogitization process was inhomogeneous, and large volumes of gabbroic rocks were not at all or were incompletely transformed into eclogite. In the eclogitization process, magnetite and ilmenite break down, with the iron substituting into garnet and the titanium remaining to form rutile. Practically all variations of rutile/ilmenite ratios can be found. For Saurdal this is illustrated in Figs. 16-18.

It is generally accepted that deformation associated with fluid infiltration stimulates eclogitization if the pressure is sufficiantly high (see Austrheim, 1990). Gabbroic rocks in the Gjølanger area are often eclogitized along distinct shear-zones, but gradual eclogitization of gabbroic bodies is also common (see Cuthbert 1985 for a more detailed description of this phenomenon). All eclogites such as those at Drøsdal and Orkheia are deformed and folded together with the surrounding gneisses. The eclogitic minerals seem to have crystallized under this deformation period. It is probable that deformation and associated fluid infiltration is an important factor in the eclogitization of basic rocks in the region.

(b) Amphibolite facies retrogression. Most eclogites in the region are retrograded. At Saurdal amphibolite facies retrogression is well reflected in the alteration of omphacitic clinopyroxene to aggregates of plagioclase and diopsidic clinopyroxene and hornblende. Rutile is normally not affected at the beginning stage of this retrogression. During more extensive retrogression, i.e. amphibolitization, rutile tends to alter to ilmenite and secondary magnetite forms.

(c) Greenschist facies retrogression. The most extensive retrogression is chloritization; this is accompanied by the breakdown of garnet and hornblende, rutile alteration to ilmenite, and formation of secondary magnetite. The end-product of this retrogression is a magnetite-bearing chloritic schist. Occasionally the magnetite-content reaches 20-30%; such magnetite mineralizations were subject to some prospecting activities at the beginning of this century, but the deposits were not of sufficiant size for mining. Relics of garnet-amphibolite are commonly found within the chloritic schists.

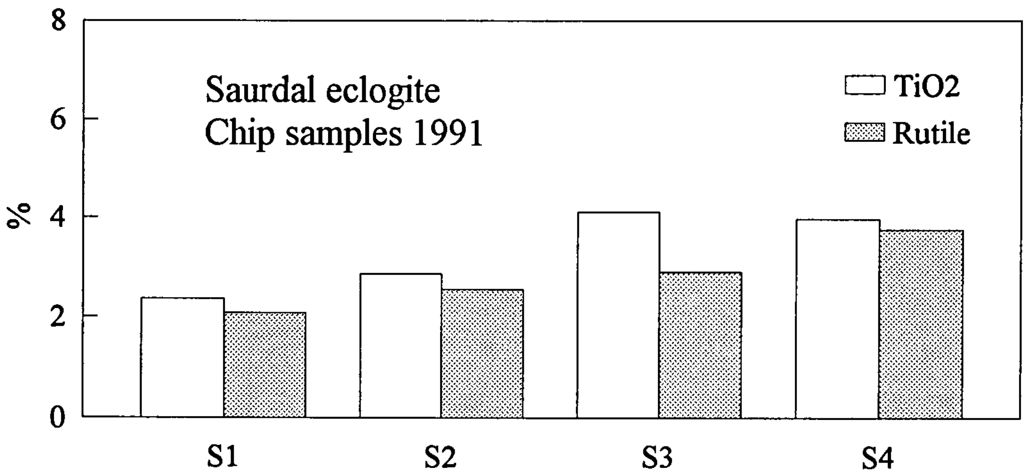


Fig. 18: Rutile and TiO_2 in four sets of chip-samples from the block-stone quarry at Saurdal. See Appendix 3 for the complete analyses.

Sampling and analytical results

Analytical results are available from the following sample-sets:

(1) Chip-samples from the block-stone quarry taken in 1991 and analysed by NGU. The rutile content varies from 2.08% to 3.74%, and the percentage of rutile vs. total TiO_2 (called relative percent rutile) varies between 70% and 94% (Fig.15, Appendix 3a).

(2) Field X-MET analyses directly on the rock surface. The values vary widely, averaging 4.78% TiO_2 (Garson 1993)

(3) X-MET analyses directly on Dh8-core analysed at NGU's core strorage at Løkken in 1992. The values vary widely, averaging 4.28% TiO_2 (Appendix 5 in Korneliussen, 1992). These analyses are much in line with the X-MET field-analyses.

(4) Laboratory analyses of 10 m-sections of Dh8 done at NGU in 1993. In order to obtain reliable information of the rutile content, the Dh8-core was divided into 10 m sections and analysed by NGU's rutile analytical procedure (Fig.19, Appendix 3b); the average is 1.18% rutile and 3.04% TiO_2.

(5) To obtain additional information on the rutile- and TiO_2-content over the outcropping parts of the Saurdal eclogite, 107 drill-dust samples, 1-2 kg each, were taken using NGU's sampling method (described in Korneliussen and Furuhaug,, 1991a), and analysed by a simplified rutile analytical procedure using the X-MET analyser for total TiO_2 determination (Appendix 3c). The sample localities are shown in Fig. 20. The rutile and TiO_2- contents in the drill-dust samples from profiles 1 to 6 are shown in Fig. 22, and illustrate the significant inhomogenity of this deposit.

Table 2 is a comparison of the average values for rutile, TiO_2, Fe_2O_3 (total) and CaO in the sample-sets from the Saurdal eclogite. Averages of Fe_2O_3 and CaO are fairly similar in all sample-sets, while TiO_2, and especially rutile, are more variable. The most probable explanation for the significant TiO_2-variation is that the rutile/ilmenite mineralization in the eclogite is much more inhomogeneous than the silicates; this is well reflected in the X-MET analyses done directly on the rock surface. In this case each analysis is representative of a very small sample, giving much larger variations in the analytical results compared to the laboratory analyses that represent much larger, more representative samples.

Comparatively high TiO_2-values for the X-MET analyses directly on the rock surface may indicate that the selection of the points for analysis have been subconsciously influenced by the field observation of local rutile/ilmenite-enrichments. An alternative explanation is that the oxides tend to stand out on the rock surface making them more exposed than the silicates. In any case these data indicate that X-MET analyses directly on the rock surface are not a reliable method for collecting data when precise information on TiO_2 content is needed. The X-MET analyses are, however, fully satisfactory in the reconnaisance stage of rutile investigations.

Table 2: Average content of rutile, TiO_2, Fe_2O_3 (total) and CaO in different sample sets from the Saurdal eclogite.

Sample set	(1) Chip-samples, quarry	(2) X-MET field anal.	(3) X-MET anal.of Dh8	(4) Rutile anal., Dh8	(5) Rutile anal., drill-dust
Samples	milled	rock surface	rock surface	milled	milled
n	3	>200	>200	21	107
Rutile	2.81	n.d.	n.d.	1.18	1.40
TiO_2	3.32	4.78	4.28	3.04	3.58
Fe_2O_3	17.21	18.51	18.63	20.79	20.18
CaO	10.88	7.09	7.40	9.57	8.98

The relatively high rutile-content in the chip-samples, 2.81% in the chip-samples vs. 1.18% in Dh8 and 1.40% in the dust-samples (Table 2), may reflect that the rock in the block-stone quarry does have a high rutile content. An alternative explanation is that the sampling was unconciously prejudiced leading to selection of non-representative samples.

The amount of titanium present as rutile is very variable. The rutile content tends to be highest in low-magnetic samples with low- to intermediate iron content (approx. 20% Fe_2O_3, Fig..21c). Iron-rich samples contain less rutile and more ilmenite, and they are more magnetic; they tend to contain magnetite as relics after the original oxide assemblage, or contain secondary magnetite formed during the chloritization process. Large samples, such as the 10-m sections of Dh8 and the drill-dust samples, may contain both types of magnetite, though relics of the original magmatic magnetite-ilmenite mineralization seem to be much more common than the secondary magnetite.

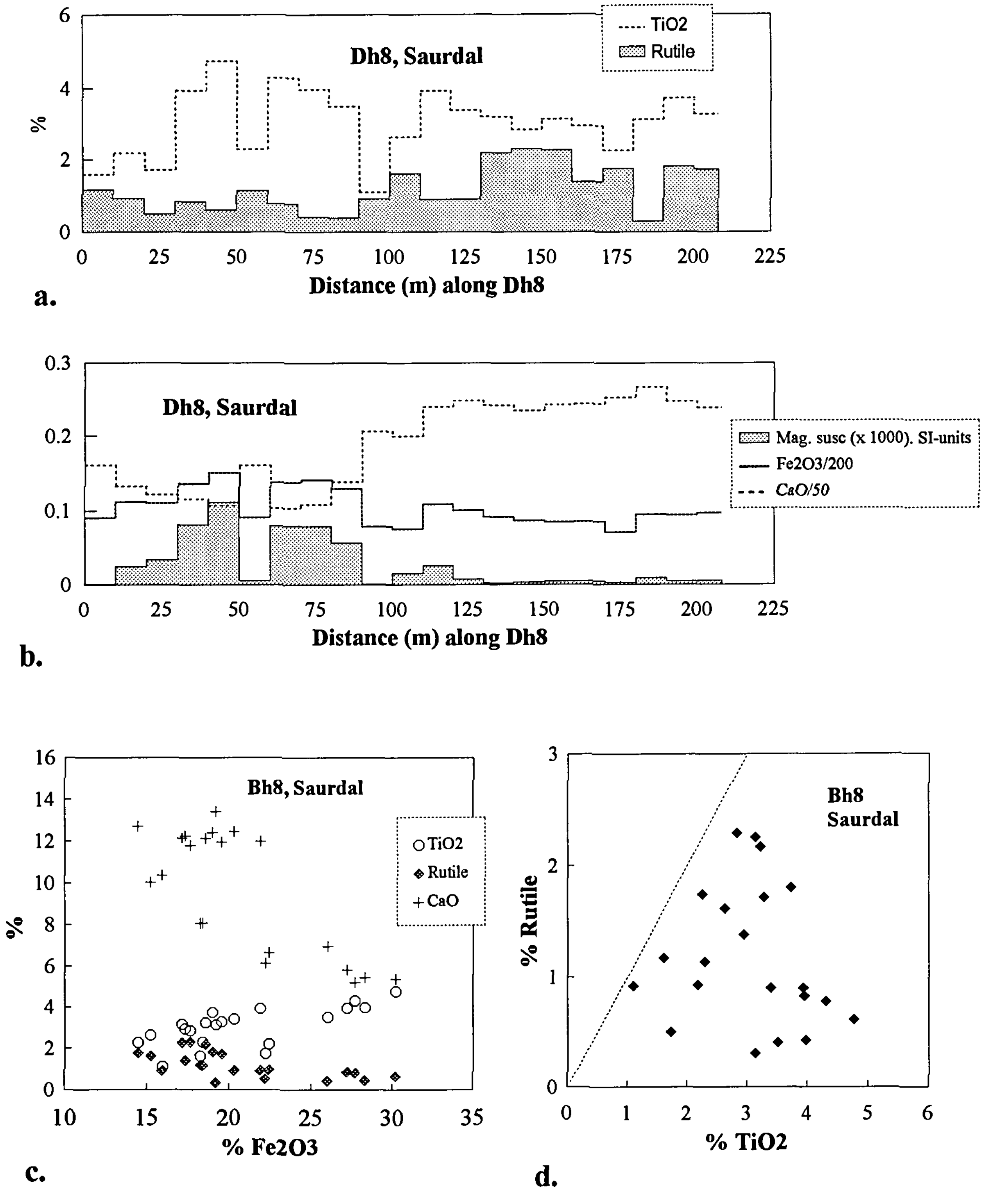
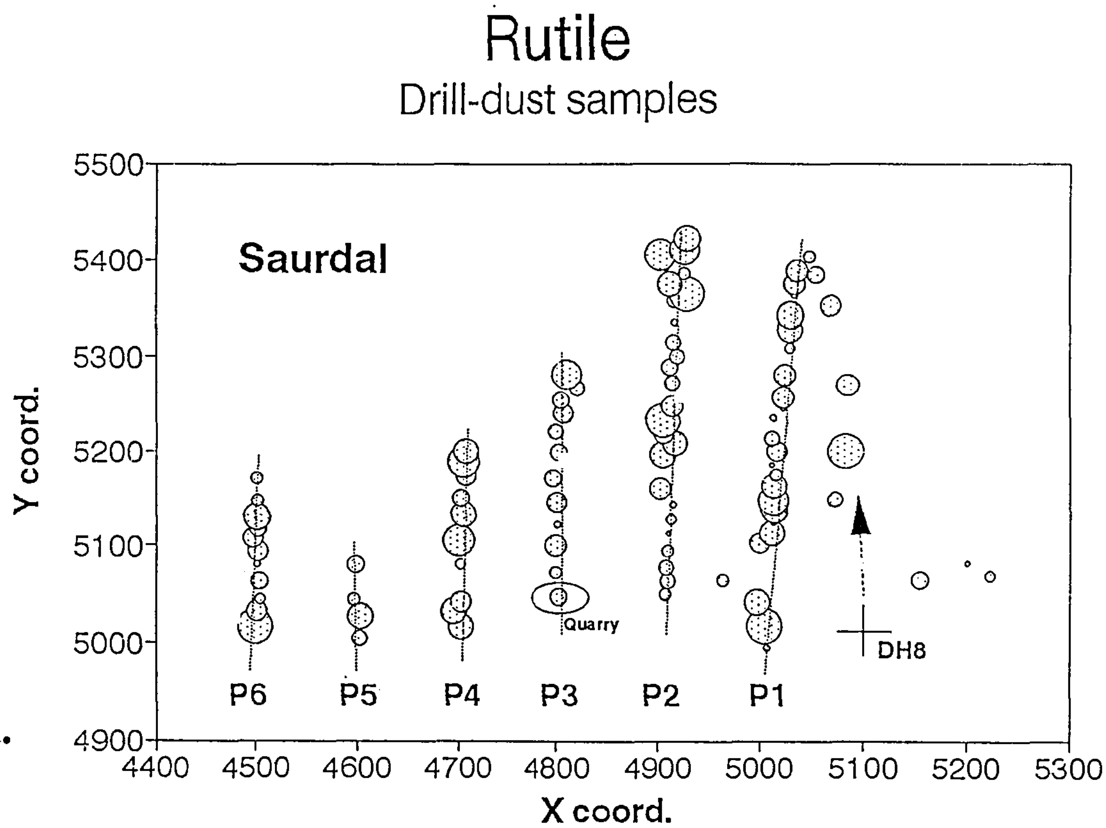


Fig.19: The variation of (a) rutile and TiO_2 and (b) magnetic susceptibility, Fe_2O_3 and CaO along Dh8, scattergram plots of (c) CaO, rutile and TiO_2 vs. Fe_2O_3, and (d) rutile vs. TiO_2, Dh8. Figs. a and b show a general tendency for rutile to be enriched in the second half of the drill-hole, together with a decrease in Fe_2O_3 and magnetic susceptibility. Fig.c shows that TiO_2 is positively correlated with Fe_2O_3, while rutile is negatively correlated with Fe_2O_3; rutile's lack of correlation with the rock's total TiO_2 is illustrated in Fig.d.

a.



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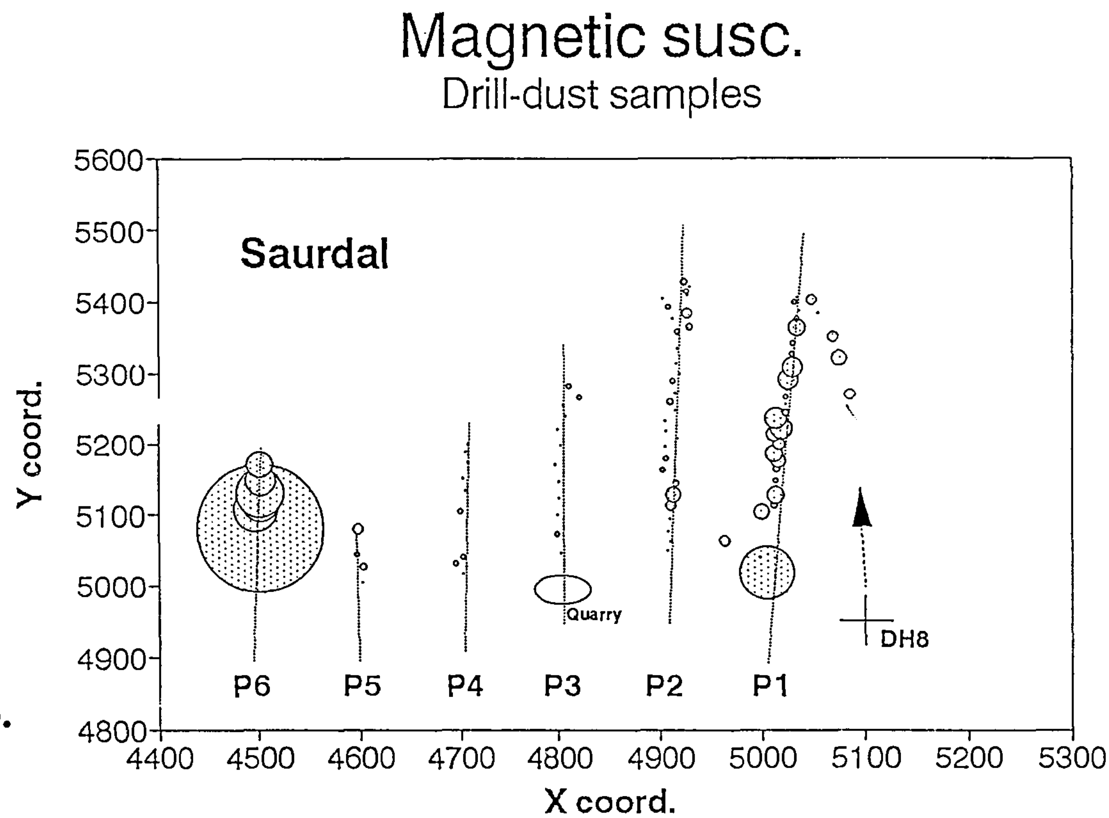


Fig. 20: (a) Bubble-diagram showing the rutile content in the drill-dust samples from the Saurdal eclogite. The variation in bubble-size reflects the relative variation in rutile content. (b) Bubble-diagram showing the relative variation of magnetic suceptibility at the drill-dust sample localities. See Fig. 22 and Appendix 3c for more detailed analytical results.

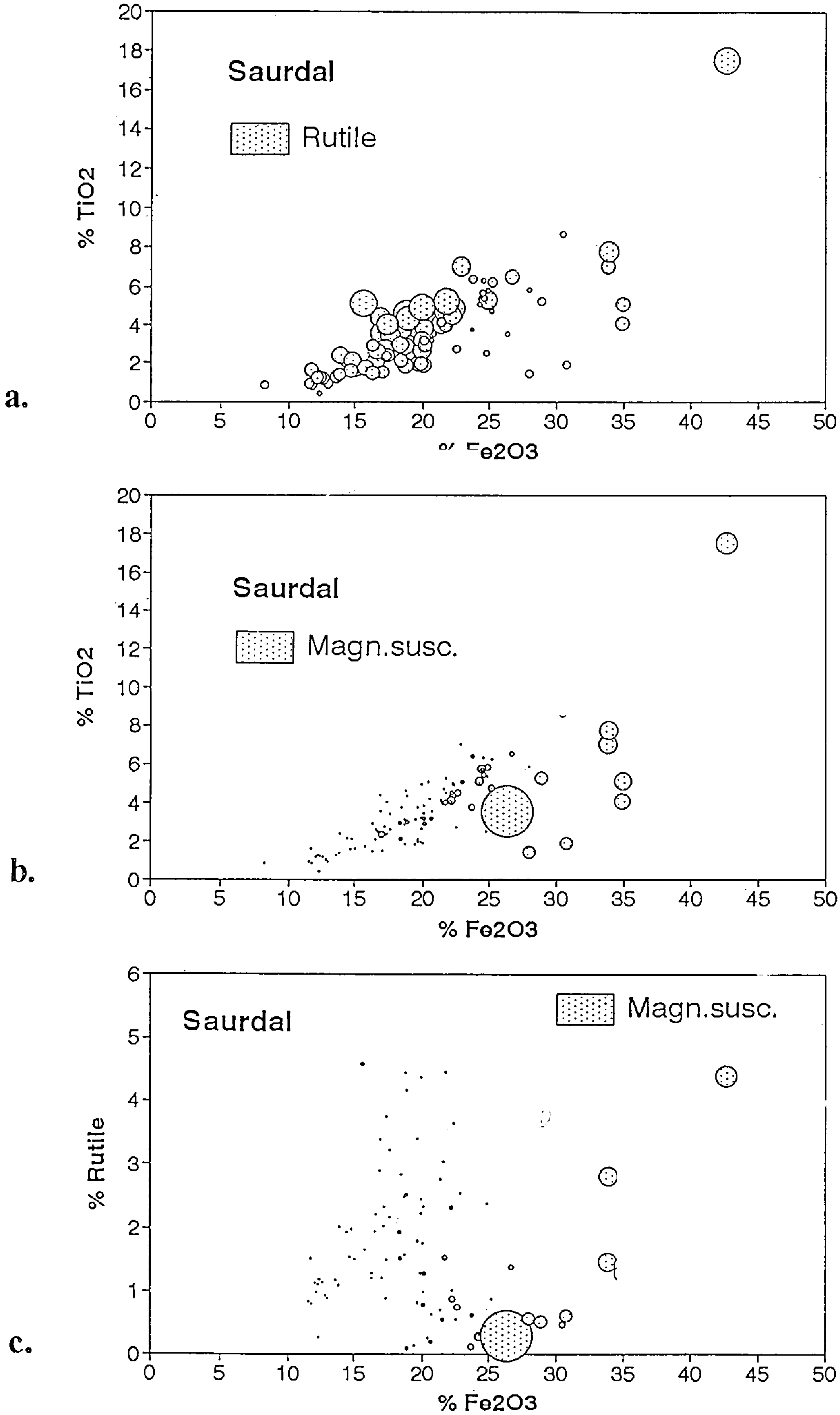


Fig.21: Bubble-diagrams showing some relations between Fe_2O_3 and rutile, TiO_2 and magnetic susceptibility. (a) TiO_2 - Fe_2O_3 scattergram plot with the bubble-size reflecting the relative variation in rutile content. (b) TiO_2 - Fe_2O_3 scattergram plot with the bubble-size reflecting the relative variation in magnetic susceptibility. (c) Rutile - Fe_2O_3 scattergram plot with the bubble-size reflecting the relative variation in magnetic susceptibility.

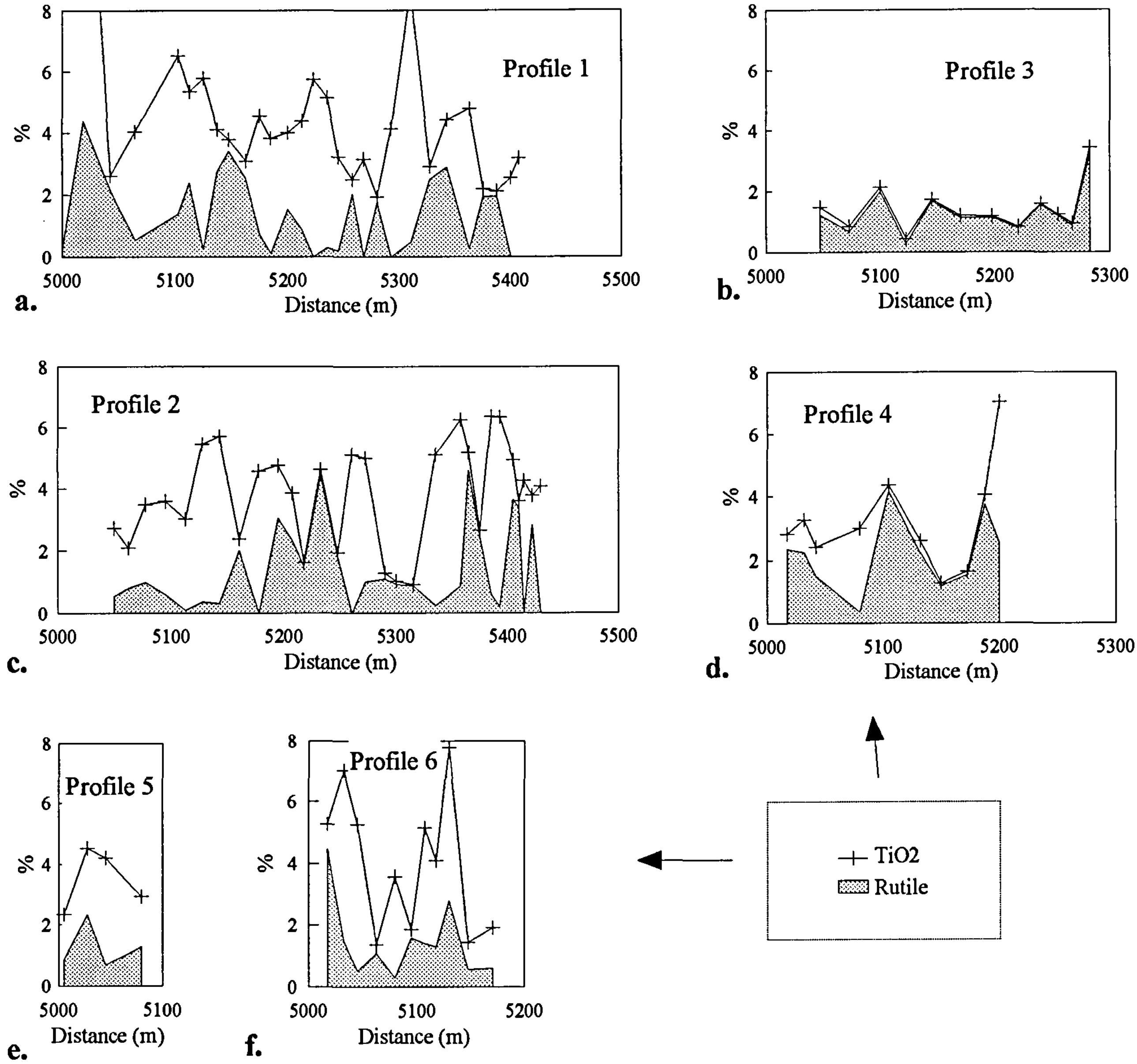


Fig.22: Rutile-and TiO_2-content in drill-dust samples from profiles 1 to 6, Saurdal eclogite. The profiles and the sample locations are shown in Fig.20 and the complete analyses in Appendix 3c. These data show that the rutile- and TiO_2-content in the Saurdal eclogite is very variable. A strong variability is also characteristic for the rutile/TiO_2-ratio; Profile 3 is exceptional in having practically all titanium in rutile.

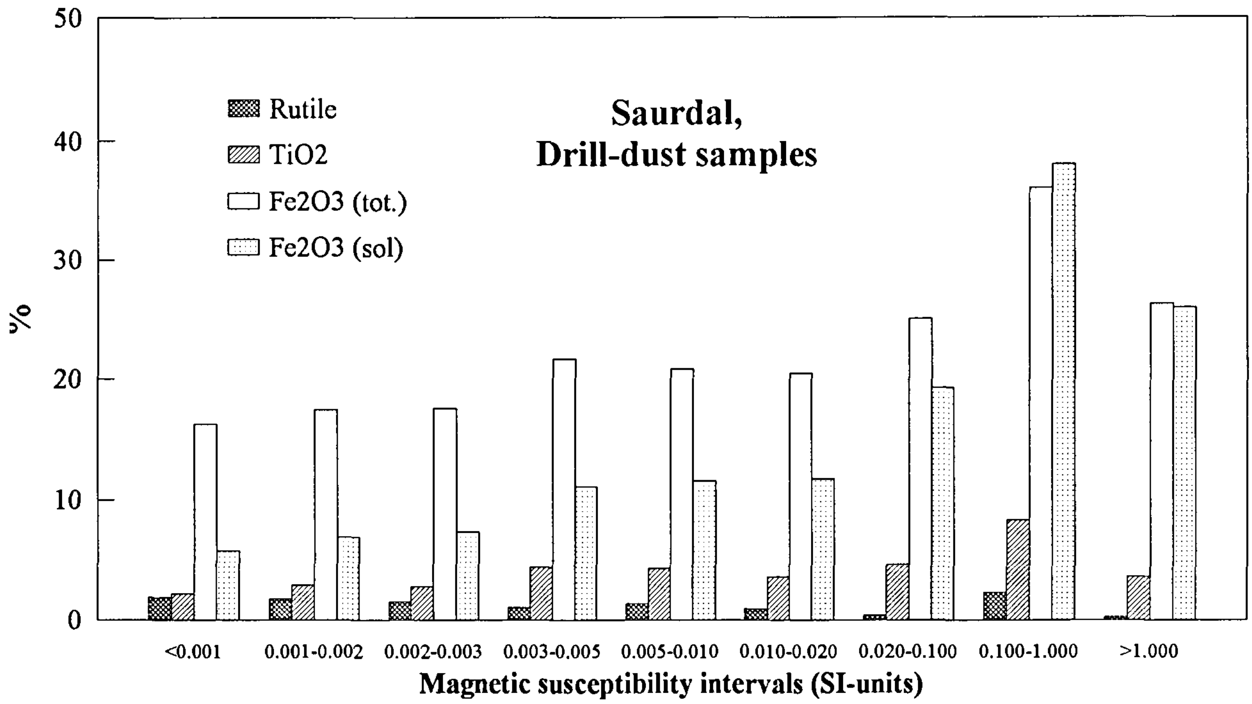


Fig.23: Average rutile, TiO_2, total Fe_2O_3 (XRF-anal.) and Fe_2O_3 (soluble in HCl; ICP-anal.) in intervals of increasing magnetic susceptibility (SI-units).

Table 3: Average rutile, TiO_2, Fe_2O_3 (total; XRF-anal.), Fe_2O_3 (soluble in HCl) and magnetic susceptibility in intervals of increasing magnetic susceptibility.

Magn.susc. intervals	Rutile	Rutile / TiO_2	TiO_2	Fe_2O_3 (tot.)	CaO	TiO_2 sol.	Fe_2O_3 sol.	Fe_2O_3 (sol.) /Fe_2O_3	Magn. susc.	n
<0.001	1,89	86%	2,20	16,22	8,22	0,31	5,67	35%	0,00071	10
0.001-0.002	1,74	60%	2,89	17,46	9,68	1,16	6,94	40%	0,00143	33
0.002-0.003	1,53	55%	2,76	17,55	10,11	1,24	7,34	42%	0,00240	17
0.003-0.005	1,08	25%	4,34	21,68	10,23	3,26	11,13	51%	0,00378	8
0.005-0.010	1,37	32%	4,26	20,84	9,67	2,89	11,60	56%	0,00644	11
0.010-0.020	0,96	27%	3,55	20,47	8,35	2,58	11,75	57%	0,01329	7
0.020-0.100	0,41	9%	4,60	25,10	8,37	4,20	19,25	77%	0,04090	14
0.100-1.000	2,27	27%	8,32	36,04	1,12	6,05	38,11	106%	0,18603	5
>1.000	0,29	8%	3,58	26,38	7,13	3,29	26,04	99%	1,32737	1

The significance of magnetism

Two strongly magnetic rock-types are known from the Saurdal-Gjølanger area: (1) Relics of primary magmatic magnetite-ilmenite mineralizations that have survived the eclogitization process. (2) Magnetite-bearing chloritized zones that have been formed by extensive greenschist retrogression of eclogite or other basic rocks. The Saurdal eclogite contains both these types of strongly magnetic rocks. The drill-dust samples are grouped in intervals according to increasing magnetic susceptibility in Table 3, which also gives the average rutile, TiO_2, Fe_2O_3 and Fe_2O_3 (HCl-soluble).

The rutile content tends to be highest at low to middle magnetic susceptibility levels, while the TiO_2-content tends to increase with magnetic susceptibility (Fig.23, Table 3). The susceptibility interval 0.100-1.00 is an exception to this general rule in that it shows a high rutile content. These data show that rutile in the Saurdal geologic situation is in some way associated with high-magnetic rocks, but there is no direct correlation between rutile and magnetic susceptibility. High magnetism is primarily an indication of magnetite-rich rocks that are iron- and titanium-enriched and carry relics of magmatic magnetite-ilmenite mineralizations. At Saurdal such rocks are eclogitized, being variably rutile-bearing and with the primary magnetite-ilmenite mineralizations partly preserved.

According to these observations magnetism may be a good regional indicater of rutile-enriched rocks of Saurdal type, but is probably less useful in the detailed scale.

Fig. 21c gives a good illustration of the low-magnetic character for the majority of the drill-dust samples, regardless of rutile content: the most magnetic samples do, however, show a positive correlation between rutile and Fe_2O_3. The Ti-richest of these anomalously magnetic samples are believed to contain relics after the primary magmatic magnetite-ilmenite mineralization, with some of the ilmenite transformed into rutile during the eclogitization of the surrounding rocks. The magnetic samples poor in Ti may, however, represent chloritized eclogite where secondary magnetite has formed.

The ground-magnetic survey

A series of ground-magnetic profiles over the Saurdal eclogite and further westwards were done in 1993 in order to follow the westward continuation of the Saurdal rocks and identify new rutile-bearing occurrences. It was considered possible that the rutile-bearing eclogite at Saurdal has a diagnostic magnetic signature which, if found elsewhere in the surroundings, could lead to new discoveries of rutile-bearing rocks.

The Saurdal rocks were found to show very variable magnetic signatures (Lauritsen, 1993), which is a characteristic feature. A similar area of variable magnetic signatures is identified approx. 1 km west of Saurdal. This western area is significantly covered by vegetation. One small hill within the area is found to contain rocks similar to the Saurdal eclogite; one small adit from the prospecting period at the beginning of this century shows that the prospectors were aware that this area could be a continuation of the Saurdal rocks. They did not find significant amounts of magnetite/ilmenite ore, but the surrounding rocks may be rutile-bearing. Drilling is needed to obtain information sufficiant to make an economic evaluation of the situation with respect to rutile.

3.3. The Orkheia and Drøsdal eclogites

Eclogites in the Drøsdal-Langsjøen-Sellevoll area were preliminarily mapped and sampled in 1978-79 (Korneliussen, 1979; 1980). The Orkheia eclogite was then found, but not regarded worth pursuing in a detailed investigation. In 1991 the Drøsdal eclogite was subject to continued drill-dust sampling by NGU (previously unreported). The localities from this sampling are shown in Appendix 9 and the analytical results in Appendix 4. Interest in the Orkheia eclogite was renewed in 1993 and intensively sampled. X-MET field analyses at Orkheia gave TiO_2-values ranging from less than 1% to 6-7% TiO_2 over this 1.5 km-long eclogite body. The field analyses were followed by drill-dust sampling with a small gasoline drill that yielded samples of 10-25 g. The results are presented in Appendix 4 and in Figs. 25 & 26.

The Drøsdal-Orkheia area is one of the areas in W. Norway with the highest portion of eclogite. The eclogites are folded together with the surrounding gneisses. Relics of primary igneous banding at Orkheia indicate that the protolith was a layered gabbroic rock, presumably with a genetic relationship to the basic intrusions in the Gjølanger area.

Table 4: Average content of rutile, TiO_2 and Fe_2O_3 in drill-dust samples from the different parts of the Orkheia eclogite.

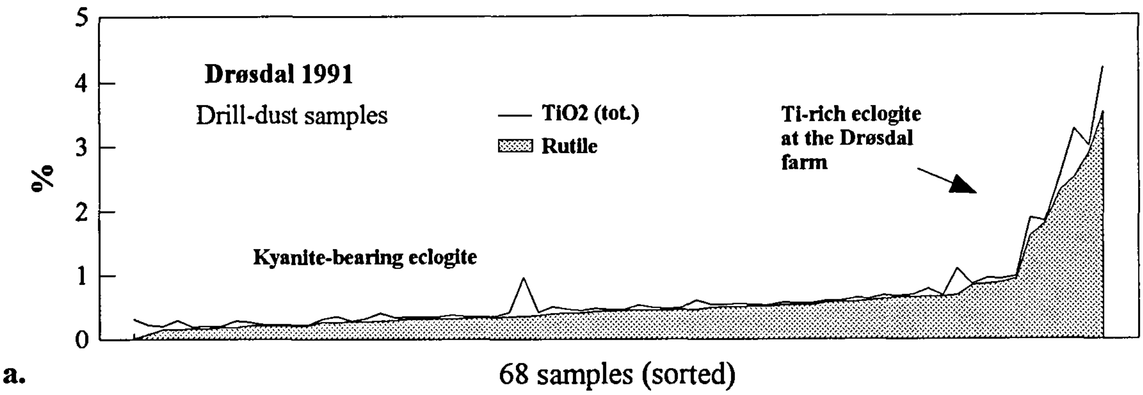
	Western part (DuPont anal.)	Central Part, Main Ridge (X-MET anal.)	Northern extension of P2 (X- MET anal.)	Eastern Part (DuPont anal.)
Rutile	1.59	-	-	2.32
TiO_2	1.93	2.16	.82	2.67
Fe_2O_3	14.46	14.92	10.22	15.97

The rutile enrichments at the Drøsdal farm and at Orkheia show that Ti-concentration mechanisms were effective when the protoliths crystallized, and are now present as rutile-enrichments in the eclogitized version of the rock.

Another important factor is that the eclogitization has been complete, and practically all the titanium in the rock occurs in rutile. No relics of primary magnetite/ilmenite have been observed.

A third important factor is that the rutile tends to occur as fairly large grains (> 0.1 mm) interstitial to the silicate minerals, making the rock more attractive for beneficiation.

The present geologic information of the area is not sufficient for a good economic evaluation of this interesting area. Continued mapping and sampling are strongly recommended.



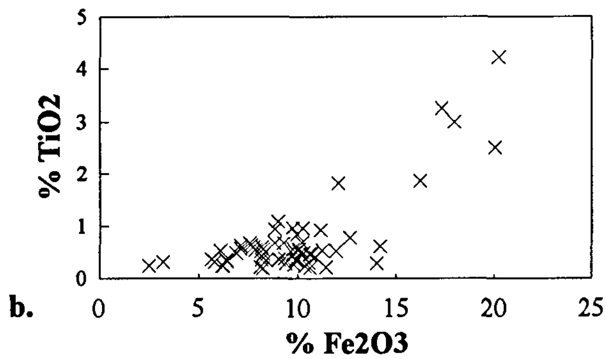


Fig.24: Analytical results for drill-dust samples (1991), Drøsdal. (a) Rutile vs.TiO_2. (b) Scattergram plot of Fe_2O_3 vs. TiO_2.

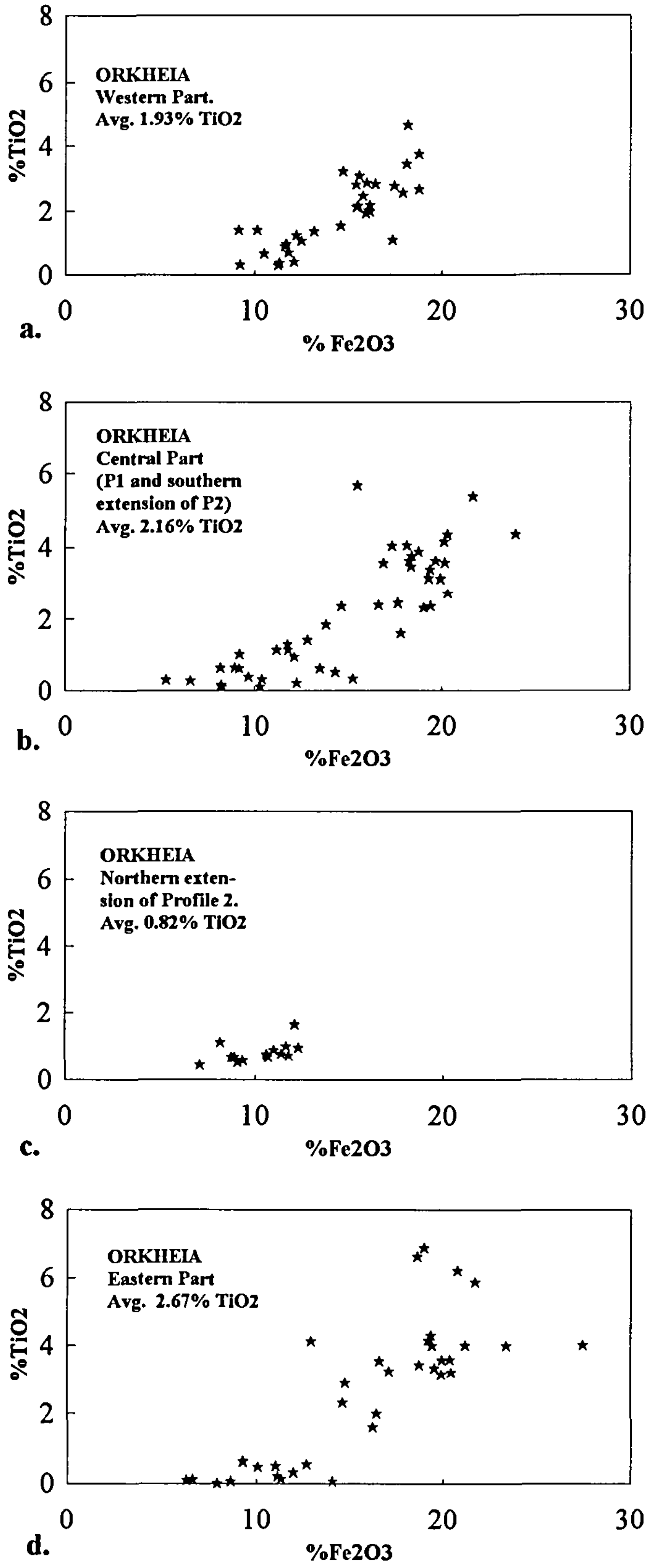


Fig.25: Analytical results, Orkheia. (a) to (d): Fe_2O_3 - TiO_2 scattergram plot of four sets of samples from the Orkheia eclogite.

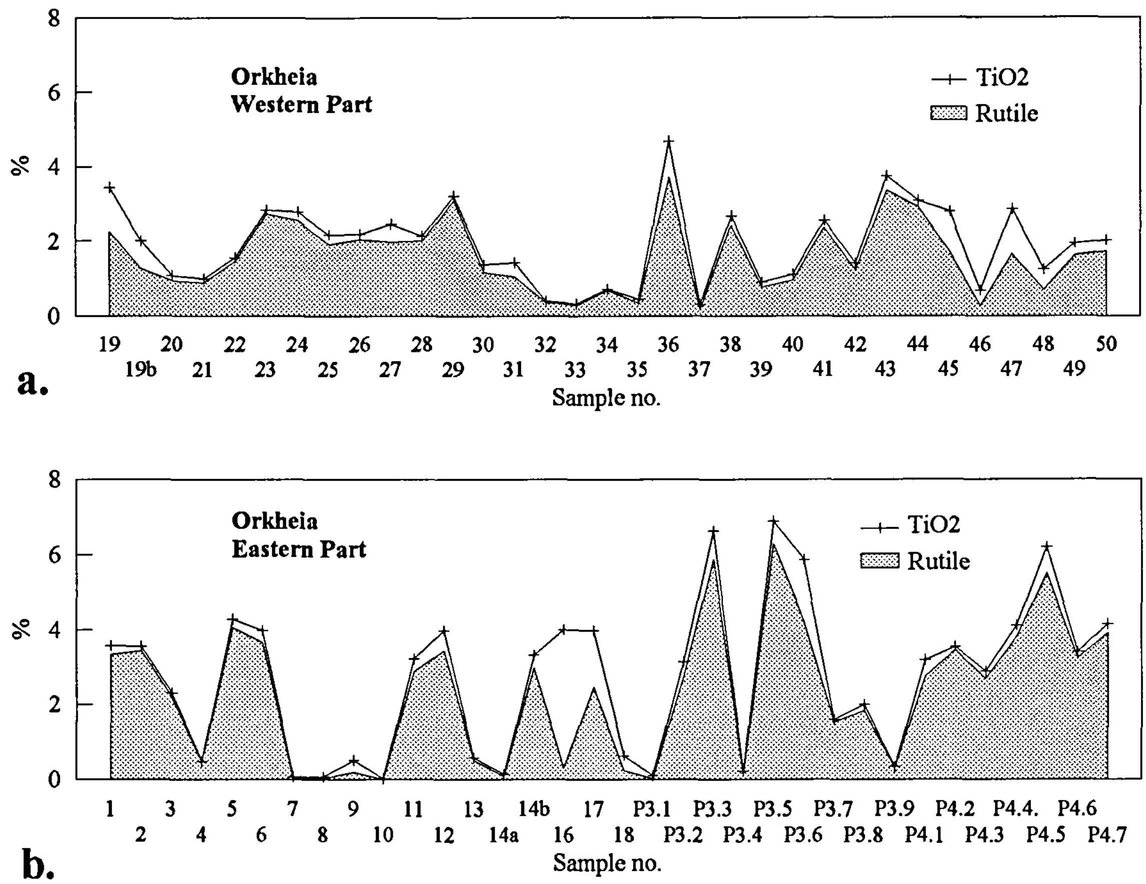
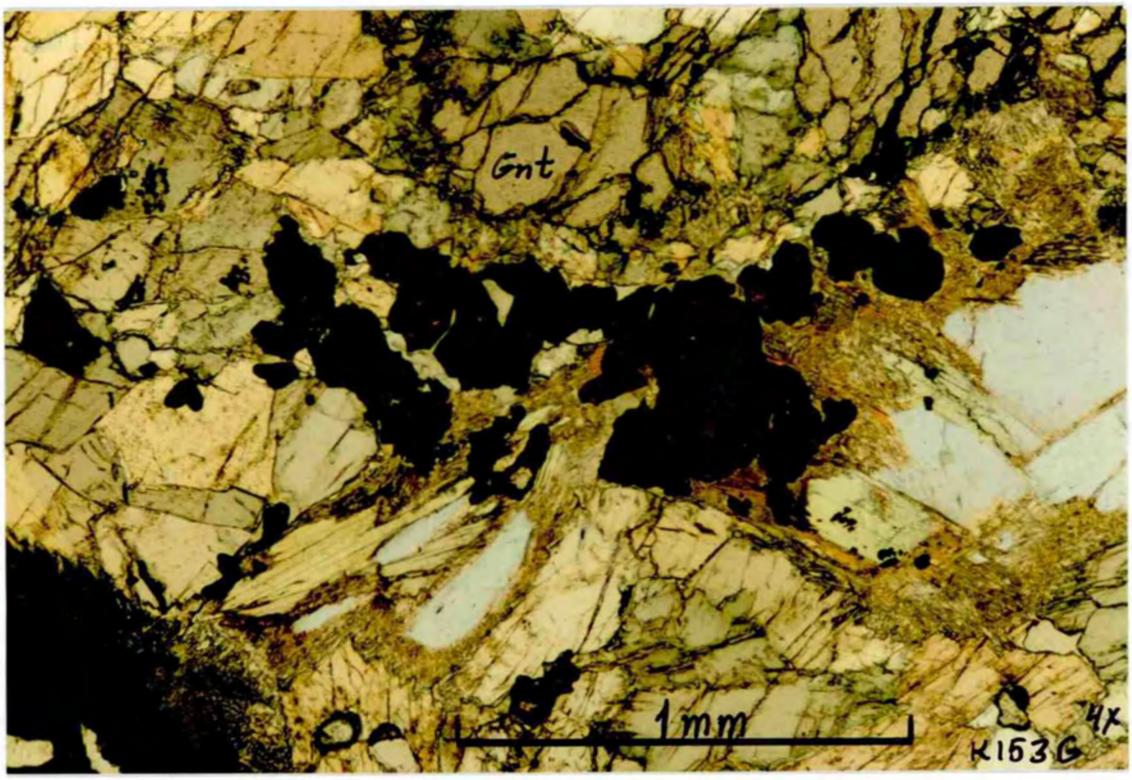


Fig.26: Rutile vs. TiO_2 for dust-samples (DuPont's sampling method) from the western and eastern part of Orkheia (same samples as in Fig. 25a and d). Analysed by DuPont (1993).

a.



b.

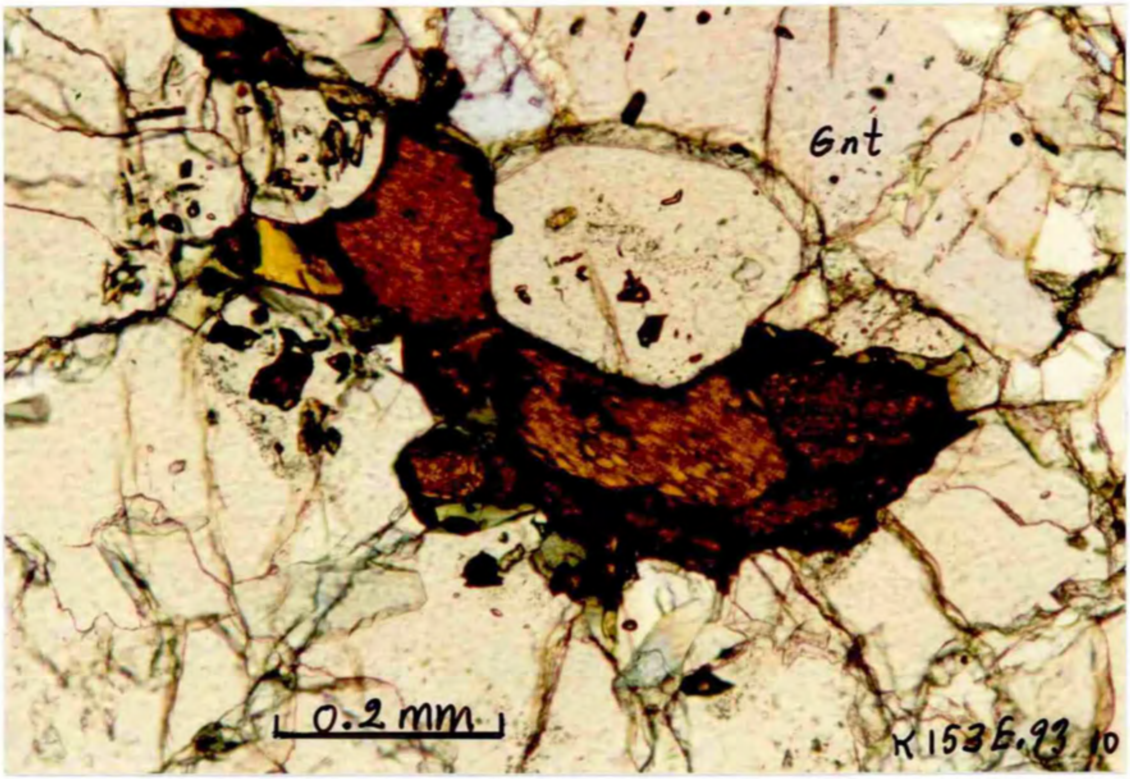
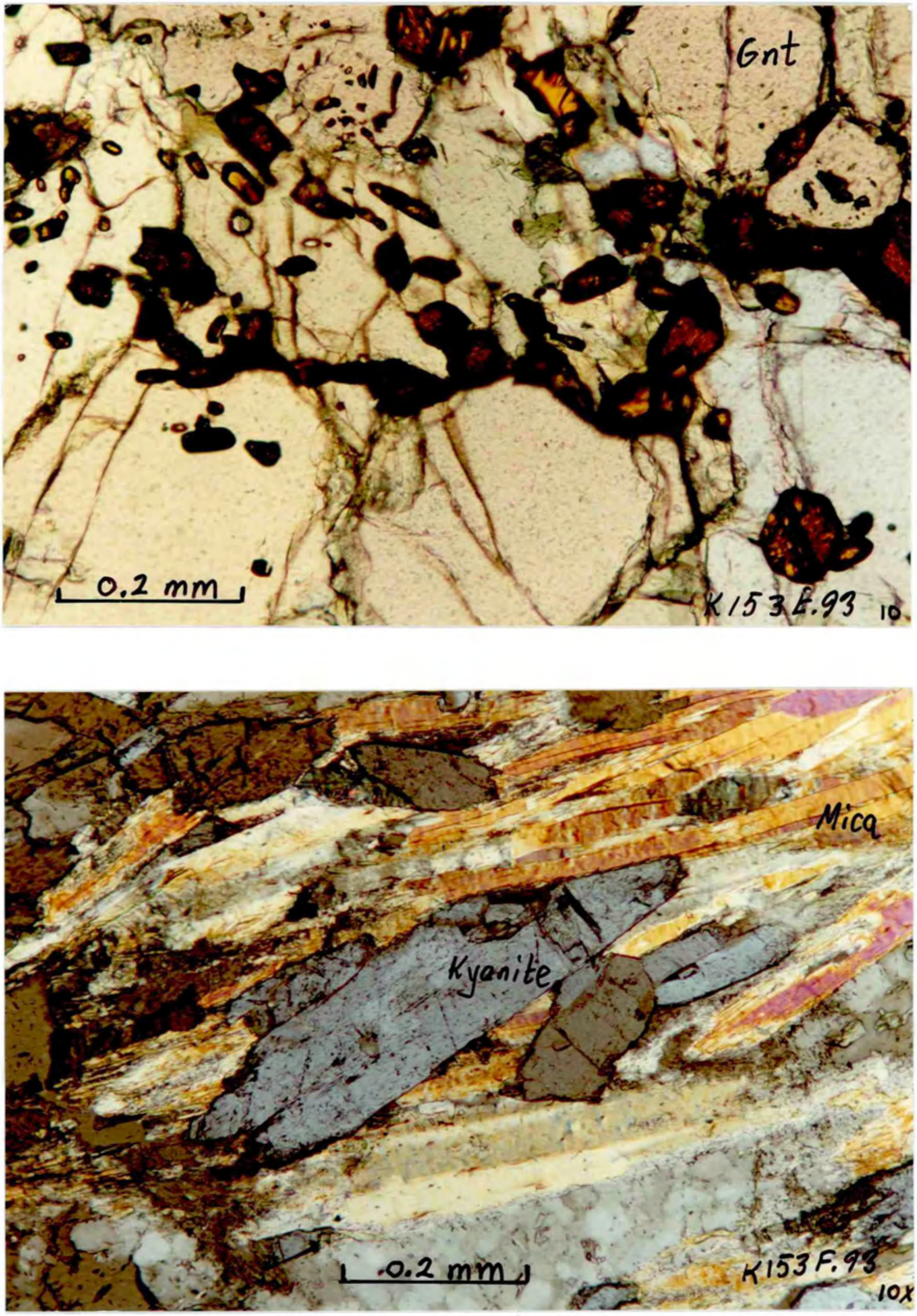


Fig. 27a-b: Photomicrographs of rutile from the Orkheia eclogite, Dalsfjord region. (a) Rutile aggregate in a variety of the Orkheia eclogite with medium garnet content (sample K153G.93). (b) Rutile in garnet-rich eclogite, Orkheia.



c.

d.

Fig. 27 c-d: Photomicrographs, Orkheia eclogite. (c) Fairly fine-grained rutile as inclusions in barroisitic amphibole.(d) Kyanite in a mica-rich eclogite variety.

4. Eclogites in the Førdefjord region

Rutile in eclogites in the Førdefjord region was first mentioned by Eskola (1921) from the Naustdal eclogite, and then by Binns (1967) who presents a TiO_2-analysis of 6.44%. H.P. Geis from Elkem A/S recognised an economic potential related to the Førdefjord rutile-bearing eclogites in the middle 1970s. In collaboration with Elkem A/S, NGU did reconnaisance mapping of eclogites in the Førdefjord (and Dalsfjord) region in 1978-80 (See Korneliussen, 1980 and 1981; Foslie, 1980, Korneliussen & Foslie 1985). These investigations resulted in the discovery of several large eclogite bodies with rutile contents of 1-3%. Locally the rutile content reaches 3-4% or more.

In 1979 Frank Barkve and his companion Tore Birkeland recognized the Engebøfjellet eclogite body as potentially suitablematerial for breakwater purposes. They did not succeed in putting the deposit into production and Birkeland withdrew from the project after a few years. Barkve's Engebø-project has now been taken over by the company Fjord Blokk in which Barkve, according to an article in the local newspaper Firda in 1993, owns approx. 25% of the shares.

Rutile-investigations were continued by Norsk Hydro in 1984-85, including beneficiation tests on the Engebøfjellet eclogite (by Warren Spring Lab., England) and Fureviknipa (by prof. K. Sandvik, Technical Univ. of Norway, Trondheim), without success. NGU did new sampling of the Engebøfjellet and Fureviknipa eclogites in 1990 in order to obtain additional information about rutile-contents and rutile/ilmenite-proportions (Korneliussen & Furuhaug, 1991).

Continued investigations were then carried out by DuPont/Stokke/NGU in 1992 to obtain additional information on TiO_2 contents in a number of previously known eclogites and to discover new rutile-bearing eclogites. No significant new discoveries were made.

Eclogites in the Førdefjord region frequently occur as several kilometer long folded and boudinaged layers with thicknesses in the range of 10 m to a few hundred m. Some of the larger boudins are fairly massive eclogite bodies covering areas of more than 100 000 m^2.

The TiO_2-contents are generally in the range 1-2%, but contents of 4-5% TiO_2 or more occur locally. The high Ti-contents are often, but not always, associated with fairly massive parts of the eclogites.

In 1993 an attempt was made to find new eclogites eastwards from Naustdal. Several localities of low-TiO_2 eclogites similar to the so-called volcanic eclogites near Førdefjord were found more-or-less directly eastwards from Naustdal. Ti-rich eclogite varieties frequently occur as thin bands and lenses within the low-TiO_2 eclogite. The situation is comparable to the areas between Naustdal and Vevring/Engebø. This type of eclogite continues eastwards from Naustdal at least as far as Kleppestølen 15 km E of Naustdal, and probably much further.

In a river at Svorstølen (near Fimlandsgrend) approx. 30 km NE of Naustdal an anomalous number of Ti-rich eclogites that resemble the Naustdal and Engebøfjellet eclogites in grain-size and TiO_2 content were identified. These boulders indicate, even though their source was not found, that eclogite-bearing terrains of the Førdefjord region can be extended far eastwards and northeastwards from Naustdal. So far this large area has been only superficially investigated for rutile-bearing eclogites.

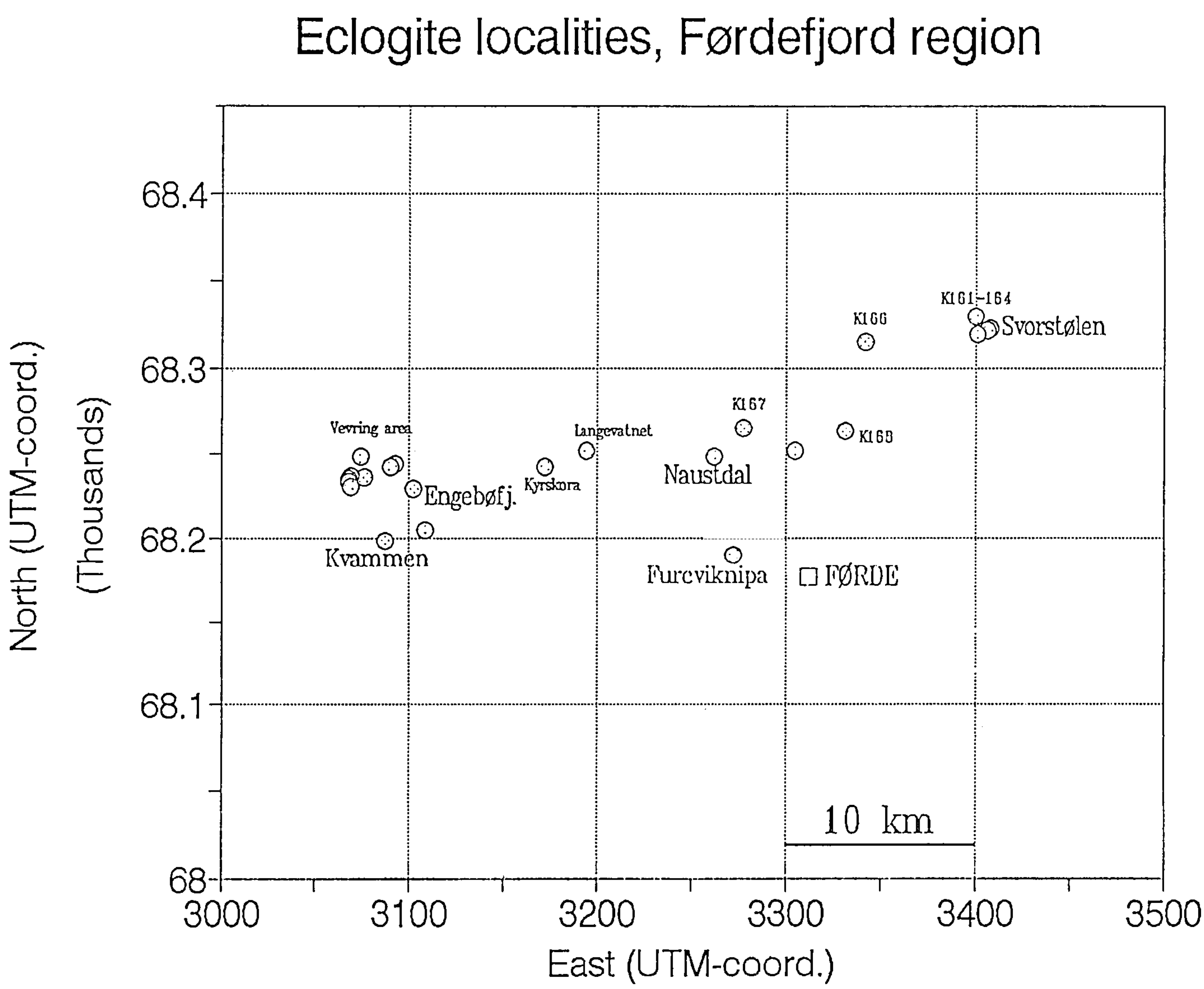


Fig. 28: Main eclogite bodies and 1993-sample localities, Førdefjord region. The location numbers refer to Appendix 1.

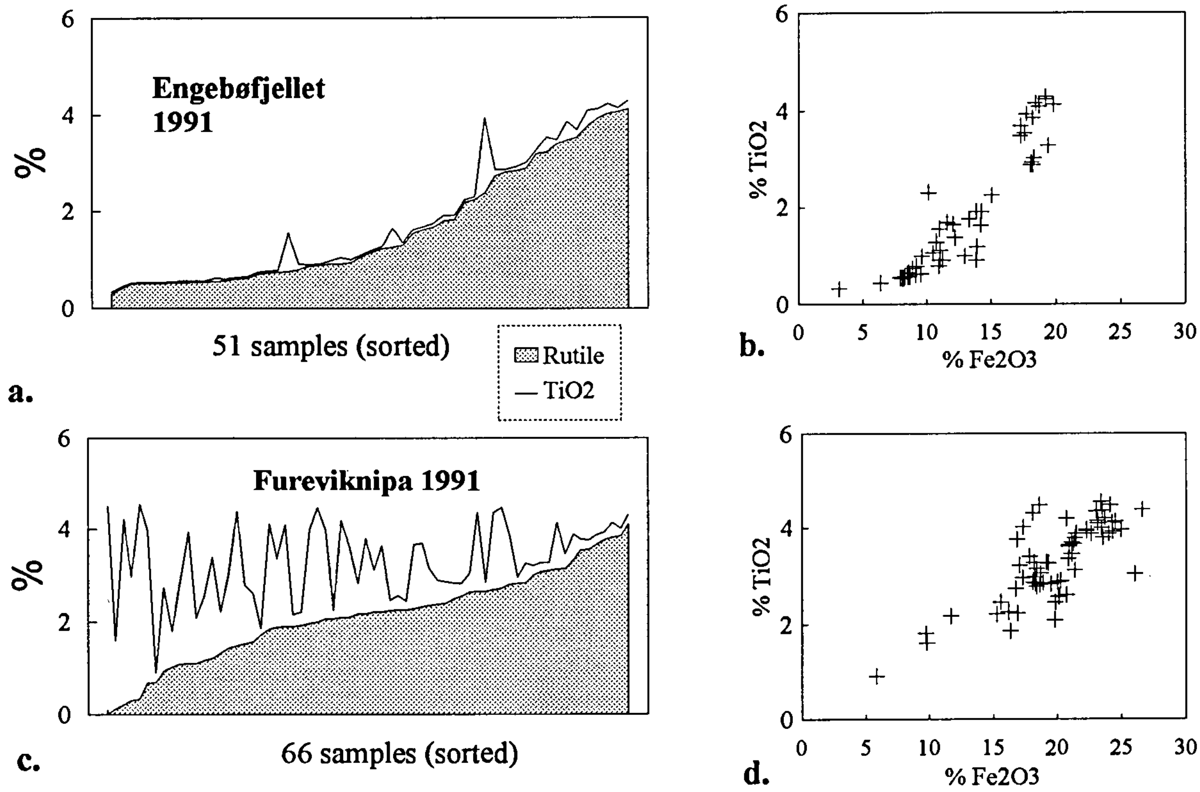


Fig. 29: Rutile vs. TiO_2 and the Fe_2O_3/TiO_2-relations for the Engebøfjellet and Fureviknipa eclogite bodies. Based on NGU-report no. 91.171 (Korneliussen and Furuhaug 1991).

5. Rutile-bearing rocks in the Bamble region, S.Norway

The Bamble-sector (the Bamble-Arendal region) of the Baltic Shield is a geologic province that is anomalously rich in mineral deposits of various types, and one where mining has traditionally been an important industry. The region's anomalous character with respect to mineral deposits may reflect unique, but poorly understood, circumstances in its geologic evolution.

The oldest rocks known in the region are supracrustals which are invaded by several generations of basic and acidic intrusions. De Haas (1992) reports Sm-Nd ages of 1770 and 1640 Ma for two gabbroic intrusions in the Arendal area. These are the oldest age determinations, and the supracrustals that surround these intrusions must be at least as old. This early period, *The Gotian Orogen,* the region's geologic evolution lasted for approximately 250 m. y. (1500-1750 Ma; see references in de Haas, 1992 and Starmer, 1991). The maximum metamorphism in this period was 700-800°C and 6-8 kb (granulite facies; see Touret, 1971 and Lamb et al., 1986).

The region then experienced a fairly quiet geologic period until *The Sveconorwegian Orogen* (990-1250 Ma), which was characterized by significant basic magmatic activity followed by a period of granulite facies metamorphism. In certain parts of the region, for example at Ødegården, significant hydrothermal activity caused extensive metasomatic alteration of the basic rocks. This geologic period was terminated by the intrusion of large, post-tectonic granites (990 Ma; Kullerud and Machado, 1991). According to Starmer (1991) the basic magmatism was associated with an anorogenic early phase in the Sveconorwegian orogeny, and was associated with extensional tectonics followed by an orogenic phase with nappe tectonics. De Haas (1992) also supports an extensional model; according to de Haas the mantle from which the Sveconorwegian gabbros were derived, domed up under a relatively thin crust. This mantle doming led to high temperature/-pressure-gradients and granulite facies metamorphism in the overlying crust.

Smalley and Field (1991) have another opinion: based on trace element characteristics for the Sveconorwegian gabbros they claim that the gabbros formed at an active continental margin.

Regardless of which of these two models are preferred, the significant hydrothermal activity that was active in the region altered the basic intrusions that are believed to have formed during the first part of the orogen, and must, therefore, be younger than the intrusions. The hydrothermal activity is most likely related to the last part of the orogenic activity.

Post-Sveconorwegian magmatism in the form of scattered carbonatitic dykes and alkaline basic dykes is associated with the Fen carbonatite complex (600 Ma.) and the Permian magmatism in the Oslo Graben (270 Ma).

The rutile and TiO_2 contents in miscellaneous rock-types are shown in Figs. 29-34, and the complete analyses in Appendix 6. Of the rutile-bearing rock-types, coordierite-bearing metasediments and scapolitized gabbros occur in large volumes and may have an economic potential with respect to rutile. No significant investigation has been done on the rutile-bearing metasediments, while the scapolitized gabbos at Ødegård have recently been investigated by NGU for rutile, including two drill-holes. The Ødegården deposit covers an area of more than 100,000 m^2 with the rutile contents varying between 1% and 4%. The deposit is heavily covered by vegetation. See Korneliussen and Furuhaug (1993) for additional information.

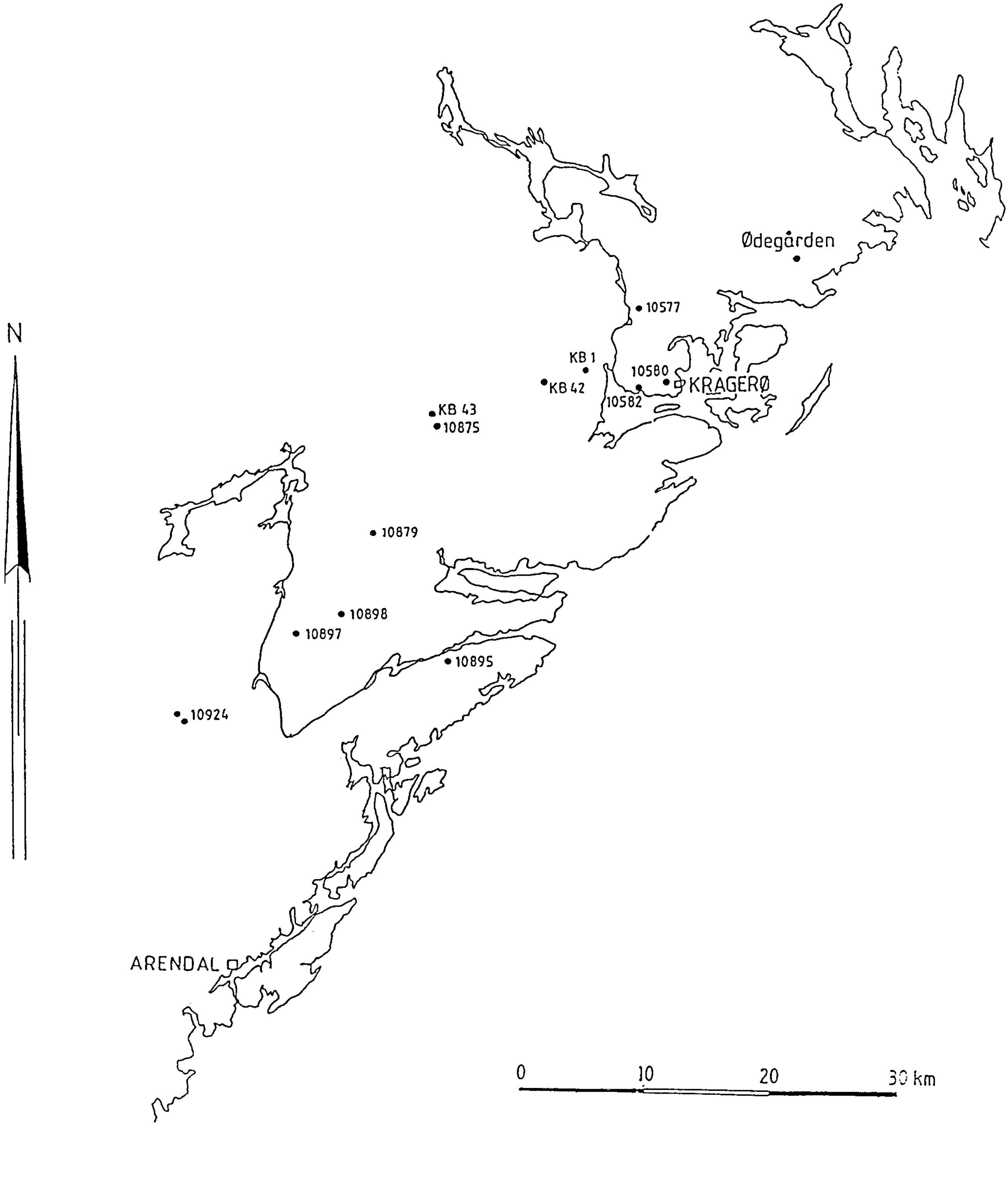


Fig.30: Rutile localities in the Bamble region, S.Norway. See NGU-reports no 92.234 (Korneliussen et al., 1992) and 93.078 (Korneliussen and Furuhaug, 1993) for additional information on the Bamble region.

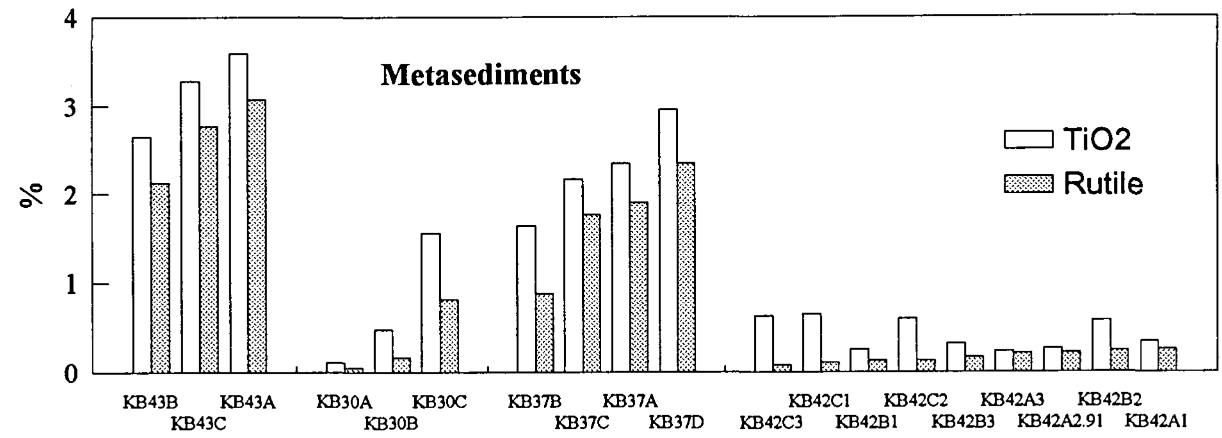


Fig.31: Rutile vs. TiO_2 for metasediments, Bamble region in S.Norway. The complete analyses are given in Appendix 6.

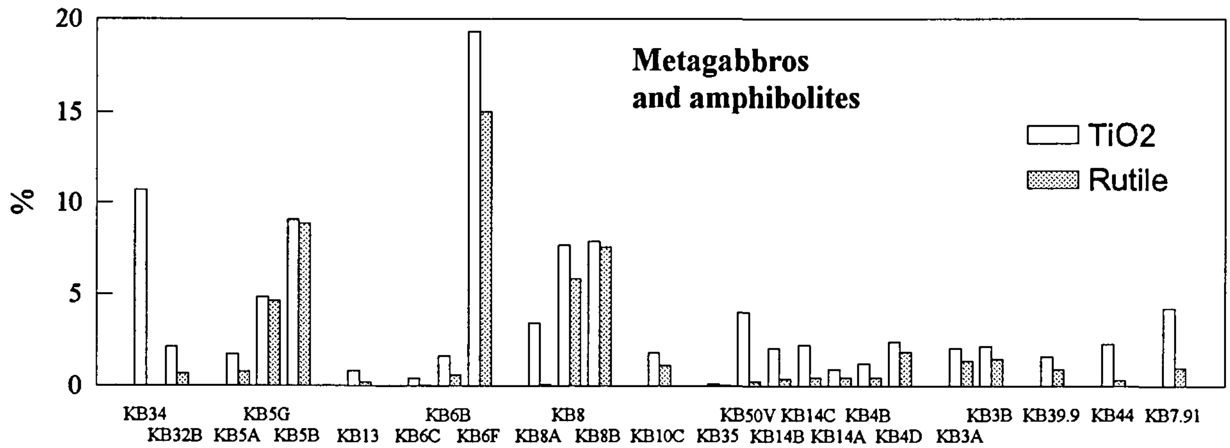


Fig.32: Rutile vs. TiO_2 for metagabbros and amphibolites, Bamble region in S.Norway. The complete analyses are given in Appendix 6.

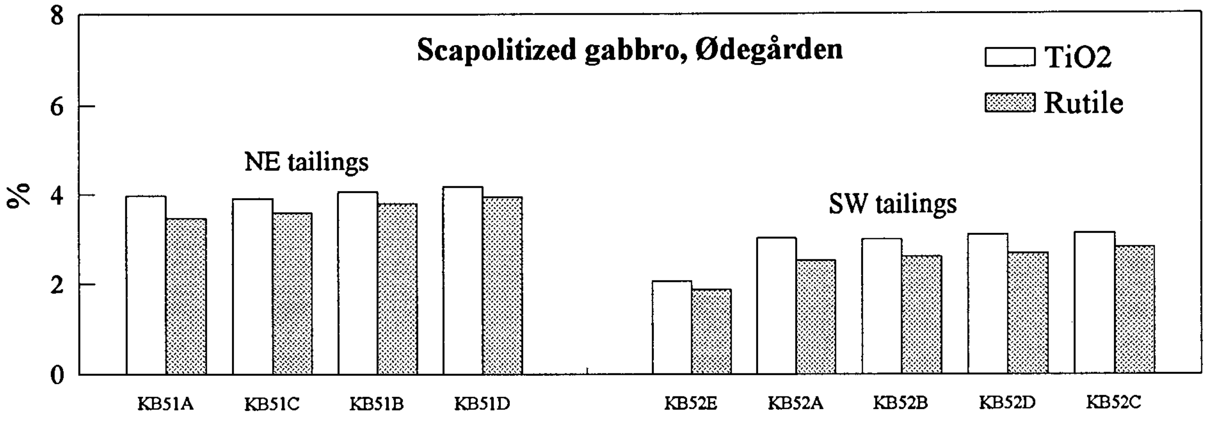


Fig.33: Rutile vs. TiO_2 for scapolitized gabbro at Ødegården, the Bamble region in S.Norway. The complete analyses are given in Appendix 6. See NGU-report no. 93.078 (Korneliussen and Furuhaug 1993) for additional information on the Ødegården deposit.

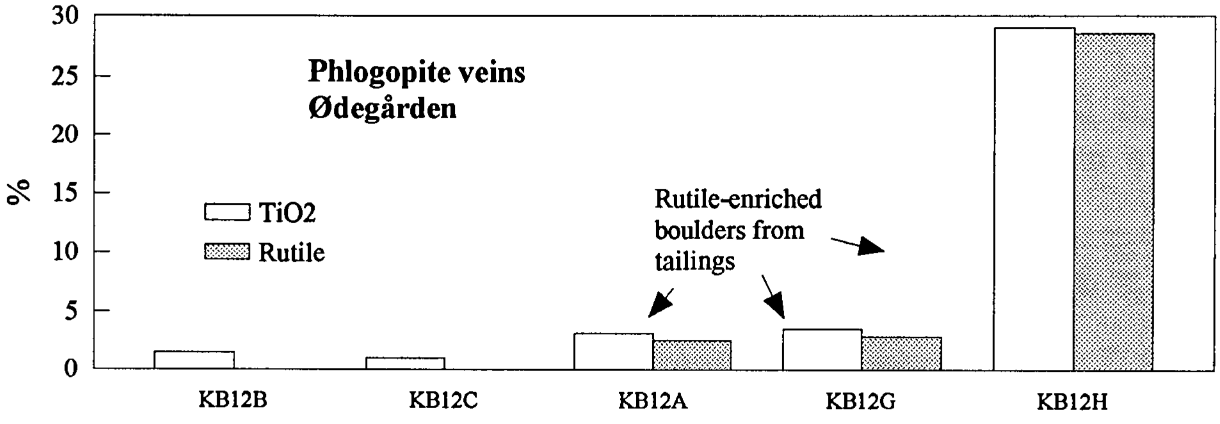


Fig. 34: Rutile vs. TiO_2 for phlogopite veins at Ødegården in the, Bamble region in S.Norway. The complete analyses are given in Appendix 6. See NGU-report no. 93.078 (Korneliussen and Furuhaug 1993) for additional information on the Ødegården deposit.

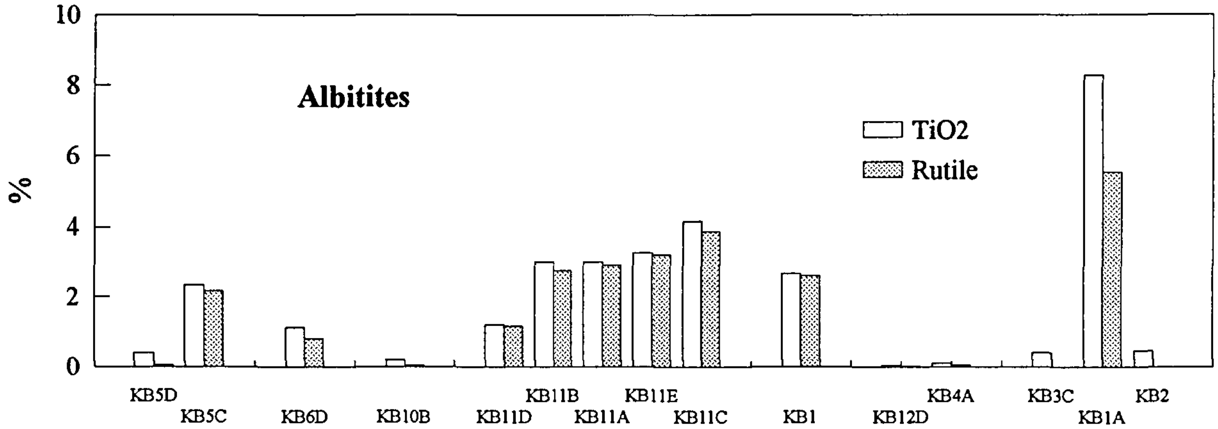


Fig.35: Rutile vs.TiO_2 for albitites, Bamble region in S.Norway. The complete analyses are given in Appendix 6.

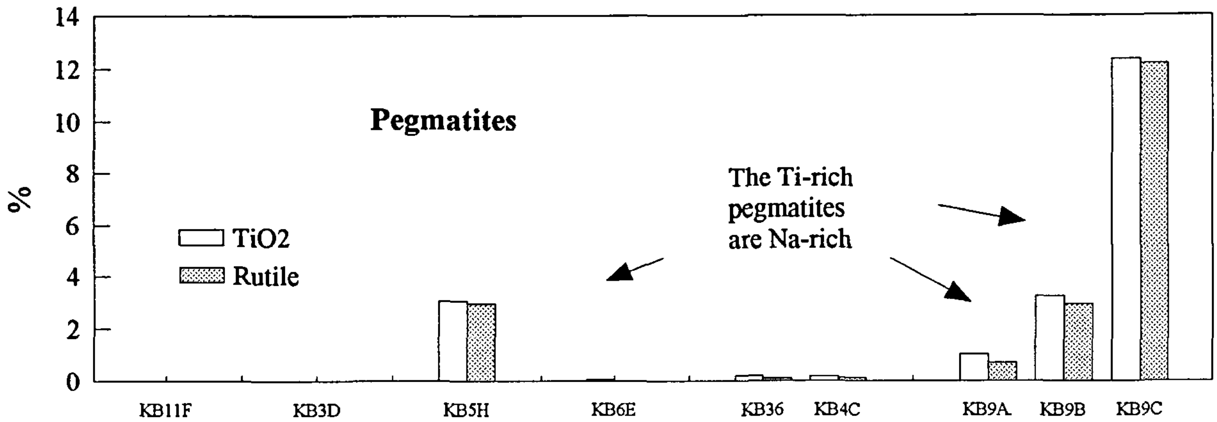


Fig.36: Rutile vs. TiO_2 for pegmatites, Bamble region in S.Norway. The complete analyses are given in Appendix 6.

6. Conclusions

The eclogite province of W. Norway is subdivided into 8 geographic regions. The three southernmost of these regions, Holsnøy, Dalsfjord and Førdefjord, are surrounded by large areas without known eclogites, while the regions from Nordfjord and northwards form parts of a large eclogite terrain.

In general, eclogites in the northwestern parts of the gneiss region of W. Norway, i.e. the western parts of the Nordfjord, Ålesund and Molde regions, have been formed at the highest P,T-conditions, but significant variations occur due to major tectonic events after the eclogitization period at c. 400 Ma. The details of such inhomogenities in the regional P,T-pattern remain to be investigated.

Eclogite protoliths are Proterozoic and probably also Cambro-Silurian. Basaltic volcanic rocks and a variety of Proterozoic intrusions belonging to ultramafic-mafic, mafic and mafic-intermediate (gabbro-anorthositic) suites are the most important protoliths.

The rutile contents are generally 1-2%; 3-4% rutile and more occur within some eclogites in the Holsnøy, Dalsfjord and Førdefjord regions. Occurrences of high-Ti eclogites are less common, but not absent, in the northern regions. The northern regions are, however, much less investigated with respect to titanium in eclogites, and other Ti-rich occurrences are likely to exist.

The amount of titanium present as rutile is highly variable. Some eclogites in the Førdefjord, Dalsfjord and Nordfjord regions have 80-90% of the titanium in the rock as rutile; many eclogites in the Førdefjord and Dalsfjord regions are large bodies, while all the known eclogites in the Nordfjord region are relatively small. Most eclogites, at least in the northern regions, have a comparatively low rutile/TiO_2-ratio. The reason for this variation is unknown except in those cases where rutile has been altered to ilmenite ± sphene as a consequence of retrograde amphibolite or greenschist facies metamorphism.

Sphene occurs in very small amounts as rims surrounding rutile/ilmenite grains in major eclogite deposits such as Husebø, Saurdal, Engebøfjellet and Vassbotn. It is frequently found in thin-sections of the most retrograded eclogites, i.e. mainly in eclogites from the eastern parts of the Kristiansund, Romsdal and Nordfjord regions. It seems to be less frequent in the western and southern terrains.

Suggestions for continued work:

A. Regional investigations. First priority: Prospecting for new eclogites in those parts of the Førdefjord and Dalsfjord regions that have been poorly investigated so far, i.e. in the areas eastwards from Naustdal and Flekke, respectively.

Second priority: Continuation of the general investigation of rutile-bearing eclogites, with special attention to the Nordfjord region that contains eclogites with favorable mineralogical characteristics, though the rutile grades are fairly low (1-2% rutile). There are, however, good chances that continued, systematic investigations will lead to identification of larger and rutile-richer eclogites than those already known.

B. Detailed investigations in areas with known eclogites of economic interest:

(a) A helicopter aeromagnetic and radiometric (U-, Th- and K-channels) survey is suggested for (1) the central to western part of the Dalsfjord region. This region is characterized by deformed and variably eclogitized mafic intrusions with local enrichment of Fe-Ti oxides. Rutile-rich eclogites usually have lowmagnetic signatures, but are spacially associated with magnetite-ilmenite bearing rocks that are distinctly magnetic. Detailed knowledge of the magnetic pattern of these areas might be to great help in prospecting for new occurrences of rutile-rich eclogites. Variations in the radiometric pattern may also be helpful in identifying eclogites since eclogites contain low amounts of U, Th and K; in most cases the surrounding gneisses will have many times higher content of these elements. (2) The second area for a helicopter magnetic/radiometric survey is the northern side of Førdefjord westwards and eastwards from Naustdal in order to identify new eclogites similar to the Naustdal and Engebøfjellet eclogite bodies.

(b) Detailed investigations of individual rutile deposits in the central and western parts of the Dalsfjord region, primarily Drøsdal-Orkheia and Saurdal-West.

(c) Continued investigations of other deposits such as Engebøfjellet (First priority) and Fureviknipa in the Førdefjord region, Husebø at Holsnøy, and Vassbotn in the Ålesund region should be considered.

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Appendix 1: Eclogite localities 1993.

Miscellaneous information

Sample no.	Locality	Map sheet	UTM-coord.		X-MET anal. (%)			Comments
			X	Y	TiO_2	Fe_2O_3	CaO	
Dalsfjord region								
106	Hestegards-nova	1117,1	6799	67992				Chip-samples from a 2x2m medium grained, garnet- and rutile-rich eclogite boulder. The area eastwards towards loc. Hd344 is poorly exposed. Some gneiss exposures. Some eclogite and metabasite boulders.
107	Hd344	1117,1	2994	67998	0.4 0.6	11.7 12.9	3.1 1.8	E/W-trending, a few meter thick, practically vertical zone of a magnetite-rich, chlorite chist (presumably a heavily retrograded basic rock) Eastwards between Samlestølen and Breiheia: Metabasite, locally eclogitized (low-Ti), frequently intruded by a felsic rock (equivalent to Simon Cuthbert's low-K gneiss). At Vardeknolten: Extensive area of eclogitized, partly coronitic basic rocks (low-Ti). Some felsic intrusions in up to a few meter thick veins and dykes that are slightly deformed, giving a gneissic impression.

108	Varde-knolten	1117,1	3000	68008	4.2 13.5 0.2 2.4 1.2 5.2 0.9 23.4 10.9 1.5	26.7 17.5 13.4 24.5 18.5 26.3 18.2 14.0 9.8 26.8	4.9 6.9 7.0 4.7 6.2 2.6 6.6 16.8 17.8 5.6	Very good eclogite exposure under tilted pine root (Photograph no. 10). Ti-rich zones in eclogitized gabbro. Irregular layers of massive, garnet-rich eclogite (in the right part of the exposure) within a coronitic eclogite (to the left) The garnet-rich eclogite is distinctly rutile-rich (highest X-MET analysis is 23% TiO_2 in rutile-rich aggregates). Such rutile-rich eclogites are frequent in the area with thicknesses up to a few meters. They are believed to represent iron- (and titanium) rich layers in an original layered gabbroic intrusion. In some cases such Fe-Ti rich eclogites have cross-cutting relationships to the layering in the surrounding metagabbro/eclogite indicating an originally intrusive origin. West of Vardeknolten: Well-preserved relict after a coarse gabbroic rock that has experienced various stages of deformation and eclogitization. *General impression:* The area is dominated by a fine-grained, deformed basic rock (called metabasite by Simon Cuthberth, 1985) that variably show remnants of a coarser texture indicating gabbroic origin. These basic rocks are variably eclogitized. Up to a few meter thick bands and lenses that are enriched in Fe and Ti are fairly frequent. In the non-eclogitic variety of these rocks the Fe-Ti oxides are magnetite/ilmenite; in the eclogitized version magnetite is absent and ilmenite is partly or totally transformed into rutile.
109	Grønstadli-heia	1117,1	2976	68005	10.5 8.6	16.4 16.8	8.2 10.9	0.5m boulder of an eclogitized, coarse-grained metagabbro that is enriched in Fe-Ti oxides
110	Grønstadli-heia	1117,1	2976	68008	4.4 4.4 3.5 .9 .5 .5	18.8 15.4 24.8 21.4 13.9 23.9	11.9 10.4 8.8 9.4 7.3 4.9	Rusty finegrained basic rock, partly eclogitic, on a new tractor-road (250 m.a.s.l.).
111	Espedals-heia	1117,1	3024	67969	1.3 1.0	8.4 8.0	6.3 4.8	Several 4-5m thick, fine-grained eclogite zones and lenses in gneiss

112	Drivar-fjellet	1117,1	2997	67982	1.7 1.7 1.3 2.1 1.3 1.5	15.1 18.9 17.3 11.1 11.0 11.8	6.1 9.3 7.1 6.5 5.8 7.2	Several 4-5m thick, fine-grained eclogite zones and lenses in gneiss General impression for the Espedalen-Dyrefjell area: Scattered occurrences of fine-grained eclogites that resemble the low-Ti varieties of eclogites in the Førdefjord region. They occur as a few meter thick zones and lenses in gneisses. This mode of occurrence is different from eclogites in the Gjølanger-Flekke area that occur as different varieties of eclogitized basic rocks far away from acidic gneisses. On the other hand eclogites west of Gjølanger (Orkheia area) do occur in gneisses. The protoliths for the Espedalen eclogites might very well have been basic dykes that were eclogitized and deformed together with the surrounding gneisses, as is the case with for example eclgites in the Orkheia-Drøsdal area, but they are smaller.
113	Drivar-fjellet	1117,1	3007	67989	1.5 2.2	10.9 9.9	7.4 6.6	Small, fine-grained eclogite lenses in gneiss
114 A	Espedalen	1117,1	3028	67985	2.4 3.2	10.1 11.8	6.2 6.0	Well-rounded, fine-grained eclogite boulders.
114B	Espedalen	1117,1	3028	67985	2.3 3.1	14.6 13.7	7.8 8.0	Less-rounded, middle-grained eclogite boulders.
114C	Espedalen	1117,1	3028	67985	2.9 2.9	17.3 16.6	9.5 10.2	Less-rounded, middle-grained eclogite boulders.
115	Rakneberg-Storlifj.	1117,1	3070	68053	2.5 2.4 1.1 1.7 3.5 4.1 1.2 3.0	17.8 15.1 12.5 13.3 16.2 17.2 13.2 14.3	9.4 8.3 12.3 16.1 7.8 16.0 7.8 9.1	Boulders of fine-grained eclogite. Rutile is visible in some of the boulders. The part of the area that is below the tree-line is extensive covered by overburden, mainly till. Eclogite boulders are frequent in the till.

116	Rakneberg-Storlifj.	1117,1	3068	68050	4.4 3.5	16.4 20.5	6.6 9.3	1x1.5m eclogite boulder (in till) that is distinctly rutile-bearing.
117	Rakneberg	1117,1	3074	68049	5.5 5.9 6.6 5.4 2.3 2.2 10.6 3.0 4.4 2.9	24.2 20.3 18.0 23.0 20.1 15.0 20.5 22.4 18.7 17.9	8.3 6.1 6.5 6.7 7.8 5.8 6.2 8.1 8.7 7.8	Up to 0.5m thick zones or lenses (boudinaged zones) of a fairly fine-grained, massive, garnet- and rutile-rich eclogite in road-cuts along a new tractor-road (not indicated on the map). Surrounding is a sheared basic rock (Simon Cuthbert's metabasite) that is generally low in iron and titanium. See Photograph no. 11 (Appendix 7)
118	Vardeheia	1117,1	2990	68035	1.1 .7 1.0 1.8 1.4 1.1 0.9 0.8 1.0 0.9 1.2	6.4 5.2 6.5 9.2 8.0 8.4 6.7 8.0 7.7 5.9 8.0	4.6 4.7 5.1 5.8 6.0 5.8 4.7 6.3 6.3 4.2 5.7	Fine-grained metabasite in road-cuts.
119	Holtane	1117,1	3078	68035	1.0 .2	16.8 6.6	6.7 4.8	Intensively folded metabasite, partly eclogitized, with <1m thick layers and lenses of more mafic varieties of these rocks. These are usually eclogitic with some visible rutile
120	Høge-varden	1117,1	3079	68028	1.8 .6 .2 .3	6.0 5.7 6.9 7.9	6.7 6.3 5.4 4.8	Very good exposures of folded, partly eclogitized basic to intermediate rocks.
120A	Høge-varden	1117,1	3079	68028	1.8 .6	6.0 5.7	6.7 6.3	Fe-Ti rich layer (<0.5m thick) in metabasite with aggregates of Fe-Ti oxides (rutile + ilmenite).

120B	Høge- varden	1117,1	3079	68028	.2 .3	6.9 7.9	5.4 4.8	Sheared white-mica rich eclogite zone in the metabasite complex.
121	Lillekletten	1117,1	3087	68038	.6 .7 .4 2.6 4.4 1.6 1.5 .9 .7 .7 .3 .6	11.5 18.4 10.9 15.3 17.1 23.0 16.6 19.8 14.5 16.2 8.2 17.7	8.5 8.6 8.1 8.4 10.4 8.2 7.0 9.7 8.4 9.0 6.9 8.9	>3m thick zone of garnet- and rutile-rich eclogite exposed on a new tractor-road. Scattered rutile aggregates. This area, which is heavily covered by soil and vegatation, needs continued investigation.
122	Storurd- fjellet	1117,1	3088	68009	.9 1.0 .8 .8	12.1 10.9 10.2 10.6	10.1 7.2 8.4 9.5	10x50m eclogite zone (retrograded) in gneiss
123	Storurd- fjellet	1117,1	3086	68009	1.9 1.7 1.1 1.2 1.2 1.0	12.4 12.4 8.4 9.2 10.6 9.2	7.8 7.2 4.4 6.3 7.9 6.2	10x50m(+?) massive rutile-bearing eclogite
124	Storurd- fjellet	1117,1	3078	68007	1.9 1.8 2.1 2.1	9.6 10.9 11.6 10.0	5.1 4.9 6.2 4.9	Northeastern end of a 1km long zone of a fairly light Fe- and Ti-poor eclogite.

125	Storurd- fjellet	1117,1	3075	68009	.4 .9 .4 .7	7.4 9.7 8.9 6.9	6.6 8.8 6.9 7.2	Large area of a low-Ti, fairly light, banded eclogite (eclogitized anorthosite?).
126	Flekke- stølen	1117,1	3072	68016	.5 .4	4.8 7.4	5.0 8.7	Banded mafic/intermediate eclogite (eclogitized gabbro/anorthosite?) with rutile aggregates especially in bands and lenses (<1m thick) of dark, garnet-rich varieties of the rock. See photograph no. 12.
126A	Flekke- stølen	1117,1	3072	68016	.1 .2 1.0 8.5	2.9 5.5 12.3 11.3	8.6 7.5 7.0 5.9	Banded eclogite (eclogitized gabbro-anorthosite) with scattered rutile-enrichments.
127	Flekke- stølen	1117,1	3070	68019	.2 .2 .1 .1 .3 .2 .2 .1	14.1 9.1 14.0 11.5 14.2 16.9 11.9 10.6	1.0 1.2 1.1 .8 1.4 .1 .2 .4	5-8m thick zone, probably a W-E trending shear-zone) of extensive chloritization of eclogite. See photographs no. 21 and 22.
128	Flekke- stølen	1117,1	3068	68021	.2 .2 .3 .3 .3 .3	10.5 12.0 13.3 16.4 15.8 11.9	.8 .5 1.0 1.3 .5 .6	2m thick magnetite-rich chloritized zone in metabasite.

129	Flekke area	1117,1	3049	68990	1.5	14.1	9.6	70-80m thick sone of fine-grained, partly retrograded eclogite
					8.2	9.3	12.0	- Minor rutile enrichment
					1.4	10.2	6.0	
					1.2	9.8	3.7	
					2.0	15.9	8.1	
					2.5	16.8	11.1	
					2.5	19.1	10.4	
					2.7	20.8	11.0	
					2.2	15.6	7.2	
					2.5	16.4	9.6	
					2.8	16.8	7.6	
					1.8	14.3	8.8	
130	Flekke area	1117,1	3058	69009	1.7	10.6	7.1	5-10m road-cut with retrograded eclogite within granitic gneisses.
					1.3	11.5	7.8	
					.9	7.0	3.4	
					.9	6.4	6.3	
					2.0	13.6	7.1	
					1.5	11.5	4.6	
131	Flekke area	1117,1	3055	69014	.8	7.9	6.5	50m+ zone of eclogite (road-cut)
					.9	8.5	7.3	
					1.5	15.6	10.3	
					1.3	13.2	7.7	
					.8	8.8	8.0	
					.6	7.7	7.6	
					.7	6.6	3.8	
					1.0	8.9	5.1	
					1.0	5.6	5.0	
					1.0	10.7	6.2	

132	Stavs-kletten	1117,1	3071	68043	3.3 4.2 3.4 4.8 .3 .2 .7 .4 1.1 .5 4.3 4.0	18.3 18.0 15.0 17.1 7.2 9.5 12.7 10.3 8.6 7.8 22.7 19.5	9.3 7.6 5.9 9.1 5.7 13.3 7.7 7.2 11.0 9.1 12.6 14.6	Eclogite boulders at the south side of Stavskletten. Most boulders are of a low-Ti type; a few are garnet-rich with distinctly visible rutile. The garnet-rich eclogite variety have 3-4 % TiO_2 (predominantly as rutile) while the garnet-poor variety have approx. 1% TiO_2 or lower.
133	Stavs-kletten	1117,1	3066	68042	1.2 3.0 2.6 1.9 3.2 2.0	5.0 10.6 7.6 14.9 15.8 16.0	4.0 6.5 6.5 9.2 6.0 6.1	Eclogite boulders. Most boulders are of a low-Ti type; a few are garnet-rich with distinctly visible rutile. This indicate that eclogite containing 3-4% rutile occurs in the hills above.
134	Holten	1117,1	3034	68006	1.7 1.7	12.1 10.0	9.4 7.7	30m+ thick eclogite lens within granitic gneisses.
135	Botna-tjørna	1117,1	3038	68013	8.7 4.5 7.4 5.3 .8 1.0	19.1 19.7 24.6 22.5 9.1 8.0	9.9 8.5 10.2 6.7 6.3 7.9	Bolders in till of garnet- and rutile-rich eclogite. These fairly high Ti-values indicate that continued investigations should be done in this area to fine the sources fore these boulders.
136	Botna-tjørna	1117.1	3038	68013	1.1 .6	23.9 14.1	.3 .5	Boulders of a magnetite-rich chlorite schist within road-aggregates. The source of this road-aggragte is presumably near Flekke.

137	Sande area	1217,4	3260	68043	1.2 1.9 1.3 1.3 1.1 2.4 1.8 2.0	6.2 9.8 7.3 8.7 10.5 13.2 9.2 10.5	5.3 7.3 4.6 6.5 7.1 8.2 7.4 7.9	Retrograded eclogite (100m road-cut) in gneiss terrain.
138	Sande area	1217,4	3247	68061	4.6 2.1 2.5 4.4 2.3 2.2	13.6 12.2 11.0 12.4 9.9 10.3	6.4 5.5 4.7 5.7 5.3 5.0	Several 5-10m thick zones of retrograded eclogite in gneisses
139	Stranda- vatnet	1117,1	3094	68037	2.9 2.7 1.0 .8 2.0 2.6	16.2 17.3 16.5 10.4 13.3 15.9	6.2 7.2 6.3 7.5 8.3 9.5	5-10m thick eclogite zone in gneiss. Some rutile.
140	Stranda- vatnet	1117,1	3095	68035	4.0 4.2 6.6 11.6 4.5 8.8	13.2 13.9 15.1 21.4 13.4 17.5	8.8 8.9 11.5 15.2 8.1 8.2	10m thick zone of a garnet- and fairly rutile-rich eclogite in gneiss along a new tractor-road. These high Ti-values indicate that the area should be investigated in more detail.

141	Myklebu- stadvatnet	1117,1	3101	68032	3.2 2.8 4.7 8.6 2.1 1.5 3.2 3.2 1.4 1.7 2.3 3.0	15.1 14.5 18.2 20.8 15.7 13.1 19.4 17.5 13.4 15.5 18.4 18.3	8.7 8.5 7.0 7.3 7.7 6.3 12.5 8.8 8.3 9.4 9.0 8.3	Miscellaneous eclogite boulders in a river.
142	Steiestøl	1117,1	3160	68028	2.0 2.5 1.3 1.5 2.2 2.4	15.9 16.4 14.3 12.4 13.5 18.2	8.4 7.9 9.7 9.5 8.6 6.5	Miscellaneous eclogite boulders from till.
143	Steiestøl	1117,1	3128	68033	1.1 .8 1.1 1.0	6.4 7.7 6.2 8.2	4.7 7.1 6.1 6.3	Approx. 10m thick eclogite zone in a tonalitic gneiss.
144	Steiestøl	1117,1	3120	68046	2.2 2.1 1.3 1.1	14.7 13.6 10.1 10.8	9.3 8.5 8.6 8.0	Small eclogite lens in tonalitic gneiss.
145	Steiestøl	1117,1	3152	68015	1.8 .9 2.0 1.7	19.4 14.1 17.8 18.3	5.5 6.0 6.7 5.9	Gnt-rich bands (Ti-enriched) in low-Ti ecl.

146	Orkheia	1117,1	2930	67983	1.0	11.8	6.8	Miscellaneous samples from the western and central parts of the Orkheia eclogite. Garnet-rich varieties of this eclogite have significantly rutile.
					1.1	13.5	8.1	
					.4	9.2	5.0	
					1.3	8.0	3.4	
					.6	9.8	4.4	
					.8	13.6	5.6	
					7.0	17.1	6.2	
					.5	15.0	7.3	
					.3	7.7	6.2	
					.4	8.7	6.1	
					.4	10.3	5.6	
					.8	9.2	3.9	
					.1	10.5	2.9	
					.2	7.4	5.6	
					.5	8.9	8.1	
					.7	8.1	7.3	
146	Orkheia	1117,1	2930	67983	2.2	17.7	8.1	Miscellaneous samples from the western and central parts of the Orkheia eclogite. Garnet-rich varieties of this eclogite have significantly rutile.
					2.1	13.9	3.7	
					.9	12.3	6.5	
					2.7	11.2	7.0	
					3.7	19.3	6.6	
					2.0	16.0	6.6	
					3.7	15.5	6.4	
					3.8	16.7	6.0	
					2.3	17.1	7.4	
					2.6	18.7	7.2	
					1.5	13.2	4.8	
					.7	7.0	5.5	

146	Orkheia	1117,1	2930	67983	1.9 .2 .6 1.1 1.0 .7 1.0 1.6 3.4 2.1	13.7 7.4 8.1 11.3 8.8 9.6 8.8 11.4 17.7 20.7	7.2 4.1 10.0 9.9 6.3 7.1 8.7 7.3 6.6 8.3	Miscellaneous samples from the western and central parts of the Orkheia eclogite. Garnet-rich varieties of this eclogite have significant rutile.
147	Saurdal	1117,1	2972	68018				Eclogite samples from the block-stone quarry. See Photograps no. 2 and 3 (Appendix 7).
147A	Saurdal	1117,1	2972	68018	.1 .6	8.0 9.8	6.1 6.4	White-mica rich eclogite
147B	Saurdal	1117,1	2972	68018	5.1 2.1	9.6 10.2	8.8 18.6	White-mica rich eclogite
147C	Saurdal	1117,1	2972	68018	3.7 1.6	21.7 37.6	5.4 1.6	Garnet- and amphibole-rich, dark eclogite
147D	Saurdal	1117,1	2972	68018	8.2 3.1	22.5 15.6	7.8 7.2	Garnet- and amphibole-rich, dark eclogite
147E	Saurdal	1117,1	2972	68018	4.3 5.3	25.3 30.2	2.2 .8	Chloritized eclogite with secondary magnetite (100m E of the quarry). Such chloritization is associated with CaO-depletion and Fe_2O_3-enrichment.
147F	Saurdal	1117,1	2972	68018	14.2 27.4	53.3 57.5	.0 .0	Ilmenite + magnetite ore.

148.93	Gjølanger	1117,1	2981	68025	.2 .1 .1 .2 .1 .3	.0 .0 .0 .0 .0 .0	1.5 1.6 1.6 1.6 1.5 1.8	Tonalitic rock (identical to Cuthbert's low-K gneiss). The central part of the Gjølanger area with the Gjølangen bay and Dalsfjord in the background is shown in Photograph no. 1.
149.93	Gjølanger	1117,1	2975	68026	.5 .9	5.9 7.6	5.8 6.3	Metabasite.
152	Orkheia	1117,1	2934	67985				The Orkheia eclogite is described in more detail elsewhere. See Photographs no 23 to 39.
153	Orkheia	1117,1	2934	67985				153A - 153E: Varieties of the Orkheia eclogite
153A	Orkheia	1117,1	2934	67985				
153B	Orkheia	1117,1	2934	67985				
153C	Orkheia	1117,1	2934	67985				
153D	Orkheia	1117,1	2934	67985				
153F	Orkheia	1117,1	2934	67985				
153E	Orkheia	1117,1	2934	67985				
153G	Orkheia	1117,1	2934	67985				

153H	Orkheia	1117,1	2934	67985				Coronitic eclogite variety from the western part of the Orkheia eclogite
153I	Orkheia	1117,1	2934	67985				Sheared, fairly light eclogite from the central part of the Orkheia eclogite
169	Botnatjørna	1117,1	3042	68015	2.40 2.13 2.62 1.77 2.47 2.67 1.89 2.05	13.85 14.46 15.31 13.07 13.26 16.00 14.85 15.21	9.29 9.88 9.05 7.83 8.91 7.52 10.40 5.72	Garnet-rich eclogite in a road-cut along the new road to Botnatjørna. Eclogites northwards from this exposure are investigated in more detail by Garson/Parr.
170	Håheia	1117,1	3040	68032	.65 .40 .59	3.90 2.94 4.41	5.04 5.64 5.78	Sheared metagabbro well exposed along a new road. See photograph no. 13.
171	Håheia	1117,1	3042	68037				Sheared metagabbro with cm-dm thick bands that may be primary magmatic layers in the originally layered mafic/intermediate intrusion.
172	Håheia	1117,1	3042	68037	.79 .44 .49 1.02 1.23	3.25 2.44 10.17 8.55 8.61	4.77 4.50 8.12 8.42 7.21	Eclogitized sheared metagabbro
173	Håheia	1117,1	3042	68037	3.92 2.22 3.48 2.06 2.96 2.53	19.54 19.36 18.82 18.13 17.67 17.41	9.28 6.34 8.50 18.91 2.26 11.98	Several 1-2dm to 3-4m thick bands of garnet- and rutile-rich eclogite in sheared, partly eclogitized metagabbro. Occasionally such eclogites show intrusive relations to the surrounding metabasite or less garnet-rich eclogite.

174	Håheia	1117,1	3042	68038	3.61 3.74 7.16 4.74 3.73 4.53 5.17 1.95 2.75 4.45 1.91 1.07	24.94 17.12 19.34 14.66 19.45 21.60 15.51 16.52 20.13 19.40 19.35 11.72	7.94 8.83 8.40 7.19 9.67 14.39 11.42 7.77 10.18 9.32 11.49 9.25	More than 10m thick garnet- and rutile-rich eclogite (road-cut) in partly eclogitized metagabbro.
175	Hålands- nipa	1117,1	3086	68055	3.21 2.86 3.11 2.33 3.47 2.94 6.16 2.74 1.61 1.62	22.67 24.72 20.42 19.39 20.39 20.22 21.28 24.71 21.10 25.90	9.83 8.29 8.37 12.89 7.75 11.60 15.11 13.60 8.82 6.89	Chip-samples of fairly garnet-rich eclogite from boulders at the base of the outcropping eclogite. See photograps no. 6 and 7.
176	Orkheia	1117,1	2934	67985	2.06 1.94 3.16 1.22 1.32 4.36	18.08 24.22 18.68 16.06 17.91 15.58	8.76 11.07 10.09 8.17 7.53 8.19	Chip-samples from 150kg sample taken for beneficiation tests

MG-C	Holtenova	1117,1	2948	67999				Samples MG-C and MG-D is taken by M.Garson. Two thin-sections made from these samples show that the titanium oxide is mainly ilmenite. Rutile is only observed in sample MG-D where it is rimmed by ilmenite. The Holtanova area is shown in Photographs no. 4 and 5. *General impression from the Holtanova area:* Much of the topographic lower parts of this area consists of a coarse gabbroic rock that shows gradual transitions into eclogite, espesially along shear-zones. Fe-Ti aggregates in the form of magnetite/ilmenite are frequent in the gabbro; in the eclogitized versions of the rock the Fe-Ti aggregates occur as ilmenite/rutile. Altogether the mineralization is extremely inhomogeneous and no good estimate can be made about rutile grades. More information is available from Garson/Parr (XMET field-measurements). The top of Holtanova is gneiss.
MG-D	Holtenova	1117,1	2946	67997				Magnus's samples

F1	Storurd-fjellet	1117.1	3075	68003	1.3	11.2	6.8	Localities F1 to F29: Miscellaneous eclogite localities sampled by Leif Furuhaug
F2	Storurd-fjellet	1117.1	3075	68006	8.3	10.1	7.5	
F3	Storurd-fjellet	1117.1	3076	68011	.7	11.9	7.6	
F4	Storurd-fjellet	1117.1	3076	68013	1.3	11.3	8.2	
F5	Storurd-fjellet	1117.1	3073	68005	.7	8.1	5.0	
F6	Storurd-fjellet	1117.1	3073	68008	.5	9.9	10.6	
F7	Storurd-fjellet	1117.1	3073	68014	1.1	7.7	5.8	
F8	Botnatjørna	1117.1	3035	68019	1.1 1.7	11.1 11.6	6.1 6.7	
F9	Botnatjørna	1117.1	3036	68018	2.3 2.6	12.8 12.3	4.4 3.9	
F10	Botnatjørna	1117.1	3038	68019	1.5 1.2	9.4 13.8	4.6 7.6	
F11	Botnatjørna	1117.1	3041	68018	1.5 .7	12.6 10.3	8.0 5.2	
F12	Botnatjørna	1117.1	3044	68015	1.7 1.5	15.2 10.3	8.2 5.8	

F13	Skadalen	1117.1	3106	68062	.9 1.0	7.6 8.5	9.6 11.0	
F14	Skadalen	1117.1	3106	68061	1.4 1.5	10.5 8.8	12.3 8.1	
F15	Skadalen	1117.1	3095	68067	1.0 2.9	11.4 13.7	7.5 7.0	
F16	Skadalen	1117.1	3110	68071	3.2 4.9	18.3 16.7	7.3 6.0	
F17	Norddalen	1217.4	3130	68060	1.2 1.0	9.3 8.2	3.9 11.7	
F18	Norddalen	1217.4	3121	68062	.7 .6	6.5 7.8	4.4 5.3	
F19	Norddalen	1217.4	3124	68050	8.4 5.6	22.5 21.3	3.8 5.1	
F20	Vassdalen	1217.4	3120	68040	2.8 2.3	12.1 13.1	7.3 6.6	
F21	Steiestølen	1217.4	3150	68043	1.7 1.3	10.3 14.5	5.1 3.1	
F22	Steiestølen	1217.4	3157	68035	1.5 2.1	16.5 13.9	6.5 5.6	
F23	Steiestølen	1217.4	3176	68021	2.9 2.7	10.2 9.2	3.7 4.4	
F24	Norddalen	1117.1	3113	68056	1.1 1.7	14.2 15.4	7.3 5.0	
F25	Hålands- heia	1117.1	3109	68052	1.1 1.0	13.5 11.8	8.1 6.8	

F26	Hålands- heia	1117.1	3108	68048	.0 .6	13.2 15.5	11.3 7.8	
F27	Stranda- vatnet	1117.1	3087	68048	19.3 33.4	14.3 20.1	9.0 12.6	Minor rutile enrichments in eclogite.
F28	Goddals- heia	1117.1	2929	68002	.7 .4	5.4 4.3	1.5 3.4	
F29	Goddals- heia	1117.1	2925	68998	.4 .5	.0 3.8	1.1 2.0	

Førdefjord region (eastern part)								All samples by A.Korneliussen
161	Fimlands-grend	1218,2	3400	68329	3.4 2.4	15.0 13.1	7.3 6.8	Eclogite boulders in till
162	Svorstølen	1218,2	3408	68322	2.8 4.1 2.2 3.1 3.0 4.8 5.9 5.3 6.4 5.6 4.2 4.9 4.5 4.3 4.6 2.8 3.5 3.9 4.3	15.3 13.9 13.1 16.3 15.2 17.0 20.9 19.8 18.7 20.3 16.8 17.1 19.5 13.4 13.9 12.4 16.0 11.0 12.9	8.5 8.1 6.7 6.5 6.6 6.3 7.6 7.6 7.5 6.9 6.0 8.4 9.3 5.4 5.9 4.6 7.3 4.5 5.4	Ti-rich 0.5-1m eclogite boulders in river. *General impression:* The eclogite boulders in this area are of a finer-grained, garnet-. and rutile-rich type that resembles eclogites at Førdefjord such as Naustdal. A short field reconnaissance in the mountains 2-3 km vestwards (towards the ice-glacier direction) did not lead to discovery of bedrock eclogites.
K162B	Svorstølen	1218,2	3408	68322	4.38 3.92 4.70 3.94 4.64	15.12 22.73 17.35 15.99 16.89	6.29 6.80 8.35 8.10 8.05	

163	Svorstølen	1218,2	3406	68321	3.1	17.4	7.0	1 to 5 m boulders
					2.8	13.9	5.4	
					3.1	14.4	5.9	
					2.0	16.0	11.7	
					3.0	16.3	7.1	
					2.6	13.1	5.7	
					1.8	9.7	4.7	
					2.4	11.8	5.2	
164	Svorstølen	1218,2	3401	68319	2.1	13.8	7.3	1m boulder
165	?	1218,2	3342	68314	2.7	11.6	5.3	10m thick eclogite zone in gneiss
					1.5	10.2	5.5	
					2.7	13.6	7.8	
					3.3	16.8	7.1	
					2.2	10.9	4.8	
					1.6	10.6	4.2	
166	Hukset	1218,3	3277	68265	1.0	8.4	6.2	10m (+?) thick eclogite zone in gneiss
					1.1	8.3	6.0	
					1.1	9.7	8.5	
167	Kleppe-stølen	1218,2	3331	68263	1.8	13.4	5.8	50m (+?) thick eclogite zone with scattered garnet- rich bands
					1.6	13.8	7.7	
					1.0	12.9	5.8	This eclogite layer resembles eclogites of the so-called volcanic type on both sides of Førdefjord, and is presumably an eastern continuation of these units. The Ti-richer samples (4-5 % TiO_2) is from dm-thick, garnet-rich bands in this unit.
					.8	9.4	5.5	
					2.3	16.7	7.2	
					2.2	15.1	7.9	
					4.0	20.6	5.7	
					1.9	9.7	7.9	
					4.9	17.3	6.4	
					5.4	16.5	6.1	
					5.0	18.7	7.4	
					2.0	13.4	8.5	

168	Byrkjelia	1218,3	3305	68252	1.9 1.4 1.6	12.7 10.5 14.4	7.1 5.7 7.2	10m (+?) eclogite zone in gneiss

Some localities from the Ålesund region								All samples by A.Korneliussen
102	Fosnavåg	1119,4	3270	69160	2.5 1.2 1.2 1.2 .9 .7 .8 .4	9.3 12.4 7.2 4.8 13.1 11.3 9.7 7.6	7.4 9.2 6.6 5.0 9.8 10.4 9.8 8.1	Retrograded coarse eclogite
103	Fosnavåg	1119.4	3254	69154	.7 .7 1.6 2.0 2.6 1.1 1.7 2.7 1.3 .9	10.4 8.4 9.3 9.2 12.6 5.6 8.1 10.9 10.7 7.8	12.6 10.6 7.5 7.6 9.6 5.0 7.9 9.2 7.8 8.1	Retrograded coarse eclogite
104	Aurvåg	1119,4	3321	69098				Retrograded eclogite
104A	Aurvåg	1119,4	3321	69098	1.8 1.1 1.4 2.3 1.0 .8	16.5 18.3 10.2 11.2 10.1 9.7	5.3 6.0 4.7 6.0 6.6 7.3	Representative sample

104B	Aurvåg	1119,4	3321	69098	5.6 6.2 11.9 1.5 3.1 7.4 5.9 1.4 9.5 2.9 8.2 5.6 8.5 .8 15.2 1.6	14.1 16.9 12.9 16.2 18.1 18.3 13.7 6.2 13.6 11.6 15.1 12.4 12.5 11.5 14.6 13.9	6.3 2.5 6.2 11.2 9.3 10.5 6.5 7.1 8.6 7.0 6.4 6.2 6.7 6.0 5.2 14.9	Sample enriched in Ti-oxides
104C	Aurvåg	1119,4	3321	69098	11.0 3.5 6.0 2.0	8.5 12.3 6.6 14.1	7.8 6.9 6.4 7.0	Sample enriched in Ti-oxides
105	Seljeset	1119,3	3289	69035				Magnetite + ilmenite bearing, approximately 50m thick amphibolite zone in gneiss. No known eclogite in the surroundings.

Appendix 2a: Analyses of eclogites sampled in 1992.

Analyses by XRF and ICP (rutile analytical procedure)
Trace element data are available (XRF- and INA-analyses).

An. no.	Sample	Locality	Kommune	Region	Map. 1:50000	X-coord. (UTM)	Y-coord. (UTM)	% TiO2 icp	% Rutile	Rel.% rutile	% SiO2 xrf	% Al2O3 xrf	% Fe2O3 xrf	% TiO2 xrf	% MgO xrf	% CaO xrf	% Na2O xrf	% K2O xrf	% MnO xrf	% P2O5 xrf	% LOI xrf	% Sum xrf
18	KF15A.92	Fuglvåg	Aure	Kristiansund	1421.3	4664	70070	1.44	0.12	8%	47.05	16.45	13.90	1.56	7.37	10.02	2.45	0.54	0.19	0.21	0.46	100.21
19	KF15B.92	Fuglvåg	Aure	Kristiansund	1421.3	4664	70070	0.73	0.77	51%	47.17	16.06	13.14	1.50	7.85	9.30	2.42	0.87	0.20	0.20	0.88	99.60
17	KM14.92	Mjosund	Aure	Kristiansund	1421.3	4751	70113	1.91	0.59	24%	46.05	15.19	16.71	2.50	6.29	8.61	2.55	0.98	0.24	0.50	0.22	99.84
10	KE8.92	Tevikåsen	Aver¢y	Kristiansund	1320.4	4173	69844	0.70	0.91	57%	47.37	14.87	11.50	1.61	7.82	12.35	2.29	0.33	0.18	0.21	1.39	99.91
29	KE30A-C.92	Helset	Aver¢y	Kristiansund	1320.4	4260	69815	0.06	0.79	93%	46.16	16.31	12.59	0.85	12.32	9.62	2.08	0.03	0.17	0.16	0.04	100.33
30	KE30D-F.92	Helset	Aver¢y	Kristiansund	1320.4	4260	69815	0.42	0.69	62%	45.66	14.04	14.02	1.11	13.85	9.02	1.49	0.46	0.18	0.17	0.04	100.03
32	KE30K.92	Helset	Aver¢y	Kristiansund	1320.4	4260	69815	3.58	0.71	17%	43.17	13.93	17.83	4.29	7.58	8.91	2.55	0.07	0.26	0.86	-0.34	99.12
31	KE30G-I.92	Helset	Aver¢y	Kristiansund	1320.4	4260	69815	2.57	1.51	37%	43.25	14.32	16.86	4.08	9.48	8.95	2.11	0.03	0.23	0.55	-0.32	99.54
34	KE32.92	Reinsfjellet	Gjemnes	Kristiansund	1320.1	4474	69772	0.58	0.58	50%	40.55	15.38	17.21	1.16	11.08	12.16	0.57	0.18	0.21	0.08	0.61	99.20
35	KE33.92	Reinsfjellet	Gjemnes	Kristiansund	1320.1	4474	69772	0.82	0.87	51%	41.44	17.98	16.69	1.69	7.38	12.17	1.32	0.46	0.15	0.12	0.39	99.79
45	KE43.92	Flemma	Gjemnes	Kristiansund	1320.1	4536	69784	0.77	0.16	17%	44.40	14.68	14.69	0.93	15.83	7.83	1.86	0.31	0.17	0.14	-0.60	100.26
39	KE37.92	Torvik	Gjemnes	Kristiansund	1320.1	4425	69804	0.77	0.69	47%	47.90	14.68	12.08	1.46	7.15	11.43	2.58	0.45	0.18	0.21	1.65	99.79
40	KE38.92	Torvik	Gjemnes	Kristiansund	1320.1	4430	69813	0.65	0.97	60%	47.67	14.53	12.88	1.62	8.40	10.75	2.54	0.23	0.21	0.18	0.44	99.46
41	KE39.92	Ranem	Gjemnes	Kristiansund	1320.1	4451	69820	0.77	0.83	52%	46.57	15.97	14.46	1.60	8.49	9.58	2.89	0.29	0.19	0.18	0.11	100.33
42	KE40.92	Skardet	Gjemnes	Kristiansund	1320.1	4481	69824	2.51	0.22	8%	44.46	13.96	19.26	2.73	6.84	7.66	2.55	1.24	0.23	0.34	0.34	99.61
43	KE41.92	H¢glinebba	Gjemnes	Kristiansund	1320.1	4500	69814	2.61	0.43	14%	46.21	14.25	18.35	3.04	5.46	8.58	2.43	0.67	0.21	0.35	0.43	99.98
44	KE42.92	Hoem	Gjemnes	Kristiansund	1320.1	4512	69818	1.33	0.31	19%	48.04	16.70	13.22	1.64	6.32	8.46	3.01	1.05	0.17	0.40	-0.02	99.00
54	KH54.92	Kj¢l¢y	Halsa	Kristiansund	1421.3	4762	70012	1.90	0.41	18%	45.15	16.06	16.71	2.31	6.49	8.72	2.46	0.57	0.24	0.31	0.87	99.88
55	KH55.92	Rennh¢gda	Halsa	Kristiansund	1421.3	4795	70038	0.86	0.44	34%	48.19	14.36	11.44	1.30	7.96	12.17	2.25	0.11	0.18	0.15	1.36	99.47
14	KV12.92	H¢gset	Halsa	Kristiansund	1421.3	4781	70008	0.72	0.11	13%	53.87	16.91	8.96	0.83	4.88	7.87	3.43	1.78	0.18	0.36	0.21	99.27
15	KV13A.92	Hesjingfjellet	Halsa	Kristiansund	1421.3	4756	69982	2.80	0.17	6%	46.59	13.07	18.63	2.97	6.54	7.82	2.47	0.99	0.22	0.32	0.23	99.86
16	KV13B.92	Hesjingfjellet	Halsa	Kristiansund	1421.3	4756	69982	1.46	0.50	26%	47.73	15.83	14.47	1.96	6.91	8.03	2.82	1.10	0.18	0.40	0.14	99.56
53	KH53.92	Indre Våglan(	Halsa	Kristiansund	1421.3	4729	70007	1.14	0.69	38%	46.97	17.75	13.46	1.83	6.07	9.65	2.71	0.80	0.17	0.27	0.10	99.78
52	KH52.92	Solli	Halsa	Kristiansund	1421.3	4661	69985	2.25	0.21	9%	46.51	14.64	16.51	2.46	6.20	8.51	2.88	1.17	0.22	0.47	0.07	99.62
51	KH51.92	Solli	Halsa	Kristiansund	1421.3	4715	69915	1.26	0.38	23%	47.37	16.94	13.47	1.64	7.05	8.14	3.09	1.18	0.18	0.33	0.48	99.88
12	KK10.92	Prestmyra	Kristiansund	Kristiansund	1321.2	4386	69922	0.82	1.14	58%	46.60	13.37	14.26	1.96	7.89	12.61	2.03	0.06	0.21	0.17	0.23	99.40
13	KK11.92	Flatset	Kristiansund	Kristiansund	1321.2	4378	69896	0.85	0.76	47%	46.80	16.62	13.50	1.61	7.69	9.44	2.83	0.68	0.19	0.25	0.27	99.88
20	KF16.92	Ramsvikbukt:	Tustna	Kristiansund	1321.2	4564	70034	1.11	0.69	38%	47.26	15.56	14.48	1.80	7.31	9.15	2.47	0.76	0.20	0.23	0.41	99.63
36	KE34.92	Hollingen	Aukra	Molde	1220.1	3975	69619	1.19	0.42	26%	46.06	16.46	15.38	1.61	8.79	7.94	2.62	0.87	0.18	0.29	-0.14	100.11
38	KE36.92	Storvasshaug(	Eide	Molde	1220.1	4132	69817	1.36	0.51	27%	48.89	14.54	13.44	1.87	7.05	9.88	2.60	0.27	0.19	0.19	1.19	100.11
9	KE7.92	Lyngstad	Eide	Molde	1320.4	4182	69819	0.60	0.80	57%	47.50	14.84	12.02	1.40	8.62	11.42	2.10	0.17	0.19	0.16	0.98	99.39
33	KE31.92	Straumsholm(	Eide	Molde	1321.3	4145	69881	0.72	0.88	55%	48.32	13.79	12.75	1.60	7.53	12.37	2.36	0.36	0.18	0.17	0.20	99.65
8	KE6.92	Nystad	Eide	Molde	1320.4	4174	69824	0.96	0.99	51%	48.30	13.77	15.23	1.95	7.00	11.17	1.97	0.25	0.24	0.23	0.15	100.26
26	KE27.92	Stavik	Fræna	Molde	1220.1	3974	69737	1.06	0.55	34%	47.75	16.87	13.52	1.61	8.27	7.88	2.72	0.89	0.17	0.26	0.57	100.52

37	KE35.92	Aureosen	Fræna	Molde	1220.1	4050	69666	1.53	0.55	26%	46.74	15.31	14.46	2.08	7.05	9.89	2.51	0.60	0.20	0.30	0.72	99.87
27	KE28.92	Stavik	Fræna	Molde	1220.1	3971	69746	0.13	0.64	83%	47.18	8.67	16.80	0.77	15.19	10.54	0.48	0.06	0.26	0.07	0.24	100.25
25	KE26.92	Stavik	Fræna	Molde	1220.1	3971	69740	1.60	0.49	23%	46.33	15.47	15.01	2.09	7.80	9.11	2.22	0.87	0.19	0.25	0.45	99.79
24	KE25.92	Stavik	Fræna	Molde	1220.1	3969	69743	1.40	0.85	38%	45.68	15.78	15.38	2.25	7.70	9.19	2.50	0.47	0.20	0.26	0.51	99.93
28	KE29.92	Stavik	Fræna	Molde	1220.1	3022	69778	0.83	0.53	39%	47.98	15.19	12.29	1.36	7.28	11.32	2.73	0.20	0.19	0.13	0.94	99.60
6	KN4.92	Almenningen	Mål¢y	Nordfjord	1118.1	3032	68701	0.13	1.08	89%	47.51	15.24	12.29	1.21	9.59	10.13	2.64	0.45	0.20	0.18	0.57	100.01
4	KN3A.92	Kroken	Mål¢y	Nordfjord	1118.1	3073	68702	0.17	1.37	89%	47.50	16.04	14.64	1.54	6.84	10.62	2.17	0.24	0.26	0.14	0.37	100.35
5	KN3B.92	Kroken	Mål¢y	Nordfjord	1118.1	3073	68702	0.77	1.96	72%	47.34	14.71	14.16	2.73	6.65	10.16	2.71	0.36	0.25	0.23	0.08	99.39
22	KL22.92	Brue	Lesja	Romsdal	1319.1	4550	69100	3.43	0.33	9%	46.23	13.58	19.04	3.76	4.71	8.46	3.32	0.38	0.27	0.34	-0.47	99.61
21	KL21.92	Kleiva	Lesja	Romsdal	1319.1	4549	69071	2.69	0.50	16%	46.64	14.83	18.31	3.19	4.26	8.26	2.68	0.94	0.24	0.42	-0.01	99.76
23	KL23.92	Kleiva	Lesja	Romsdal	1319.1	4550	69073	2.27	0.19	8%	47.63	16.44	14.31	2.46	4.97	9.19	3.23	0.89	0.18	0.25	-0.06	99.50
7	KU5.92	Dimn¢y	Ulsteinvik	Ålesund	1119.1	4182	69819	1.38	0.44	24%	47.01	15.44	11.51	1.82	7.99	10.55	2.82	0.57	0.18	0.23	1.20	99.31
48	KE46.92	Rausand	Nesset	other areas	1320.1	4555	69685	1.16	0.28	19%	44.99	16.85	16.09	1.44	5.57	10.23	2.26	0.81	0.16	0.15	1.00	99.55
47	KE45.92	Rausand	Nesset	other areas	1320.1	4555	69685	0.37	0.12	24%	64.82	17.35	2.93	0.49	0.54	1.36	4.97	6.44	0.12	0.09	0.25	99.38
49	KE47.92	Rausand	Nesset	other areas	1320.1	4555	69685	7.26	0.18	2%	13.35	7.04	68.25	7.44	3.27	2.37	0.34	0.13	0.21	0.04	-1.58	100.86
46	KE44.92	Rausand	Nesset	other areas	1320.1	4552	69687	0.23	0.04	15%	69.57	15.33	2.16	0.27	0.72	2.39	4.29	3.93	0.06	0.09	0.34	99.14
50	KS48.92	Vika	Sunndal	other areas	1420.3	4743	69534	1.18	0.49	29%	47.63	16.57	13.00	1.67	6.62	9.77	2.50	0.77	0.19	0.24	0.67	99.64
57	KD83.92	Gr¢nstadlihei	Fjaler	Dalsfjord	1117.1	2973	68014	0.77	0.11	13%	65.42	14.16	6.61	0.88	1.17	3.21	3.72	2.88	0.09	0.20	0.56	98.90
56	KD78.92	Gyttavatnet	Fjaler	Dalsfjord	1117.1	3032	68017	0.17	2.78	94%	44.67	16.09	18.13	2.95	6.00	9.02	2.10	0.04	0.24	0.56	-0.07	99.74
2	KF1B.92	Russenes	Naustdal	F¢rdefjord	1117.1	3108	68205	0.15	1.73	92%	45.19	14.63	17.47	1.88	7.97	9.70	2.10	0.15	0.20	0.09	0.58	99.95
1	KF1A.92	Russenes	Naustdal	F¢rdefjord	1117.1	3108	68205	0.16	4.21	96%	43.50	13.33	19.13	4.37	6.41	9.75	2.87	0.05	0.18	0.10	0.18	99.87
3	KB2.92	Kletten	Naustdal	F¢rdefjord	1117.1	3073	68702	0.07	0.18	72%	78.25	10.84	2.32	0.25	0.15	0.47	4.07	2.20	0.04	0.01	0.64	99.23

Appendix 2b: Miscellaneous analyses, Vassbotn eclogite, Ålesund region

Analysed by NGU (Rutile analytical procedure)

Sample	Rock	SiO2 xrf	Al2O3 xrf	Fe2O3 xrf	TiO2 xrf	MgO xrf	CaO xrf	Na2O xrf	K2O xrf	MnO xrf	P2O5 xrf	LOI xrf	SUM xrf	TiO2 icp	Rutile calc.
VB1a.91	eclogite	38.92	11.47	20.28	2.43	6.04	8.36	0.90	0.46	0.19	0.09	not determined		0.65	1.78
VB1b.91	eclogite	40.30	11.36	19.79	2.88	6.45	8.12	1.16	0.73	0.22	0.04	not determined		1.03	1.85
VB1c.91	eclogite	39.02	10.58	20.65	2.28	5.38	8.79	1.08	0.04	0.20	0.08	not determined		0.52	1.76
VB1d.91	eclogite	39.32	10.90	18.31	2.17	5.98	9.64	1.04	0.26	0.20	0.08	not determined		0.48	1.69
VE1e.91	eclogite	43.54	14.01	13.11	1.81	5.75	10.98	1.53	0.75	0.12	0.13	not determined		0.99	0.82
	eclogite	41.15	18.00	19.40	2.30	7.86	10.45	1.03	0.22	0.20	0.09	0.10	100.80	not analysed	
	eclogite	40.73	17.96	22.07	2.37	7.38	9.31	0.95	0.04	0.20	0.09	-0.21	100.89	not analysed	
	eclogite	40.88	17.74	20.18	3.08	7.64	8.64	1.09	0.64	0.23	0.05	0.03	100.20	not analysed	
VB1a.91	eclogite	38.92	11.47	20.28	2.43	6.04	8.36	0.90	0.46	0.19	0.09	not determined		0.65	1.78
VB1b.91	eclogite	40.30	11.36	19.79	2.88	6.45	8.12	1.16	0.73	0.22	0.04	not determined		1.03	1.85
VB1c.91	eclogite	39.02	10.58	20.65	2.28	5.38	8.79	1.08	0.04	0.20	0.08	not determined		0.52	1.76
VB1d.91	eclogite	39.32	10.90	18.31	2.17	5.98	9.64	1.04	0.26	0.20	0.08	not determined		0.48	1.69
VB1d.91	eclogite	43.54	14.01	13.11	1.81	5.75	10.98	1.53	0.75	0.12	0.13	not determined		0.99	0.82
VP6	eclogite	41.50	19.32	15.24	2.34	6.64	10.23	1.67	1.12	0.16	0.09	0.91	99.22	1.49	0.85
VP7	eclogite	41.68	19.04	15.60	2.32	6.73	10.58	1.40	0.84	0.16	0.09	0.56	99.00	1.54	0.78
VP8	eclogite	41.65	17.11	18.60	2.75	7.20	10.52	1.51	0.05	0.19	0.08	-0.08	99.58	0.68	2.07
VP9	eclogite	39.71	18.40	22.22	2.50	7.29	9.07	0.69	0.06	0.21	0.05	-0.46	99.74	0.30	2.20
VP10	eclogite	39.73	18.04	22.75	2.35	7.30	8.90	0.75	0.04	0.20	0.06	-0.46	99.66	0.28	2.07
VP11	eclogite	39.65	17.95	18.57	2.57	6.80	10.08	1.03	0.75	0.19	0.13	0.56	98.28	1.63	0.94
VP12	eclogite	38.06	19.68	22.96	3.11	6.62	9.14	0.49	0.14	0.20	0.04	-0.23	100.21	0.60	2.51
VP13GNT	garnet	37.83	20.84	25.95	1.79	6.55	8.63	0.05	0.03	0.27	0.04	-0.68	101.30	0.82	0.97
VP14GNT	garnet	37.11	20.12	24.56	1.76	6.38	8.58	0.05	0.03	0.25	0.05	-0.39	98.50	0.41	1.35
VP15GNT	garnet	39.26	19.20	22.55	2.51	6.89	9.38	0.64	0.06	0.22	0.05	-0.21	100.55	0.46	2.05
Average (gnt-samples excl.		40.35	14.99	19.09	2.44	6.53	9.44	1.10	0.42	0.19	0.08	0.04	99.76	0.69	1.60

Appendix 3: Miscellaneous analyses, Saurdal eclogite, Dalsfjord region

A. Analyses of four sets of chip-samples from the block-stone quarry, Saurdal eclogite

Sample		% *Rutile*	% TiO2 icp	Rel.% Rutile	% SiO2 xrf	% Al2O3 xrf	% Fe2O3 xrf	% TiO2 xrf	% MgO xrf	% CaO xrf	% Na2O xrf	% K2O xrf	% MnO xrf	% P2O5 xrf	% Gl.t. xrf	% Sum xrf
S1	White-mica-rich ecl.	***2.08***	0.28	89%	44.90	16.19	15.47	2.36	7.24	9.41	2.97	0.31	0.20	0.19	0.30	99.55
S2	White-mica-rich ecl.	***2.54***	0.32	89%	43.35	15.02	15.66	2.86	6.22	12.07	2.39	0.15	0.20	0.22	0.14	98.29
S3	Dark, amph.-rich ecl.	***2.89***	1.21	70%	43.48	12.16	19.80	4.10	7.87	10.18	1.57	0.11	0.23	0.12	-0.06	99.56
S4	Dark, amph.-rich ecl.	***3.74***	0.22	94%	43.79	12.52	18.12	3.96	6.81	11.85	2.42	0.03	0.13	0.26	-0.60	99.27
	Average values:	2.81	0.51	0.86	43.88	13.97	17.26	3.32	7.04	10.88	2.34	0.15	0.19	0.20	-0.06	99.17

B. Analyses of Dh 8, Saurdal eclogite

Drilled in 1956 by Rausand Gruber A/S. Reanalysed by NGU (rutile analytical procedure) in 1993.

Sample no.	Distance along Dh8 (m)	Magn. susc. (crushed)	% *Rutile*	% TiO2 icp	Rel.% Rutile	% SiO2 xrf	% Al2O3 xrf	% Fe2O3 xrf	% TiO2 xrf	% MgO xrf	% CaO xrf	% Na2O xrf	% K2O xrf	% MnO xrf	% P2O5 xrf	% LOI xrf	% Sum xrf
1	-10	0.00083	**1.17**	0.43	73%	43.18	17.07	18.22	1.60	7.60	8.05	3.34	0.24	0.21	0.33	0.22	100.06
2	-20	0.02549	**0.93**	1.25	43%	39.76	15.44	22.42	2.18	9.45	6.64	2.40	0.24	0.24	0.29	0.69	99.75
3	-30	0.03461	**0.50**	1.23	29%	39.62	15.22	22.19	1.73	11.46	6.11	2.19	0.24	0.20	0.07	0.90	99.93
4	-40	0.08144	**0.83**	3.12	21%	35.52	13.24	27.21	3.95	10.90	5.79	1.67	0.17	0.22	0.13	1.20	100.00
5	-50	0.11117	**0.61**	4.15	13%	33.05	11.90	30.22	4.76	10.35	5.36	1.40	0.20	0.26	0.27	1.34	99.11
6	-60	0.00592	**1.14**	1.15	50%	42.60	16.49	18.35	2.29	7.83	8.07	3.36	0.26	0.17	0.17	0.19	99.78
7	-70	0.08025	**0.78**	3.53	18%	35.40	12.01	27.71	4.31	11.20	5.20	1.73	0.28	0.22	0.08	1.07	99.21
8	-80	0.07966	**0.42**	3.55	11%	35.31	11.35	28.31	3.97	11.75	5.44	1.18	0.18	0.26	0.18	1.38	99.31
9	-90	0.05733	**0.40**	3.10	11%	36.97	12.09	26.03	3.50	11.19	6.96	1.27	0.16	0.23	0.08	1.24	99.72
10	-100	0.00097	**0.92**	0.18	84%	45.47	16.69	15.92	1.10	6.04	10.35	3.58	0.18	0.18	0.15	-0.02	99.64
11	-110	0.01546	**1.61**	1.02	61%	43.64	17.72	15.20	2.63	5.58	10.01	3.29	0.61	0.16	0.15	0.32	99.31
12	-120	0.02665	**0.90**	3.03	23%	40.53	10.73	21.89	3.93	8.33	11.99	1.42	0.15	0.23	0.23	-0.16	99.27
13	-130	0.00729	**0.90**	2.49	27%	42.01	9.70	20.29	3.39	9.51	12.44	1.31	0.14	0.23	0.07	0.11	99.20
14	-140	0.00213	**2.17**	1.04	68%	43.08	11.29	18.54	3.21	8.79	12.11	1.77	0.14	0.22	0.11	0.05	99.31
15	-150	0.00376	**2.29**	0.54	81%	44.24	12.73	17.60	2.83	7.71	11.78	2.21	0.23	0.20	0.11	-0.06	99.58
16	-160	0.00467	**2.25**	0.89	72%	44.08	11.61	17.12	3.14	8.35	12.13	2.16	0.17	0.19	0.12	0.20	99.27
17	-170	0.00466	**1.38**	1.56	47%	44.22	11.39	17.28	2.94	8.43	12.22	2.23	0.27	0.20	0.12	0.16	99.46
18	-180	0.00276	**1.74**	0.51	77%	45.34	12.75	14.44	2.25	7.77	12.68	2.69	0.38	0.19	0.12	0.41	99.02
19	-190	0.00958	**0.30**	2.83	10%	42.65	8.16	19.18	3.13	10.65	13.38	1.10	0.11	0.24	0.08	0.25	98.93
20	-200	0.00505	**1.80**	1.93	48%	42.74	10.52	18.97	3.73	8.97	12.41	1.45	0.10	0.21	0.09	0.11	99.30
21	-208	0.00585	**1.71**	1.57	52%	42.75	11.73	19.53	3.28	8.11	11.94	1.81	0.13	0.21	0.11	-0.02	99.58
	Average values:		**1.18**	1.86	39%	41.06	12.85	20.79	3.04	9.05	9.57	2.07	0.22	0.21	0.15	0.46	99.46

Appendix 3c: Analyses of drill-dust samples, Saurdal eclogite

Sampled in 1993 (1-2 kg samples; NGU's sampling method)

Anal no.	Coordinates in local coord. system X meter	Y meter	X-MET analyses on pulverized samples (1) TiO2	Fe2O3	CaO	Magn. susc.	(1)-(2) RUTILE calc.	Rel.% Rutile	ICP-analyses (HCl-soluble) SiO2 sol.	Al2O3 sol.	Fe2O3 sol.	(2) TiO2 sol.	MgO sol.	CaO sol.	Na2O sol.	K2O sol.	MnO sol.	P2O5 sol.
Profile 1																		
59	5008	4994	**5.84**	27.98	10.55	0.00427	**0.25**	4%	12.11	4.72	14.70	**5.59**	0.87	3.62	0.25	0.12	0.17	1.39
58	5005	5019	**17.56**	42.67	3.71	0.26545	**4.39**	25%	0.21	6.39	50.08	**13.17**	2.91	1.24	0.18	0.17	0.18	0.11
57	4998	5043	**2.62**	17.55	7.23	0.00162	**2.17**	83%	0.23	6.10	7.44	**0.45**	2.44	2.48	0.97	0.13	0.07	0.23
56	4965	5065	**4.03**	21.51	8.30	0.01192	**0.54**	13%	0.21	4.59	12.27	**3.49**	2.05	2.06	0.40	0.12	0.11	0.11
55	5000	5103	**6.53**	26.71	6.92	0.02023	**1.38**	21%	0.33	6.45	19.09	**5.15**	3.01	2.68	0.58	0.42	0.12	0.11
54	5013	5113	**5.34**	24.84	6.90	0.00502	**2.37**	44%	1.42	6.60	13.05	**2.97**	2.29	2.46	0.53	0.20	0.08	0.11
53	5014	5125	**5.79**	24.86	9.15	0.02597	**0.23**	4%	0.12	3.42	16.71	**5.56**	2.13	2.65	0.56	0.30	0.13	0.35
52	5015	5138	**4.11**	21.39	8.60	0.00200	**2.77**	67%	0.67	4.84	8.86	**1.34**	1.78	2.23	0.45	0.22	0.07	0.11
51	5014	5148	**3.78**	19.60	10.35	0.00272	**3.40**	90%	0.75	3.74	6.27	**0.38**	1.04	1.74	0.22	0.12	0.06	0.11
50	5015	5163	**3.09**	18.82	10.79	0.00591	**2.52**	82%	0.44	3.79	7.14	**0.57**	1.11	1.88	0.24	0.37	0.13	0.11
49	5016	5175	**4.54**	22.69	11.55	0.02478	**0.74**	16%	0.24	3.43	14.05	**3.80**	1.61	2.00	0.23	0.21	0.12	0.11
48	5013	5185	**3.81**	23.71	7.70	0.02800	**0.11**	3%	0.17	4.18	14.68	**3.70**	2.38	1.74	0.32	0.12	0.11	0.11
47	5018	5200	**4.00**	21.68	7.17	0.01428	**1.53**	38%	0.02	7.80	14.73	**2.47**	3.85	2.84	0.80	0.14	0.13	0.11
46	5013	5213	**4.38**	22.29	11.66	0.02480	**0.87**	20%	0.30	3.85	13.31	**3.51**	1.50	2.46	0.30	0.12	0.11	0.11
45	5020	5223	**5.74**	24.40	10.47	0.04406	**-0.09**	-2%	0.09	2.69	20.69	**5.83**	1.73	1.89	0.31	0.20	0.12	0.11
44	5014	5235	**5.14**	24.31	9.96	0.04221	**0.28**	5%	0.02	3.33	17.36	**4.86**	1.46	1.61	0.16	0.12	0.17	0.11
43	5024	5245	**3.21**	20.60	12.18	0.00571	**0.19**	6%	0.36	3.43	10.76	**3.02**	1.37	2.13	0.22	0.12	0.10	0.11
42	5024	5258	**2.48**	17.09	13.97	0.00185	**2.02**	81%	0.59	3.43	4.97	**0.46**	1.02	2.30	0.19	0.12	0.07	0.11
41	5024	5268	**3.14**	19.42	13.13	0.00267	**-0.02**	-1%	0.26	2.42	8.75	**3.16**	1.02	1.86	0.13	0.12	0.09	0.11
40	5025	5280	**1.92**	20.05	10.09	0.00205	**1.76**	92%	2.02	5.98	7.87	**0.16**	1.47	2.61	0.15	0.20	0.08	0.14

39	5026	5293	**4.13**	22.18	11.31	0.03515	**-0.16**	-4%	0.02	2.30	16.72	**4.29**	1.73	1.94	0.22	0.12	0.11	0.18
38	5030	5310	**8.63**	30.46	9.57	0.03261	**0.46**	5%	0.02	2.45	31.52	**8.17**	2.01	1.38	0.15	0.12	0.12	0.11
37	5030	5328	**2.91**	18.62	11.21	0.00256	**2.48**	85%	0.33	4.62	6.75	**0.43**	1.51	2.51	0.32	0.12	0.09	0.26
36	5031	5343	**4.42**	16.77	11.60	0.00448	**2.89**	65%	0.02	3.22	6.99	**1.53**	1.55	2.06	0.30	0.12	0.09	0.13
35	5035	5363	**4.79**	25.22	6.18	0.02738	**0.25**	5%	0.02	9.14	22.52	**4.54**	5.46	3.09	0.77	0.28	0.19	0.14
34	5035	5375	**2.18**	14.44	7.86	0.00297	**1.93**	89%	0.62	4.85	5.75	**0.25**	1.29	1.89	0.42	0.21	0.06	0.17
33	5038	5388	**2.10**	16.47	7.65	0.00096	**1.95**	93%	0.90	6.15	6.46	**0.15**	1.80	2.18	0.52	0.12	0.06	0.18
32	5033	5400	**2.55**	16.64	13.54	0.00423	**-0.38**	-15%	0.02	1.61	7.16	**2.93**	0.96	1.22	0.10	0.12	0.09	0.11
31	5035	5408	**3.17**	18.61	12.40	0.00162	**-0.10**	-3%	0.02	2.85	8.28	**3.27**	1.08	1.72	0.15	0.12	0.09	0.19
<u>Profile 2</u>																		
1	4908	5050	**2.74**	22.51	4.72	0.00145	**0.55**	20%	7.21	8.83	14.02	**2.19**	7.32	1.85	0.59	0.18	0.09	0.11
2	4910	5063	**2.10**	19.62	7.17	0.00047	**0.81**	39%	1.53	6.36	8.83	**1.29**	4.23	2.07	0.65	0.14	0.07	0.18
3	4909	5078	**3.48**	20.11	11.39	0.00105	**0.99**	28%	0.79	3.06	7.76	**2.49**	1.08	1.76	0.25	0.12	0.08	0.11
4	4910	5095	**3.60**	20.66	12.25	0.00102	**0.62**	17%	0.49	2.70	8.60	**2.98**	0.92	1.69	0.15	0.12	0.08	0.11
5	4911	5113	**3.03**	18.84	11.18	0.01210	**0.09**	3%	0.30	3.04	10.54	**2.94**	1.49	1.90	0.25	0.12	0.12	0.11
6	4914	5128	**5.44**	24.58	10.09	0.01980	**0.38**	7%	0.18	2.94	16.45	**5.06**	1.08	1.61	0.19	0.12	0.10	0.11
7	4916	5143	**5.71**	24.47	9.99	0.00602	**0.31**	5%	0.15	2.46	18.55	**5.40**	0.98	1.33	0.17	0.12	0.09	0.11
8	4903	5160	**2.38**	13.90	10.24	0.00267	**2.01**	84%	0.41	4.00	4.87	**0.37**	1.08	1.98	0.25	0.26	0.06	0.20
9	4906	5178	**4.56**	21.77	11.92	0.00406	**-0.30**	-7%	0.22	2.48	12.60	**4.86**	0.97	1.53	0.16	0.12	0.09	0.15
10	4905	5195	**4.75**	21.54	8.04	0.00193	**3.04**	64%	0.90	4.69	8.78	**1.71**	1.70	1.67	0.23	0.16	0.08	0.17
11	4918	5208	**3.86**	20.10	10.53	0.00100	**2.33**	60%	0.97	4.25	7.88	**1.53**	1.26	1.98	0.24	0.12	0.09	0.11
12	4906	5218	**1.64**	15.05	7.76	0.00161	**1.50**	91%	0.12	3.87	4.96	**0.14**	1.42	1.54	0.25	0.20	0.06	0.21
13	4905	5233	**4.63**	18.70	9.80	0.00067	**4.44**	96%	0.41	3.39	5.17	**0.19**	0.99	1.71	0.21	0.12	0.07	0.17
14	4915	5248	**1.93**	19.65	11.11	0.00200	**1.80**	93%	0.83	4.26	6.04	**0.13**	1.14	2.29	0.32	0.12	0.07	0.29
15	4910	5260	**5.09**	22.97	9.72	0.00598	**-0.04**	-1%	0.12	3.22	13.70	**5.13**	1.44	1.72	0.31	0.16	0.10	0.13
16	4915	5273	**4.99**	22.28	9.77	0.00196	**1.01**	20%	0.33	3.39	11.32	**3.98**	1.14	1.54	0.16	0.12	0.09	0.11
17	4913	5290	**1.29**	12.26	9.03	0.00214	**1.11**	86%	0.25	6.30	5.17	**0.18**	1.84	2.35	0.54	0.12	0.06	0.19
18	4920	5300	**1.04**	12.83	8.01	0.00124	**0.93**	89%	0.31	6.24	5.57	**0.11**	2.15	2.17	0.44	0.27	0.07	0.14
19	4916	5315	**0.92**	12.94	7.70	0.00047	**0.88**	96%	0.49	4.67	4.38	**0.04**	1.81	2.10	0.41	0.12	0.06	0.24
20	4918	5335	**5.10**	20.40	10.51	0.00146	**0.25**	5%	0.03	2.67	11.75	**4.85**	1.11	1.51	0.15	0.12	0.09	0.11
22	4918	5358	**6.26**	25.28	8.54	0.00357	**0.87**	14%	0.42	3.67	16.20	**5.39**	1.11	1.77	0.18	0.12	0.11	0.15

23	4930	5365	**5.18**	15.57	11.78	0.00720	**4.58**	88%	0.34	3.90	5.94	**0.60**	1.18	3.72	0.35	0.12	0.08	1.44
21	4913	5375	**2.66**	19.89	10.71	0.00130	**2.44**	92%	0.76	4.91	7.40	**0.22**	1.48	2.58	0.32	0.12	0.09	0.32
24	4928	5385	**6.37**	23.79	8.70	0.00866	**0.61**	10%	0.11	3.06	15.75	**5.76**	1.21	1.54	0.18	0.12	0.10	0.13
25	4909	5393	**6.34**	24.57	9.64	0.00218	**0.20**	3%	0.25	3.10	16.38	**6.14**	1.34	1.59	0.20	0.12	0.09	0.13
26	4903	5405	**4.93**	22.33	10.08	0.00119	**3.64**	74%	0.70	4.05	8.43	**1.29**	1.17	2.23	0.09	0.12	0.09	0.11
27	4928	5410	**3.60**	16.84	10.52	0.00150	**3.39**	94%	0.81	4.27	6.01	**0.21**	1.20	1.87	0.18	0.12	0.08	0.11
28	4926	5415	**4.26**	20.53	11.62	0.00242	**-0.11**	-3%	0.20	3.31	11.55	**4.37**	1.24	1.67	0.16	0.16	0.09	0.13
29	4930	5423	**3.78**	18.37	11.17	0.00197	**2.83**	75%	0.28	3.52	6.37	**0.95**	1.10	1.88	0.20	0.12	0.08	0.20
30	4924	5430	**4.07**	22.07	11.07	0.00634	**-0.19**	-5%	0.02	2.44	16.18	**4.26**	0.92	1.26	0.10	0.12	0.10	0.15
Profile 3																		
67	4803	5048	**1.48**	16.97	7.81	0.00150	**1.21**	82%	0.26	3.76	4.97	**0.27**	1.52	1.61	0.31	0.12	0.06	0.15
68	4800	5073	**0.84**	8.25	8.14	0.00212	**0.68**	81%	0.02	4.11	3.31	**0.16**	1.20	1.65	0.61	0.12	0.03	0.12
69	4800	5100	**2.12**	14.77	11.42	0.00140	**1.98**	93%	0.48	3.71	4.18	**0.14**	1.07	2.15	0.24	0.21	0.07	0.19
70	4801	5123	**0.44**	12.29	8.46	0.00115	**0.26**	59%	0.02	5.13	4.66	**0.18**	1.90	2.13	0.43	0.18	0.06	0.22
71	4799	5145	**1.71**	15.75	8.45	0.00088	**1.65**	97%	0.45	3.53	4.06	**0.06**	1.13	1.59	0.18	0.12	0.05	0.11
72	4798	5170	**1.20**	12.57	8.47	0.00072	**1.13**	94%	0.33	3.86	3.84	**0.07**	1.17	1.66	0.28	0.39	0.04	0.12
73	4803	5198	**1.18**	12.08	7.30	0.00110	**1.12**	95%	0.27	3.68	3.68	**0.06**	1.12	1.56	0.31	0.12	0.04	0.11
74	4800	5220	**0.83**	11.74	8.39	0.00042	**0.80**	96%	0.35	3.18	2.91	**0.03**	1.10	1.47	0.25	0.12	0.04	0.15
75	4808	5240	**1.58**	14.65	8.33	0.00070	**1.54**	98%	0.35	3.64	3.73	**0.04**	1.26	1.66	0.23	0.20	0.04	0.16
76	4805	5255	**1.24**	12.39	8.54	0.00108	**1.19**	96%	0.35	4.15	4.11	**0.05**	1.26	1.79	0.31	0.21	0.05	0.15
77	4820	5268	**0.93**	11.56	7.97	0.00228	**0.85**	91%	0.02	4.41	3.85	**0.08**	1.61	1.69	0.60	0.12	0.04	0.11
78	4810	5283	**3.43**	17.58	10.74	0.00251	**3.22**	94%	1.13	4.52	6.08	**0.21**	1.22	2.08	0.26	0.26	0.07	0.11
Profile 4																		
88	4702	5018	**2.81**	17.19	9.28	0.00145	**2.34**	83%	0.44	5.20	6.93	**0.47**	2.39	3.76	0.90	0.31	0.09	1.02
86	4695	5033	**3.27**	19.92	10.46	0.00266	**2.23**	68%	0.92	3.86	8.02	**1.04**	1.43	2.49	0.32	0.12	0.11	0.19
87	4703	5043	**2.41**	17.29	11.41	0.00230	**1.48**	61%	0.47	3.33	6.68	**0.93**	1.08	2.09	0.22	0.12	0.12	0.11
85	4701	5080	**3.00**	18.70	10.60		**0.35**	12%	0.13	2.67	9.14	**2.65**	1.13	1.64	0.18	0.16	0.10	0.12
84	4700	5105	**4.36**	18.83	8.08	0.00303	**4.17**	96%	0.95	4.62	6.57	**0.19**	1.16	1.92	0.16	0.12	0.07	0.22
83	4705	5133	**2.61**	16.53	11.88	0.00184	**2.21**	85%	0.19	3.03	4.56	**0.40**	0.79	2.19	0.16	0.12	0.06	0.18
82	4703	5150	**1.27**	13.62	8.12	0.00145	**1.17**	92%	0.16	3.09	4.01	**0.10**	1.08	1.28	0.16	0.24	0.05	0.13

81	4708	5173	**1.64**	11.69	8.47	0.00101	**1.52**	93%	0.16	3.25	3.35	**0.12**	0.88	1.81	0.30	0.37	0.05	0.41
80	4705	5188	**4.06**	17.30	10.02	0.00140	**3.75**	92%	0.76	4.17	5.72	**0.31**	1.02	2.05	0.18	0.12	0.07	0.11
79	4708	5200	**7.04**	22.88	11.16	0.00185	**2.53**	36%	0.34	2.60	12.49	**4.51**	0.87	1.33	0.09	0.12	0.09	0.12
Profile 5																		
89	4603	5005	**2.35**	17.22	8.54	0.00109	**0.88**	37%	0.02	6.51	8.38	**1.47**	3.59	2.93	0.81	0.12	0.09	0.18
90	4604	5028	**4.53**	22.19	9.36	0.00575	**2.32**	51%	0.71	4.59	10.57	**2.21**	1.39	2.39	0.29	0.12	0.10	0.19
91	4598	5045	**4.20**	21.37	10.26	0.00351	**0.69**	16%	0.33	3.97	11.08	**3.51**	1.42	2.14	0.23	0.28	0.13	0.11
92	4596	5080	**2.95**	20.15	8.25	0.00903	**1.28**	43%	0.29	6.22	10.62	**1.67**	2.59	2.93	0.53	0.53	0.11	0.44
Profile 6																		
93	4500	5018	**5.27**	21.75	8.67	0.00133	**4.46**	85%	1.11	5.07	8.13	**0.81**	1.46	2.21	0.26	0.25	0.09	0.11
94	4501	5033	**7.02**	33.82	1.89	0.17941	**1.46**	21%	0.02	7.09	34.15	**5.56**	8.99	0.24	0.04	0.12	0.12	0.11
95	4505	5045	**5.26**	28.88	5.97	0.08624	**0.50**	10%	0.02	6.73	26.61	**4.76**	6.62	2.45	0.47	0.24	0.19	0.18
96	4504	5063	**1.35**	13.82	7.62	0.00522	**1.10**	81%	0.19	4.64	5.39	**0.25**	1.90	2.24	0.68	0.12	0.06	0.21
97	4501	5080	**3.58**	26.38	7.13	1.32737	**0.29**	8%	0.02	5.56	26.04	**3.29**	8.06	0.48	0.05	0.32	0.14	0.11
98	4503	5095	**1.86**	18.68	11.60	0.00160	**1.57**	84%	1.45	5.51	7.56	**0.29**	1.77	3.26	0.32	0.12	0.14	0.62
99	4498	5108	**5.14**	34.99	0.00	0.16558	**1.40**	27%	1.21	1.84	32.15	**3.74**	11.18	0.21	0.03	0.22	0.12	0.13
100	4503	5118	**4.10**	34.88	0.00	0.12444	**1.28**	31%	0.18	2.34	35.25	**2.82**	16.87	0.20	0.04	0.29	0.28	0.14
101	4501	5130	**7.78**	33.85	0.00	0.19526	**2.80**	36%	0.02	5.01	38.90	**4.98**	9.53	0.07	0.02	0.12	0.22	0.12
102	4503	5148	**1.42**	27.99	1.24	0.08489	**0.56**	39%	0.85	3.27	22.01	**0.86**	12.51	0.45	0.03	0.12	0.15	0.37
103	4499	5170	**1.91**	30.77	1.26	0.07282	**0.60**	31%	1.32	2.61	27.64	**1.31**	16.51	0.40	0.03	0.15	0.22	0.26
Profile 7																		
63	5075	5313	**2.35**	16.93	14.23	0.02350	**-0.06**	-3%	0.02	1.50	6.59	**2.41**	1.49	7.86	0.44	0.16	0.09	5.39
64	5070	5340	**2.13**	18.31	8.10	0.01240	**1.51**	71%	1.45	6.30	7.79	**0.62**	1.71	2.46	0.74	0.12	0.07	0.16
65	5055	5380	**2.92**	16.29	11.50	0.00104	**1.21**	41%	0.02	2.24	5.55	**1.71**	1.83	2.12	0.44	0.15	0.05	0.25
66	5050	5400	**3.20**	20.07	7.24	0.01004	**0.77**	24%	0.02	7.92	13.40	**2.43**	4.60	3.14	0.91	0.46	0.11	0.11
60			**1.25**	12.11	10.45	0.00158	**0.99**	79%	4.36	5.03	4.31	**0.26**	1.38	2.63	0.88	0.12	0.05	0.38
61			**4.95**	19.89	8.02	0.00097	**4.38**	88%	1.52	5.41	8.54	**0.57**	2.42	2.01	0.41	0.22	0.08	0.14
62			**3.00**	18.29	6.38	0.01248	**1.93**	64%	0.73	3.58	7.05	**1.07**	1.92	1.46	0.63	0.21	0.04	0.13
104			**1.84**	19.39	10.23	0.00252	**0.14**	8%	1.36	4.30	8.61	**1.70**	1.22	2.16	0.26	0.12	0.15	0.38

105	**2.55**	24.79	7.38	0.00310	**0.44**	17%	0.87	7.91	13.71	**2.11**	4.76	3.35	0.59	0.25	0.16	0.11
106	**1.46**	16.29	7.14	0.00150	**1.28**	88%	1.12	5.25	6.78	**0.18**	2.17	1.88	0.85	0.20	0.07	0.12
107	**1.93**	19.84	8.20	0.00085	**1.28**	66%	0.23	6.95	8.74	**0.65**	3.15	3.12	0.71	0.12	0.08	0.30
Av.	**3.58**	20.18	8.98		**1.40**	39%	0.66	4.28	11.26	**2.18**	2.43	2.01	0.33	0.17	0.09	0.25
Addiotional sample no 108:																
108	**3.74**	20.41	10.54		**1.00**	27%	0.67	4.19	11.23	**2.74**	1.62	2.05	0.29	0.36	0.10	0.11
107p							0.47	7.29	9.16	**0.66**	3.28	3.26	0.74	0.25	0.08	0.34
14p							1.77	5.03	7.10	**0.13**	1.26	2.63	0.29	0.12	0.08	0.30
40p							3.00	6.62	8.64	**0.16**	1.63	2.90	0.15	0.12	0.09	0.13
78p							1.22	4.23	5.73	**0.22**	1.17	1.97	0.28	0.12	0.07	0.11

Appendix 3d: X-MET analyses of Dh8, Saurdal

Analysed directly on the drill-cores (NGU/Løkken 1992; see Korneliussen 1992)

Core length (m)	% TiO2	% Fe2O3 (tot.)	% CaO
1.3	1.72	17.14	6.30
3.8	2.49	21.43	8.07
4.4	0.52	16.18	6.23
5.7	2.08	15.52	5.37
6.7	4.66	18.06	6.76
10.3	1.64	12.99	6.39
10.8	1.02	16.84	6.03
12.2	1.79	14.24	5.53
12.9	0.83	25.40	5.84
13.7	1.25	10.53	7.09
14.6	0.68	24.88	7.32
99.0	12.87	19.97	5.77
15.9	3.48	22.06	3.63
99.0	3.50	22.17	6.49
18.0	0.97	22.17	6.49
99.0	2.54	17.07	5.67
22.0	0.76	15.76	6.42
99.0	1.61	14.31	6.25
26.8	6.03	26.55	1.25
99.0	6.35	29.29	2.83
31.2	1.07	24.31	5.56
99.0	10.91	20.69	2.57
37.6	4.95	31.01	1.62
99.0	3.79	26.39	2.45
41.0	4.61	17.96	8.18
99.0	1.52	23.90	7.71
45.0	26.29	38.03	2.91
99.0	17.09	35.49	1.77
50.5	1.61	19.29	6.66
99.0	1.31	19.09	8.59
53.3	1.77	16.13	8.16
99.0	3.35	12.93	3.33
58.5	2.14	17.35	6.56
99.0	2.39	14.70	6.63
64.0	7.49	32.52	1.02
67.0	2.72	18.48	5.52
99.0	1.80	17.87	6.63
69.6	4.12	26.21	4.08
99.0	6.75	30.57	3.49
73.8	3.27	18.37	6.42
99.0	3.97	17.30	5.12
77.9	2.96	20.25	7.65
99.0	2.14	22.66	7.34
79.9	2.49	22.82	5.79
99.0	14.04	37.20	3.02

Core length (m)	% TiO2	% Fe2O3 (tot.)	% CaO
85.0	3.04	23.86	9.28
99.0	6.34	21.82	8.19
89.5	6.33	21.30	9.86
99.0	7.42	22.09	8.26
95.9	0.71	15.37	8.73
99.0	1.17	19.04	9.20
99.0	0.41	16.38	8.08
99.0	0.83	14.95	7.65
104.7	0.91	7.49	4.85
99.0	1.83	9.03	6.43
108.0	2.38	13.62	9.53
99.0	2.83	14.13	10.13
110.0	3.50	18.26	9.12
99.0	10.41	23.12	7.23
114.5	2.03	12.41	10.13
99.0	2.58	13.22	12.95
118.7	1.52	12.83	12.27
99.0	1.73	15.30	12.37
123.5	2.85	15.04	9.97
99.0	9.06	19.77	9.26
126.5	1.47	11.44	11.63
99.0	8.79	20.42	8.73
133.0	1.17	7.76	8.81
99.0	1.20	11.45	10.94
134.0	3.34	14.32	11.53
140.0	2.87	18.95	8.09
141.0	9.17	21.97	8.98
150.0	1.54	9.61	7.78
151.0	3.15	17.09	7.66
99.0	7.51	13.34	8.40
158.0	2.05	14.30	10.44
99.0	2.24	14.63	10.13
161.6	9.25	22.10	7.67
99.0	15.09	25.61	7.22
170.0	1.85	8.98	8.28
99.0	1.71	10.77	9.58
179.0	4.65	16.81	9.78
99.0	3.79	14.27	11.46
99.0	6.54	17.75	7.60
186.0	5.38	15.42	8.90
99.0	2.18	11.89	12.16
99.0	3.18	11.30	9.81
191.0	15.05	20.35	6.79
99.0	4.34	15.09	10.13
206.0	10.46	25.77	6.53
99.0	1.65	12.75	11.42
210.5	3.55	16.75	9.82
99.0	5.17	18.21	10.29
Av.	4.27	18.63	7.40

Appendix 4: Miscellaneous analyses, Orkheia and Drøsdal eclogites, Dalsfjord region

Appendix 4a: Analyses of drill-dust samples 1993, Orkheia

DuPont's sampling method (rutile analytical procedure)

Western part
DuPont lab. anal.

Sample	TiO2 %	Fe2O3 %	TiO2 sol.	Rutile
19	3.44	18.12	1.18	**2.26**
19b	2.00	16.17	0.74	**1.26**
20	1.07	12.47	0.13	**0.94**
21	0.98	11.66	0.10	**0.88**
22	1.56	14.59	0.11	**1.45**
23	2.84	16.47	0.10	**2.74**
24	2.78	17.46	0.22	**2.56**
25	2.17	15.54	0.27	**1.90**
26	2.19	16.16	0.15	**2.04**
27	2.47	15.80	0.51	**1.96**
28	2.13	15.48	0.14	**1.99**
29	3.22	14.74	0.12	**3.10**
30	1.36	13.15	0.20	**1.16**
31	1.41	9.14	0.38	**1.03**
32	0.39	11.31	0.04	**0.35**
33	0.32	9.22	0.03	**0.29**
34	0.72	11.80	0.04	**0.68**
35	0.43	12.07	0.10	**0.33**
36	4.67	18.19	0.95	**3.72**
37	0.31	11.25	0.15	**0.16**
38	2.68	18.75	0.23	**2.45**

Central Part, Main Ridge
XMET anal. (Magnus)

Sample	TiO2 %	Fe2O3 %
P1.1	1.16	11.13
P1.2	0.34	15.27
P1.3	0.54	14.34
P1.4	2.41	16.65
P1.5	3.90	18.77
P1.6	2.33	19.06
P1.7	5.67	15.52
P1.8	1.03	9.21
P1.9	1.15	11.19
P1.10	0.63	9.17
P1.11	0.63	13.45
P1.12	1.86	13.80
P1.13	0.97	12.13
P1.14	2.73	20.32
P1.15	3.18	19.31
P1.16	3.39	19.39
P1.17	4.04	17.37
P1.18	4.36	20.30
P1.19	0.29	6.62
P1.20	1.42	12.82
P1.21	1.63	17.81

Northern extension of P2
XMET anal. (Magnus)

Sample	TiO2 %	Fe2O3 %
P2.22	0.87	11.01
P2.23	0.96	12.32
P2.24	0.75	10.62
P2.25	0.68	8.77
P2.26	0.58	9.37
P2.27	0.53	9.08
P2.28	0.77	11.40
P2.29	1.66	12.12
P2.30	0.67	10.70
P2.31	0.98	11.68
P2.32	0.68	8.93
P2.33	0.72	11.81
P2.34	0.45	7.08
P2.35	1.11	8.20
Avg.	0.82	10.22

Eastern Part
DuPont lab. anal.

Sample	TiO2 %	Fe2O3 %	% TiO2 sol.	% Rutile
1	3.58	20.38	0.24	**3.34**
2	3.57	19.93	0.13	**3.44**
3	2.31	14.65	0.12	**2.19**
4	0.49	10.08	0.03	**0.46**
5	4.30	19.34	0.23	**4.07**
6	3.99	19.42	0.32	**3.67**
7	0.08	8.64	0.05	**0.03**
8	0.08	14.09	0.04	**0.04**
9	0.51	11.02	0.31	**0.20**
10	0.03	7.94	0.04	**-0.01**
11	3.23	17.12	0.35	**2.88**
12	3.99	21.18	0.55	**3.44**
13	0.58	12.67	0.07	**0.51**
14a	0.14	6.62	0.07	**0.07**
14b	3.32	19.55	0.33	**2.99**
16	4.01	27.46	3.69	**0.32**
17	3.99	23.39	1.53	**2.46**
18	0.64	9.31	0.40	**0.24**
P3.1	0.11	6.30	0.08	**0.03**
P3.2	3.14	19.91	0.39	**2.75**
P3.3	6.62	18.63	0.74	**5.88**

39	0.91	11.59	0.14	**0.77**
40	1.10	17.35	0.14	**0.96**
41	2.56	17.91	0.19	**2.37**
42	1.41	10.13	0.18	**1.23**
43	3.75	18.77	0.38	**3.37**
44	3.09	15.59	0.16	**2.93**
45	2.81	15.43	1.09	**1.72**
46	0.68	10.50	0.42	**0.26**
47	2.88	16.00	1.22	**1.66**
48	1.25	12.23	0.55	**0.70**
49	1.94	15.96	0.32	**1.62**
50	2.03	16.05	0.31	**1.72**
Avg.	1.93	14.46	0.33	**1.59**
				(82%)

P1.22	1.30	11.77
P1.23	1.15	11.80
P1.24	2.48	17.68
P1.25	0.65	8.21
P1.26	0.23	12.24
P2.1	0.40	9.66
P2.2	0.33	10.39
P2.3	0.18	8.24
P2.4	5.37	21.65
P2.5	4.16	20.12
P2.6	4.38	23.96
P2.7	3.59	20.18
P2.8	3.56	16.92
P2.9	3.64	19.69
P2.10	0.66	8.97
P2.11	2.38	19.43
P2.12	0.13	10.30
P2.13	3.16	19.95
P2.14	0.32	5.29
P2.15	3.63	18.29
P2.16	4.06	18.16
P2.17	0.13	8.26
P2.19	3.78	18.41
P2.20	2.38	14.68
P2.21	3.49	18.37
Avg.	**2.16**	**14.92**
P2.18	18.78	15.33

P3.4	0.23	11.12	0.10	**0.13**
P3.5	6.88	19.00	0.60	**6.28**
P3.6	5.86	21.71	1.62	**4.24**
P3.7	1.60	16.26	0.06	**1.54**
P3.8	2.00	16.48	0.16	**1.84**
P3.9	0.34	11.97	0.02	**0.32**
P4.1	3.20	20.43	0.44	**2.76**
P4.2	3.54	16.62	0.08	**3.46**
P4.3	2.89	14.79	0.20	**2.69**
P4.4.	4.13	12.92	0.31	**3.82**
P4.5	6.21	20.80	0.70	**5.51**
P4.6	3.41	18.73	0.17	**3.24**
P4.7	4.16	19.22	0.24	**3.92**
P4.8	0.15	11.31		
Avg.	2.67	15.97	0.42	**2.32**
				(87%)
	2.67	15.97		

Appendix 4b: X-MET analyses, Orkheia

Analysed by: A.K./L.F.

	TiO2	Fe2O3	CaO
Ortheia (AK)	2.7	13.3	6.7
Ortheia (AK)	7.9	12.8	4.1
Ortheia (AK)	5.7	13.6	4.6
Ortheia (AK)	5.1	15.3	5.7
Ortheia (AK)	5.1	16.8	6.1
Ortheia (AK)	4.2	17.7	6.9
Ortheia (AK)	2.7	14.4	7.6
Ortheia (AK)	0.9	6.8	3.7
Ortheia (AK)	0.9	7.5	9.2
Ortheia (AK)	1.5	8.3	7.2
Ortheia (AK)	1.1	9.9	6.7
Ortheia (AK)	1.4	10.9	9.6
Ortheia (AK)	3.8	15.0	6.6
Ortheia (AK)	1.5	12.6	6.5
Ortheia (AK)	0.9	11.4	5.2
Ortheia (AK)	2.2	10.4	7.1
Ortheia (AK)	1.2	10.8	7.9
Ortheia (AK)	3.1	17.2	6.4
Ortheia (AK)	1.5	14.3	7.1
Ortheia (AK)	0.8	10.2	
Ortheia (AK)	5.0	14.8	6.1
Ortheia (AK)	1.3	9.7	6.9
Ortheia (AK)	1.5	10.7	7.6
Ortheia (AK)	3.9	17.2	5.7
Ortheia (AK)	2.1	13.6	7.6
Ortheia (AK)	20.1	15.6	1.7
Ortheia (AK)	2.9	19.6	8.2
Ortheia (AK)	0.7	15.4	6.5
Ortheia (AK)	4.9	15.7	4.3
Ortheia (AK)	0.6	5.1	6.5
Ortheia (AK)	0.7	9.6	6.3
Ortheia (AK)	4.5	17.5	7.0
Ortheia (AK)	1.8	7.3	5.3
Ortheia (AK)	4.1	15.6	5.3
Ortheia (AK)	0.2	4.3	4.1
Ortheia (AK)	3.7	14.9	6.2
Ortheia (AK)	1.4	6.9	3.8
Ortheia (AK)	4.6	18.1	17.3
Ortheia (AK)	4.6	19.1	8.6
Ortheia (AK)	3.3	16.6	8.6
Ortheia (AK)	3.0	14.3	7.6
Ortheia (AK)	6.5	17.8	9.2
Ortheia (AK)	5.0	17.3	8.7
Ortheia (AK)	3.3	13.7	8.5
Ortheia (AK)	3.4	16.9	8.0
Ortheia (AK)	3.2	11.6	7.3
Ortheia (AK)	5.5	13.2	6.9

Analysed by: M.G.

	TiO2	Fe2O3
P1.1	1.16	11.13
P1.2	0.34	15.27
P1.3	0.54	14.34
P1.4	2.41	16.65
P1.5	3.90	18.77
P1.6	2.33	19.06
P1.7	5.67	15.52
P1.8	1.03	9.21
P1.9	1.15	11.19
P1.10	0.63	9.17
P1.11	0.63	13.45
P1.12	1.86	13.80
P1.13	0.97	12.13
P1.14	2.73	20.32
P1.15	3.18	19.31
P1.16	3.39	19.39
P1.17	4.04	17.37
P1.18	4.36	20.30
P1.19	0.29	6.62
P1.20	1.42	12.82
P1.21	1.63	17.81
P1.22	1.30	11.77
P1.23	1.15	11.80
P1.24	2.48	17.68
P1.25	0.65	8.21
P1.26	0.23	12.24
P2.1	0.40	9.66
P2.2	0.33	10.39
P2.3	0.18	8.24
P2.4	5.37	21.65
P2.5	4.16	20.12
P2.6	4.38	23.96
P2.7	3.59	20.18
P2.8	3.56	16.92
P2.9	3.64	19.69
P2.10	0.66	8.97
P2.11	2.38	19.43
P2.12	0.13	10.30
P2.13	3.16	19.95
P2.14	0.32	5.29
P2.15	3.63	18.29
P2.16	4.06	18.16
P2.17	0.13	8.26
P2.18	18.78	15.33
P2.19	3.78	18.41

Ortheia (AK)	4.4	15.6	7.5
Ortheia (AK)	4.2	16.9	6.7
Ortheia (AK)	0.3	6.8	4.9
Ortheia (AK)	0.3	12.6	4.9
Ortheia (AK)	0.4	6.5	5.5
Ortheia (AK)	3.1	16.7	8.3
Orkeheia (LF)	5.3	7.6	5.0
Orkeheia (LF)	0.2	5.1	5.0
Orkeheia (LF)	0.4	6.3	6.9
Orkeheia (LF)	2.0	2.2	4.5
Orkeheia (LF)	2.5	12.4	7.3
Orkeheia (LF)	0.2	8.8	3.2
Orkeheia (LF)	1.0	9.8	2.4
Orkeheia (LF)	1.2	11.2	5.3
Orkeheia (LF)	0.5	6.6	2.4
Orkeheia (LF)	0.2	5.6	1.9
Orkeheia (LF)	0.9	7.3	3.9
Orkeheia (LF)	3.0	10.8	4.8
Orkeheia (LF)	1.9	9.8	3.7
Orkeheia (LF)	1.9	12.9	4.8
Orkeheia (LF)	4.4	11.2	3.3
Orkeheia (LF)	1.7	9.5	2.9
Orkeheia (LF)	1.8	10.3	3.9
Orkeheia (LF)	1.8	10.8	4.1
Orkeheia (LF)	1.4	11.6	3.4
Orkeheia (LF)	1.2	8.5	2.7
Orkeheia (LF)	1.7	11.8	3.3
Orkeheia (LF)	3.5	13.7	4.5
Orkeheia (LF)	3.6	13.7	3.9
Orkeheia (LF)	1.5	9.4	2.1
Orkeheia (LF)	4.5	12.9	2.9
Orkeheia (LF)	2.5	8.5	2.9
Orkeheia (LF)	5.2	14.7	4.5
Orkeheia (LF)	1.7	9.1	3.6
Orkeheia (LF)	4.3	18.3	4.4
Orkeheia (LF)	2.2	8.2	1.7
Orkeheia (LF)	1.7	8.7	3.9
Orkeheia (LF)	3.6	13.4	2.7
Orkeheia (LF)	4.4	14.1	3.7
Orkeheia (LF)	1.5	14.9	4.0
Orkeheia (LF)	2.0	12.4	3.8
Orkeheia (LF)	2.1	11.5	3.6
Orkeheia (LF)	2.1	12.2	3.6
Orkeheia (LF)	1.6	12.1	1.0
Orkeheia (LF)	3.8	8.5	2.6
Orkeheia (LF)	1.9	7.7	3.3
Orkeheia (LF)	0.9	7.4	4.1
Orkeheia (LF)	1.1	5.4	3.2

P2.20	2.38	14.68
P2.21	3.49	18.37
P2.22	0.87	11.01
P2.23	0.96	12.32
P2.24	0.75	10.62
P2.25	0.68	8.77
P2.26	0.58	9.37
P2.27	0.53	9.08
P2.28	0.77	11.40
P2.29	1.66	12.12
P2.30	0.67	10.70
P2.31	0.98	11.68
P2.32	0.68	8.93
P2.33	0.72	11.81
P2.34	0.45	7.08
P2.35	1.11	8.20

Orkeheia (LF)	1.4	6.1	3.1
Orkeheia (LF)	9.5	15.4	3.8
Orkeheia (LF)	5.1	11.3	2.6
Orkeheia (LF)	2.1	11.7	2.6
Orkeheia (LF)	2.4	13.1	3.9
Orkeheia (LF)	4.6	16.5	5.9
Orkeheia (LF)	1.7	7.4	7.0
Orkeheia (LF)	1.8	11.9	7.8
Orkeheia (LF)	1.9	15.4	5.8
Orkeheia (LF)	0.3	9.2	6.7
Orkeheia (LF)	2.5	14.2	5.2
Orkeheia (LF)	2.0	8.6	4.6
Orkeheia (LF)	3.0	10.0	3.6
Orkeheia (LF)	1.8	11.3	5.7
Orkeheia (LF)	5.3	15.8	6.4
Orkeheia (LF)			
Orkeheia (LF)	7.4	18.9	7.2
Orkeheia (LF)	9.3	16.8	6.4
Orkeheia (LF)	6.9	17.3	5.7
Orkeheia (LF)	5.7	17.8	6.9
Orkeheia (LF)	3.7	15.7	7.7
Orkeheia (LF)			
Orkeheia (LF)	0.5	3.6	5.9
Orkeheia (LF)	0.3	12.8	5.7
Orkeheia (LF)	0.2	10.7	5.7
Orkeheia (LF)	0.3	9.3	5
Orkeheia (LF)	24	13	2.6
Orkeheia (LF)			
Orkeheia (LF)	4.2	12.7	3.6
Orkeheia (LF)	3.6	11.9	4.8
Orkeheia (LF)	3.2	16.7	5.3
Orkeheia (LF)	5.8	14.6	4.5
Orkeheia (LF)	5.2	13	7
Orkeheia (LF)			
Orkeheia (LF)	2.2	9.9	3.5
Orkeheia (LF)	5.7	12.5	5
Orkeheia (LF)	0.9	7.9	5.5
Orkeheia (LF)	0.3	11.7	4.9
Orkeheia (LF)	6.9	17.1	5.6
Orkeheia (LF)			
Orkeheia (LF)	1	7.8	6.4
Orkeheia (LF)	0.4	7.2	7.5
Orkeheia (LF)	0.3	6.5	4
Orkeheia (LF)	0.6	9	5.7
Orkeheia (LF)	2.3	11.7	7.1
Orkeheia (LF)			
Orkeheia (LF)	0.8	16.3	6.4
Orkeheia (LF)	6	17.7	4.4
Orkeheia (LF)	1.9	18	5.8
Orkeheia (LF)	3.8	13.8	4.3
Orkeheia (LF)	1	12.1	6.4
Orkeheia (LF)			
Orkeheia (LF)	0.2	5.9	3.5
Orkeheia (LF)	0.1	6.6	3.3
Orkeheia (LF)	0.3	7.2	3.2

Orkeheia (LF)			
Orkeheia (LF)	**0.5**	**5.1**	**3.6**
Orkeheia (LF)	**0.6**	**8.8**	**6.5**
Orkeheia (LF)	**1.5**	**11.4**	**5.5**

Appendix 4c: Analyses, Drøsdal eclogite, Dalsfjord region

Sampled by L.Furuhaug and A.Korneliussen 1991
XRF analyses on pressed powder samples (rutile analytical procedure; NGU 1991)

Sample no.	% SiO_2	% Al_2O_3	% Fe_2O_3	% TiO_2	% MgO	% CaO	% Na_2O	% K_2O	% MnO	% P_2O_5	% TiO_2 icp	% Rutil	Rel% rutile
1	45.36	12.54	11.15	0.92	6.14	9.20	2.85	0.89	0.17	0.18	0.06	0.86	94%
2	45.99	8.52	11.94	0.52	11.19	8.79	1.25	0.22	0.17	0.04	0.08	0.44	85%
3	46.37	11.59	10.05	0.53	7.99	9.60	2.47	0.46	0.15	0.06	0.03	0.50	94%
4	47.55	8.90	10.32	0.48	10.79	8.90	1.89	0.22	0.16	0.04	0.03	0.45	94%
5	45.14	12.58	10.63	0.20	10.43	9.12	1.68	0.23	0.14	0.03	0.02	0.18	90%
6	45.37	10.83	10.92	0.40	9.30	9.96	1.67	0.36	0.17	0.04	0.12	0.28	70%
7	46.21	13.07	9.99	0.34	9.12	8.96	1.56	0.54	0.13	0.03	0.03	0.31	92%
8	43.80	8.56	14.19	0.60	12.08	7.79	0.90	0.26	0.20	0.05	0.15	0.45	75%
9	45.51	12.77	10.55	0.30	9.61	8.94	1.51	0.28	0.13	0.03	0.14	0.16	53%
10	48.51	10.70	10.21	0.68	8.29	10.84	1.78	0.23	0.17	0.08	0.03	0.65	95%
11	43.16	8.07	20.04	2.52	6.52	9.14	1.19	0.03	0.22	0.04	0.23	2.29	91%
12	49.29	16.75	6.09	0.52	4.17	11.10	2.49	0.25	0.10	0.06	0.02	0.50	97%
13	44.98	13.51	9.39	0.28	7.88	9.96	2.30	0.22	0.12	0.04	0.00	0.28	99%
14	46.76	13.38	8.18	0.34	7.13	10.65	2.43	0.34	0.12	0.04	0.03	0.31	92%
15	45.85	12.74	9.82	0.26	10.21	9.12	1.73	0.34	0.13	0.04	0.05	0.21	83%
16	45.05	10.42	11.42	0.21	11.00	8.71	1.45	0.32	0.15	0.03	0.05	0.16	75%
17	70.14	12.82	2.50	0.23	1.16	2.80	4.20	2.06	0.05	0.08	0.15	0.08	35%
18	45.88	16.93	6.42	0.32	5.67	10.95	2.54	0.43	0.09	0.05	0.04	0.28	87%
19	42.37	10.19	14.01	0.28	12.26	6.61	1.28	0.23	0.21	0.03	0.10	0.18	65%
20	48.51	15.48	7.11	0.55	5.04	11.68	2.45	0.39	0.11	0.08	0.02	0.53	96%
21	44.69	16.55	8.11	0.21	8.11	9.61	2.16	0.34	0.10	0.04	0.04	0.17	80%
22	51.95	12.65	9.74	0.96	4.52	7.70	3.28	1.09	0.15	0.18	0.60	0.36	38%
23	49.29	10.56	10.03	0.56	7.23	10.19	1.99	0.27	0.16	0.04	0.03	0.53	94%
24	46.82	11.42	10.25	0.44	8.52	9.48	1.75	0.44	0.14	0.05	0.03	0.41	92%
25	49.39	14.56	6.90	0.47	5.33	10.48	2.45	0.43	0.11	0.07	0.02	0.45	95%
26	50.17	15.90	7.09	0.62	4.53	10.41	2.75	0.64	0.11	0.07	0.03	0.59	95%
27	54.24	16.43	5.65	0.36	4.16	8.00	2.86	0.83	0.12	0.11	0.04	0.32	89%
28	45.63	12.52	10.69	0.45	8.88	8.56	1.94	0.38	0.14	0.06	0.01	0.44	97%
29	48.82	14.18	7.55	0.66	5.40	10.86	2.68	0.51	0.12	0.08	0.02	0.64	97%
30	43.52	13.34	10.38	0.23	10.68	8.51	1.76	0.24	0.13	0.06	0.01	0.22	94%
31	43.72	13.26	10.38	0.23	10.59	8.55	1.76	0.24	0.13	0.06	0.01	0.22	94%
32	49.04	16.03	5.81	0.31	5.37	9.58	2.95	0.79	0.10	0.04	0.05	0.26	84%
33	46.90	15.56	8.12	0.50	6.38	9.43	2.69	0.41	0.11	0.04	0.11	0.39	78%
34	49.63	14.81	6.39	0.35	5.53	9.56	3.53	0.64	0.11	0.04	0.02	0.33	95%
35	45.25	11.14	10.60	0.45	8.66	10.34	2.15	0.16	0.14	0.05	0.01	0.44	98%
36	43.67	8.49	12.65	0.77	10.53	8.03	1.23	0.22	0.16	0.06	0.12	0.65	84%
37	47.07	13.79	8.82	0.67	6.33	10.11	2.70	0.36	0.12	0.07	0.02	0.65	97%
38	48.91	14.60	7.63	0.63	5.69	10.82	2.72	0.51	0.12	0.07	0.05	0.58	91%
39	47.03	10.83	10.13	0.48	8.70	8.93	2.41	0.49	0.14	0.04	0.04	0.44	93%
40	46.19	16.42	6.23	0.23	5.36	11.38	2.36	0.32	0.08	0.05	0.01	0.22	95%
41	46.41	16.72	6.19	0.23	5.38	11.33	2.43	0.33	0.08	0.05	0.01	0.22	94%
42	46.60	13.57	7.84	0.53	7.47	11.23	2.51	0.40	0.12	0.06	0.05	0.48	91%
43	48.57	14.19	7.75	0.59	5.97	9.95	2.60	0.39	0.11	0.10	0.02	0.57	96%
44	48.94	10.57	12.06	1.82	6.34	8.87	2.03	0.28	0.16	0.22	0.04	1.78	98%
45	48.27	15.07	8.17	0.59	6.32	9.73	2.35	0.51	0.12	0.09	0.02	0.57	97%
46	45.86	9.52	10.25	0.96	7.11	11.44	2.67	0.14	0.15	0.09	0.04	0.92	96%
47	48.89	12.16	9.75	0.55	9.50	10.92	2.61	0.39	0.14	0.10	0.02	0.53	96%
48	49.21	11.48	9.96	0.84	8.13	11.10	2.38	0.20	0.15	0.09	0.02	0.82	98%
49	49.72	15.14	8.17	0.41	8.21	8.72	3.78	1.25	0.12	0.04	0.06	0.35	85%
50	48.35	12.68	8.82	0.93	5.87	9.90	3.11	1.10	0.13	0.10	0.09	0.84	90%
51	44.32	9.44	17.99	2.99	5.79	8.44	1.76	0.08	0.24	0.46	0.11	2.88	96%
52	48.16	7.05	20.25	4.22	4.55	8.46	1.69	0.03	0.31	0.74	0.70	3.52	83%

53	50.29	8.74	17.32	3.25	3.81	7.50	2.99	0.16	0.26	0.43	0.76	2.49	77%
54	56.93	11.13	8.98	1.08	3.82	5.55	2.41	1.63	0.12	0.34	0.41	0.67	62%
55	47.57	11.96	9.78	0.47	8.22	8.31	2.23	0.60	0.13	0.09	0.04	0.43	90%
56	45.81	13.10	9.88	0.35	8.34	8.88	2.21	0.29	0.13	0.05	0.01	0.34	96%
57	46.81	12.86	9.05	0.34	7.99	9.02	2.17	0.59	0.13	0.10	0.03	0.31	91%
58	46.86	14.82	8.22	0.19	8.38	9.54	2.06	0.50	0.10	0.04	0.03	0.16	85%
59	47.79	12.08	9.34	0.37	7.96	9.84	2.13	0.44	0.14	0.04	0.05	0.32	86%
60	47.37	14.27	8.26	0.46	7.12	9.79	2.56	1.03	0.11	0.06	0.06	0.40	88%
61	47.56	11.70	9.28	0.67	6.94	9.82	2.77	0.71	0.14	0.07	0.06	0.61	91%
62	49.69	11.11	8.40	0.33	5.98	9.37	3.23	0.99	0.14	0.04	0.04	0.29	88%
63	68.91	12.85	3.21	0.31	0.94	1.64	4.82	2.70	0.06	0.06	0.30	0.01	3%
64	47.73	14.12	8.16	0.41	7.02	9.05	2.60	0.79	0.11	0.06	0.05	0.37	89%
65	48.86	12.40	8.23	0.54	7.11	9.97	2.93	0.59	0.13	0.07	0.04	0.50	92%
66	48.42	8.03	16.21	1.87	5.07	8.55	1.98	0.40	0.21	0.10	0.28	1.59	85%
67	47.29	13.94	9.06	0.36	7.36	9.47	2.26	0.64	0.12	0.06	0.09	0.27	74%
68	45.60	11.47	11.25	0.53	9.01	9.30	1.81	0.23	0.15	0.05	0.04	0.49	93%

Appendix 5: Rutile and major element analyses, Engebøfjellet and Fureviknipa eclogites, Førdefjord region

Sampled by L.Furuhaug and A.Korneliussen 1990
Reported by Korneliussen and Furuhaug (1991b)
XRF analyses on pressed powder samples (rutile analytical procedure; NGU)

Engebøfjellet eclogite

Sample no.	Distance (m) along profile	SiO2	Al2O3	Fe2O3	TiO2	MgO	CaO	Na2O	K2O	MnO	P2O5	Sum	TIO2 *icp*	Rutil	Rel.% rutile
V-1-90	0	50.00	15.40	8.13	0.53	6.66	9.18	2.78	0.27	0.12	0.12	95.90	0.04	0.49	93%
V-2-90	20	49.42	16.05	7.95	0.55	5.93	9.02	2.90	0.29	0.12	0.12	95.47	0.03	0.52	95%
V-3-90	45	49.98	15.01	8.29	0.57	6.68	8.88	2.66	0.31	0.12	0.11	95.60	0.03	0.54	94%
V-4-90	70	49.73	16.21	7.92	0.54	6.07	8.79	3.43	0.29	0.11	0.09	95.91	0.03	0.51	94%
V-5-90	85	49.65	15.12	8.22	0.54	7.05	8.54	2.82	0.25	0.12	0.11	95.20	0.02	0.52	96%
V-6-90	95	48.87	14.22	9.11	0.61	7.80	7.69	2.90	0.35	0.13	0.09	94.52	0.05	0.56	92%
V-7-90	105	49.97	12.69	9.52	0.63	8.27	8.33	2.36	0.26	0.14	0.09	95.10	0.03	0.60	96%
V-8-90	115	49.72	14.91	8.54	0.56	6.60	8.62	2.79	0.24	0.13	0.12	95.20	0.03	0.53	95%
V-9-90	165	49.72	13.99	8.69	0.57	7.43	8.55	2.46	0.29	0.13	0.10	94.83	0.03	0.54	95%
V-10-90	200	49.06	15.51	8.08	0.54	6.23	8.73	2.53	0.35	0.11	0.10	94.44	0.03	0.51	95%
V-11-90	265	50.27	16.21	6.38	0.44	4.49	8.61	2.35	0.69	0.10	0.11	93.31	0.04	0.40	92%
V-12-90	325	45.22	10.43	13.88	1.19	8.57	7.50	2.40	0.16	0.17	0.17	93.32	0.04	1.15	97%
V-13-90	360	43.30	11.05	12.93	1.00	8.22	8.12	2.49	0.30	0.15	0.20	91.84	0.07	0.93	93%
V-14-90	385	47.53	12.10	11.24	0.91	7.50	7.77	2.44	0.56	0.15	0.19	93.74	0.12	0.79	87%
V-15-90	425	49.83	14.46	8.91	0.74	6.10	7.00	2.84	0.33	0.12	0.18	93.96	0.04	0.70	95%
V-16-90	445	48.17	15.40	8.46	0.62	5.84	7.60	3.02	0.54	0.11	0.13	93.44	0.07	0.55	89%
V-17-90	470	43.37	8.77	18.24	2.86	5.58	9.52	1.79	0.32	0.19	0.07	95.17	0.05	2.81	98%
V-18-90	500	43.77	8.26	19.42	3.27	5.39	9.57	1.73	0.22	0.21	0.09	96.13	0.08	3.19	98%
V-19-90	535	46.24	10.30	14.17	1.62	6.22	8.48	1.86	1.16	0.20	0.05	94.06	0.08	1.54	95%
V-20-90	560	43.85	8.68	18.47	4.15	4.96	9.37	1.82	0.49	0.22	0.10	96.90	0.08	4.07	98%
V-21-90	585	58.55	10.58	10.12	2.29	2.85	5.67	1.11	2.24	0.10	0.08	97.17	0.05	2.24	98%
V-22-90	625	45.85	9.34	17.29	3.48	4.62	9.00	1.89	0.42	0.23	0.10	96.61	0.09	3.39	97%
V-23-90	655	43.40	8.85	18.30	3.01	4.58	9.26	2.09	0.18	0.20	0.10	94.75	0.13	2.88	96%
V-24-90	690	45.96	11.42	13.84	1.91	4.71	9.58	1.98	0.75	0.14	0.09	94.38	0.11	1.80	94%
V-25-90	735	45.15	7.84	13.81	0.90	11.91	6.75	1.42	0.28	0.19	0.13	92.15	0.02	0.88	97%
V-26-90	775	49.47	10.95	10.95	0.78	8.37	6.14	1.98	0.63	0.15	0.10	92.82	0.05	0.73	94%
V-27-90	820	49.09	10.30	11.05	0.91	8.37	7.29	2.17	0.33	0.15	0.21	93.77	0.03	0.88	97%
V-28-90	880	48.68	14.21	9.20	0.77	6.13	7.60	2.66	0.58	0.13	0.14	93.66	0.04	0.73	95%
V-29-90	930	68.60	11.13	3.14	0.32	2.37	2.26	2.40	1.47	0.04	0.06	95.55	0.04	0.28	89%
V-30-90	980	48.46	14.19	8.59	0.65	5.97	7.74	2.57	0.34	0.12	0.13	92.51	0.03	0.62	95%
V-31-90	1025	43.77	10.63	15.04	2.23	3.91	9.72	2.13	0.27	0.14	0.10	93.23	0.05	2.18	98%
V-32-90	1075	46.31	14.15	11.57	1.68	2.96	9.53	2.84	0.39	0.11	0.12	94.25	0.06	1.62	96%
V-33-90	1125	47.18	12.27	11.01	1.10	4.90	9.03	2.53	0.38	0.13	0.09	93.25	0.05	1.05	96%
V-34-90	1170	49.14	14.43	9.61	0.98	4.48	8.31	3.29	0.47	0.12	0.12	94.74	0.07	0.91	93%
V-35-90	1205	48.00	13.76	10.71	1.28	4.02	7.87	3.42	0.69	0.12	0.14	94.37	0.06	1.22	96%
V-36-90	1240	42.04	9.22	18.07	2.86	4.45	9.66	2.18	0.11	0.18	0.09	94.31	0.13	2.73	95%
V-37-90	1260	45.50	10.90	12.16	1.37	5.30	8.52	2.51	1.21	0.15	0.23	92.42	0.05	1.32	96%
V-38-90	1285	43.90	7.42	18.10	2.91	4.76	9.91	1.41	0.33	0.20	0.12	94.34	0.08	2.83	97%
V-39-90	1310	47.20	13.14	12.05	1.64	3.60	8.90	2.71	0.58	0.12	0.13	94.27	0.38	1.26	77%
V-40-90	1335	46.26	9.50	14.21	1.91	4.88	9.33	1.76	0.52	0.16	0.24	93.61	0.09	1.82	95%
V-41-90	1375	47.55	11.33	13.30	1.75	4.30	7.41	2.36	0.69	0.16	0.14	93.48	0.08	1.67	95%
V-42-90	1425	44.47	9.77	17.73	3.93	4.67	8.81	2.57	0.42	0.21	0.11	97.29	1.55	2.38	61%
V-43-90	1500	48.78	11.99	10.48	1.05	4.44	7.27	3.24	1.11	0.14	0.17	93.13	0.14	0.91	87%
V-44-90	1580	43.52	7.83	19.82	4.13	4.96	8.99	1.75	0.24	0.24	0.14	96.54	0.21	3.92	95%
V-45-90	1605	53.71	11.87	10.99	1.55	1.86	6.28	3.22	0.90	0.14	0.59	94.78	0.80	0.75	48%
V-46-90	1625	44.31	7.26	19.25	4.23	4.75	9.44	1.11	0.57	0.24	0.15	96.40	0.20	4.03	95%
V-47-90	1655	44.42	8.33	19.22	4.29	4.24	8.69	2.26	0.05	0.24	0.18	96.73	0.16	4.13	96%
V-48-90	1680	44.67	8.81	18.71	4.09	4.24	9.17	2.19	0.33	0.24	0.19	97.22	0.33	3.76	92%
V-49-90	1700	44.49	8.23	17.57	3.53	3.78	9.01	2.03	0.59	0.24	2.08	96.61	0.32	3.21	91%
V-50-90	1730	48.63	8.28	18.23	3.85	3.95	7.51	1.93	0.38	0.25	0.31	97.60	0.38	3.47	90%
V-51-90	1750	45.03	8.64	17.29	3.68	3.53	8.37	1.95	0.69	0.22	0.26	95.00	0.15	3.53	96%

Fureviknipa eclogite

Sample no.	Distance (m) along profile	SiO_2 xrf	Al_2O_3 xrf	Fe_2O_3 xrf	TiO_2 xrf	MgO xrf	CaO xrf	Na_2O xrf	K_2O xrf	MnO xrf	P_2O_5 xrf	Sum xrf	TIO_2 icp	Rutil	Rel.% rutile
F-1-90	0	41.91	11.01	20.24	2.89	4.31	9.19	2.96	0.03	0.32	2.09	98.16	0.51	2.38	82%
F-2-90	28	37.14	7.81	23.67	4.21	5.42	10.98	1.71	0.09	0.36	3.77	98.84	4.01	0.20	5%
F-3-90	62	41.54	8.97	24.50	4.14	5.12	7.98	1.99	0.06	0.32	0.20	98.45	0.31	3.83	93%
F-4-90	68	37.58	4.68	31.06	4.50	10.55	6.22	0.26	0.02	0.46	1.82	100.30	5.24	-0.74	-16%
F-5-90	107	44.14	11.89	20.10	2.56	5.11	7.84	3.32	0.17	0.27	0.77	99.02	0.31	2.25	88%
F-6-90	118	43.95	11.60	19.86	2.46	3.86	9.06	3.12	0.18	0.34	0.69	98.34	0.22	2.24	91%
F-7-90	175	42.87	11.08	20.87	3.37	4.86	9.42	3.10	0.05	0.33	2.37	100.95	1.48	1.89	56%
F-8-90	186	42.63	8.35	23.99	3.89	5.12	9.12	2.03	0.10	0.34	0.68	99.50	0.55	3.34	86%
F-9-90	191	42.25	11.55	18.70	3.05	4.05	10.37	3.12	0.26	0.28	2.39	99.14	0.42	2.63	86%
F-10-90	225	40.99	9.77	20.93	3.65	5.04	10.02	2.49	0.12	0.32	2.52	98.98	1.43	2.22	61%
F-11-90	248	39.97	7.62	24.28	3.93	5.92	10.01	1.76	0.05	0.41	2.42	99.98	2.82	1.11	28%
F-12-90	276	40.62	7.74	26.00	3.04	5.61	7.10	1.37	0.14	0.48	0.90	96.05	1.60	1.44	47%
F-13-90	321	42.27	7.60	23.53	3.80	4.11	9.29	2.07	0.08	0.39	0.56	97.24	1.62	2.18	57%
F-14-90	338	44.33	10.98	19.49	2.83	3.63	8.47	3.19	0.36	0.35	1.74	98.43	0.66	2.17	77%
F-15-90	388	43.88	9.65	20.69	2.60	3.53	9.51	2.94	0.02	0.41	1.51	97.80	1.03	1.57	60%
F-16-90	422	45.55	11.63	19.82	2.09	4.42	6.85	2.69	0.37	0.33	0.27	96.94	0.98	1.11	53%
F-17-90	428	47.90	9.28	16.18	2.26	4.06	10.44	2.61	0.25	0.28	0.29	97.18	0.19	2.07	92%
F-18-90	450	44.20	11.01	19.98	2.87	3.90	8.37	3.04	0.16	0.37	1.79	98.70	1.78	1.09	38%
F-19-90	456	44.22	9.25	21.38	3.12	3.48	8.75	2.29	0.03	0.39	1.73	98.07	0.91	2.21	71%
F-21-90	462	45.32	12.75	16.88	2.22	3.17	9.43	3.96	0.63	0.32	1.32	98.73	0.28	1.94	87%
F-20-90	462	42.07	9.18	21.09	3.70	4.63	10.41	2.53	0.15	0.35	2.36	99.57	1.38	2.32	63%
F-22-90	467	43.46	13.53	18.39	2.78	3.35	9.39	3.18	0.26	0.32	1.81	99.19	1.24	1.54	55%
F-23-90	470	43.26	13.38	18.27	2.84	3.40	9.29	3.64	0.23	0.28	1.92	99.28	0.35	2.49	88%
F-24-90	518	38.76	7.87	23.11	4.10	5.67	10.87	1.78	0.15	0.35	3.06	99.08	2.19	1.91	47%
F-25-90	529	37.35	7.70	23.39	4.55	6.48	11.03	1.70	0.14	0.28	3.74	99.80	4.22	0.33	7%
F-26-90	580	42.71	10.37	23.42	4.01	4.89	8.60	1.86	0.08	0.28	0.11	99.10	2.03	1.98	49%
F-27-90	586	39.40	9.01	26.61	4.40	4.93	8.13	1.87	0.17	0.26	0.24	98.20	2.91	1.49	34%
F-28-90	591	40.28	8.43	24.23	4.12	5.17	9.71	1.75	0.12	0.26	0.27	97.98	2.27	1.85	45%
F-29-90	597	38.38	7.38	22.28	3.97	5.37	12.15	1.66	0.16	0.29	3.91	99.13	1.90	2.07	52%
F-30-90	636	49.44	24.30	5.86	0.90	1.51	8.53	5.52	0.38	0.07	0.67	99.51	0.21	0.69	77%
F-31-90	676	41.11	12.76	21.11	3.46	5.42	7.53	2.83	0.18	0.22	0.38	98.07	0.31	3.15	91%
F-34-90	698	42.23	11.34	19.29	3.27	4.58	10.47	3.19	0.05	0.28	2.31	99.71	0.43	2.84	87%
F-32-90	704	42.53	11.89	20.14	2.57	4.84	8.11	2.96	0.21	0.29	1.24	97.53	1.40	1.17	46%
F-33-90	709	47.76	19.26	9.76	1.81	1.79	9.65	5.16	0.20	0.12	1.47	99.65	0.79	1.02	56%
F-35-90	732	39.22	8.40	23.13	4.15	5.45	10.21	2.12	0.18	0.31	3.18	99.39	1.02	3.13	75%
F-36-90	732	41.22	9.99	22.60	3.88	4.70	9.58	2.01	0.10	0.24	0.39	97.99	0.21	3.67	95%
F-37-90	743	41.76	9.23	20.93	3.62	5.06	9.86	2.95	0.11	0.31	2.56	99.49	1.52	2.10	58%
F-38-90	760	38.41	7.69	24.08	4.48	5.50	10.50	1.82	0.14	0.36	2.97	99.34	2.47	2.01	45%
F-40-90	771	40.50	9.02	22.25	3.94	4.52	10.20	1.98	0.07	0.24	0.33	97.10	0.17	3.77	96%
F-39-90	783	39.43	7.47	21.48	3.89	5.67	11.87	1.84	0.14	0.31	3.38	98.92	1.09	2.80	72%
F-41-90	783	45.95	14.05	16.32	1.87	4.15	8.29	3.73	0.29	0.23	0.58	98.06	0.14	1.73	93%
F-42-90	799	40.25	8.39	21.34	3.79	5.27	11.11	2.00	0.18	0.31	2.69	98.78	0.24	3.55	94%
F-43-90	811	38.57	7.68	23.04	4.36	5.67	11.37	1.86	0.15	0.31	3.48	99.83	1.67	2.69	62%
F-49-90	811	42.34	12.78	18.63	2.82	3.94	9.33	3.41	0.21	0.27	2.04	98.85	0.27	2.55	90%
F-46-90	816	39.06	7.70	23.49	4.37	5.75	10.62	1.77	0.16	0.33	2.91	99.59	1.73	2.64	60%
F-48-90	833	42.39	12.26	18.92	2.85	4.09	9.34	3.34	0.13	0.27	2.07	98.83	0.21	2.64	93%
F-51-90	850	45.13	11.72	18.11	4.32	4.78	9.75	2.71	0.13	0.23	0.43	100.24	0.20	4.12	95%
F-47-90	856	40.74	9.16	21.27	3.67	5.19	10.35	2.31	0.04	0.32	2.67	99.04	1.38	2.29	62%
F-45-90	856	44.77	12.88	19.16	3.29	3.37	8.38	3.21	0.18	0.23	0.58	99.00	0.19	3.10	94%
F-52-90	861	44.46	12.33	17.28	2.96	4.75	9.99	3.06	0.25	0.24	2.21	100.81	0.13	2.83	96%
F-50-90	867	45.07	15.66	15.58	2.45	3.41	8.08	3.68	0.48	0.20	0.54	98.12	0.20	2.25	92%
F-44-90	867	44.82	12.81	18.20	3.28	3.78	9.12	3.38	0.21	0.23	0.40	99.25	0.20	3.08	94%
F-54-90	895	46.79	11.61	17.30	4.02	4.38	9.53	2.66	0.22	0.23	0.55	100.16	0.17	3.85	96%
F-53-90	901	45.81	11.43	16.85	3.77	5.33	9.64	2.54	0.10	0.23	0.49	99.22	0.21	3.56	94%
F-55-90	929	46.03	12.57	17.04	3.22	5.05	8.76	2.84	0.15	0.22	0.38	98.98	0.21	3.01	93%
F-56-90	980	40.37	10.22	24.96	3.97	5.65	7.40	2.02	0.13	0.26	0.30	98.02	3.30	0.67	17%
F-57-90	1013	47.02	18.42	9.77	1.61	3.09	10.41	3.88	0.25	0.12	0.74	97.82	1.49	0.12	7%
F-58-90	1036	42.36	14.94	18.26	2.98	4.19	8.20	2.74	0.20	0.21	0.40	97.36	2.68	0.30	10%
F-59-90	1081	47.08	16.93	11.70	2.16	3.23	10.11	4.10	0.14	0.15	0.73	98.91	0.25	1.91	88%
F-60-90	1109	45.03	13.07	18.10	2.87	3.90	8.99	3.31	0.15	0.26	1.24	99.51	0.47	2.40	84%
F-61-90	1160	47.68	13.13	15.26	2.21	3.98	8.77	3.46	0.12	0.25	0.61	98.34	0.88	1.33	60%
F-62-90	1210	48.15	8.96	18.38	3.15	4.34	9.91	1.36	0.09	0.32	2.05	99.65	0.79	2.36	75%
F-63-90	1250	41.95	11.16	20.70	4.19	5.21	9.92	2.13	0.04	0.22	0.97	99.41	2.09	2.10	50%
F-64-90	1312	43.96	13.08	16.72	2.73	5.07	8.74	2.47	0.88	0.16	0.11	96.83	1.81	0.92	34%

F-65-90	1334	43.46	14.02	17.86	3.40	4.81	9.44	2.65	0.19	0.18	0.29	98.72	2.18	1.22	36%
F-66-90	1340	44.05	11.83	18.60	4.48	5.71	9.74	2.33	0.23	0.22	0.25	100.21	1.77	2.71	60%

Appendix 6: Rutile and major element analyses of miscellaneous rutile mineralization types
Bamble region, Southern Norway

Sample	Rock	Loc.	SiO2	Al2O3	Fe2O3	TiO2	MgO	CaO	Na2O	K2O	MnO	P2O5	LOI	Sum	TiO2 *icp*	Rutile	Rel.% rutile	Map	UTM-X	UTM-Y
ALBITITES																				
KB5D.91	alb?	Fone	71.93	13.96	2.67	0.39	0.53	1.32	6.21	2.68	0.05	0.09	0.42	100.26	0.35	***0.04***	***10%***	1612.1	5042	65229
KB5C.91	alb.	Fone	62.96	19.92	0.45	2.32	0.32	3.06	9.33	1.05	0.01	0.04	0.92	100.38	0.18	***2.14***	***92%***	1612.1	5042	65229
KB6D.91	alb	Gruvetjønn	62.78	20.31	0.89	1.12	0.91	3.44	9.30	0.63	0.01	0.03	0.91	100.34	0.32	***0.80***	***71%***	1612.1	4978	65148
KB10B.91	alb	Laget	75.29	12.60	0.86	0.20	0.42	0.96	5.53	2.76	0.01	0.03	0.59	99.25	0.17	***0.03***	***15%***	1612.2	5044	65046
KB11D.91	alb	Lindvikkollen	64.93	20.13	0.53	1.20	0.44	1.18	10.23	0.69	0.01	0.06	0.57	99.97	0.03	***1.17***	***98%***	1712.4	5214	65254
KB11B.91	alb	Lindvikkollen	65.76	18.53	0.28	2.97	0.07	1.26	9.83	0.88	0.01	0.23	0.21	100.04	0.25	***2.72***	***92%***	1712.4	5214	65254
KB11A.91	alb	Lindvikkollen	62.99	18.82	0.24	2.98	0.08	1.08	7.13	5.26	0.01	0.16	0.39	99.12	0.10	***2.88***	***97%***	1712.4	5214	65254
KB11E.91	alb	Lindvikkollen	62.78	20.03	0.90	3.22	0.81	1.15	10.18	0.24	0.01	0.15	0.48	99.96	0.05	***3.17***	***98%***	1712.4	5214	65254
KB11C.91	alb	Lindvikkollen	63.70	18.24	0.40	4.15	0.25	1.28	9.73	0.90	0.01	0.21	0.21	99.09	0.28	***3.87***	***93%***	1712.4	5214	65254
KB1.91	alb	Lofthus	62.36	18.14	1.26	2.63	0.17	0.98	9.64	0.27	0.01	0.12	4.69	100.28	0.06	***2.57***	***98%***	1712.4	5164	65278
KB1A.91	alb	Lofthus	57.56	16.91	4.24	8.28	0.45	1.87	9.13	0.12	0.02	0.83	0.28	99.70	2.75	***5.53***	***67%***	1712.4	5164	65278
KB12D.91	alb	Ødegård	76.66	14.20	0.17	0.03	0.26	0.85	7.85	0.12	0.01	0.12	0.45	100.71	0.01	***0.02***	***67%***	1712.4	5318	65357
KB4A.91	alb	Ødergård-W	65.32	20.26	1.00	0.11	0.51	1.58	10.39	0.63	0.01	0.02	0.99	100.82	0.06	***0.05***	***45%***	1712.4	5307	65356
KB3C.91	alb.	Ringsjø	70.45	14.90	1.04	0.40	0.98	4.90	5.32	0.45	0.01	0.08	1.12	99.66	0.42	***-0.02***	***-5%***	1712.4	5306	65352
KB2.91	alb	Ringsjø	70.51	15.33	1.00	0.45	0.54	4.30	6.16	0.42	0.01	0.08	0.99	99.79	0.45	***0.00***	***0%***	1712.4	5310	65355

			SiO2	Al2O3	Fe2O3	TiO2	MgO	CaO	Na2O	K2O	MnO	P2O5	Gl.t.	Sum	TiO2	Rutile	*Rel.% rutile*	Map	UTM-X	UTM-Y
AMPHIBOLITES AND METAGABBROS																				
KB34.91	amphibolite	Farsjø	36.80	12.13	21.35	10.69	6.06	7.75	1.80	0.69	0.17	0.22	-0.17	97.48	10.99	***-0.30***	***-3%***	1712.4	5200	65337
KB32B.91	basic dyke	Farsjø	46.28	14.17	14.56	2.15	7.45	8.59	2.78	1.45	0.20	0.47	0.86	98.97	1.47	***0.68***	***32%***	1712.4	5191	65343
KB5A.91	amphibolite	Fone	45.43	15.61	12.27	1.78	8.07	7.52	6.01	0.69	0.03	0.24	0.86	98.50	0.98	***0.80***	***45%***	1612.1	5042	65229
KB5G.91	rutile amph.	Fone	53.48	5.50	4.85	4.82	10.55	14.68	3.71	0.11	0.03	0.09	0.66	98.48	0.22	***4.60***	***95%***	1612.1	5042	65229
KB5B.91	metas. amph.	Fone	50.55	5.58	4.15	9.05	10.00	13.99	3.52	0.14	0.03	0.08	0.68	97.78	0.22	***8.83***	***98%***	1612.1	5042	65229
KB13.91	basic dyke	Froste	63.81	16.36	4.00	0.85	0.59	0.46	6.43	5.91	0.18	0.23	0.51	99.34	0.63	***0.22***	***26%***	1712.4	5285	65340
KB6C.91	metas. amph.	Gruvetjønn	55.74	7.23	6.62	0.43	9.55	14.05	4.04	0.16	0.08	0.08	0.74	98.72	0.39	***0.04***	***9%***	1612.1	4978	65148
KB6B.91	amphibolite	Gruvetjønn	45.13	15.52	14.78	1.68	7.27	9.04	4.12	0.76	0.09	0.23	0.79	99.40	1.09	***0.59***	***35%***	1612.1	4978	65148
KB6F.91	rutile amph.	Gruvetjønn	39.87	2.48	8.44	19.34	9.43	13.39	1.35	0.11	0.09	0.07	1.80	96.37	4.28	***15.06***	***78%***	1612.1	4978	65148
KB8A.91	gabbro	Krefjell	50.76	15.79	6.20	3.42	5.32	9.88	6.05	0.39	0.03	0.20	0.32	98.37	3.35	***0.07***	***2%***	1612.2	4955	65082
KB8.91	gabbro	Krefjell	48.70	13.36	5.79	7.69	6.85	9.00	5.48	0.28	0.03	0.14	0.47	97.79	1.83	***5.86***	***76%***	1612.2	4955	65082
KB8B.91	metas. gab.	Krefjell	53.23	14.49	2.99	7.87	4.85	7.45	6.43	0.33	0.02	0.09	0.59	98.34	0.29	***7.58***	***96%***	1612.2	4955	65082
KB10C.91	amph./pegm	Laget	55.67	10.75	3.52	1.84	5.94	9.32	5.85	0.16	0.08	0.33	5.69	99.13	0.70	***1.14***	***62%***	1612.2	5044	65046
KB35.91	amf,gang	Ødegård	6.40	1.48	6.88	0.10	5.52	42.38	0.18	0.02	0.42	3.51	29.28	96.18	0.07	***0.03***	***30%***	1712.4	5321	65360
KB50V.91	amf.gang	Ødegård	45.73	14.22	13.26	4.00	4.82	6.58	4.19	1.46	0.17	0.89	2.94	98.27	3.73	***0.27***	***7%***	1712.4	5314	65355
KB14B.91	gab,omv	Ødegårdvt.-N	50.87	14.71	15.55	2.09	3.06	3.97	6.79	0.37	0.03	0.82	1.47	99.73	1.69	***0.40***	***19%***	1712.4	5330	65369
KB14C.91	gab,omv	Ødegårdvt.-N	49.89	14.02	18.69	2.25	2.48	4.18	6.18	0.62	0.03	0.81	0.71	99.86	1.79	***0.46***	***20%***	1712.4	5330	65369
KB14A.91	gab	Ødegårdvt.-N	44.33	16.43	11.36	0.94	11.38	9.24	3.33	1.04	0.07	0.10	1.26	99.46	0.46	***0.48***	***51%***	1712.4	5330	65369
KB4B.91	amf	Ødegård-W	46.06	16.05	12.20	1.23	8.60	9.32	3.97	0.95	0.10	0.18	0.77	99.44	0.76	***0.47***	***38%***	1712.4	5307	65356
KB4D.91	amf,gang	Ødegård-W	40.93	10.55	14.04	2.42	18.61	9.85	1.25	0.21	0.06	0.07	0.72	98.72	0.54	***1.88***	***78%***	1712.4	5307	65356
KB3A.91	gab	Ringsjø	45.80	15.46	14.20	2.10	6.87	8.63	3.69	0.78	0.15	0.28	0.84	98.80	0.72	***1.38***	***66%***	1712.4	5306	65352
KB3B.91	amf	Ringsjø	45.78	15.14	14.33	2.20	6.91	8.33	3.87	0.80	0.14	0.28	1.28	99.06	0.72	***1.48***	***67%***	1712.4	5306	65352
KB39.91	amf	Sannidal	46.17	14.72	11.11	1.62	10.83	8.17	2.70	2.03	0.08	0.27	1.44	99.15	0.68	***0.94***	***58%***	1712.4	5186	65312
KB44.91	amf	Søndeled	45.38	16.57	14.30	2.31	6.40	8.54	2.91	1.18	0.19	0.27	0.67	98.73	1.97	***0.34***	***15%***	1612.1	5050	65149
KB7.91	gab	Tranbæråsen	46.45	14.91	9.78	4.20	7.00	8.29	5.76	0.43	0.06	0.20	0.64	97.72	3.20	***1.00***	***24%***	1612.1	4989	68140
PHLOGOPITE - ENSTATITE - APATITE VEINS , ØDEGÅRD																				
KB12B.91	Phlog.vein	Ødegård	30.43	8.11	2.70	1.46	17.64	14.35	0.83	3.68	0.01	12.37	3.81	95.38	1.55	***-0.09***	***-6%***	1712.4	5318	65357
KB12C.91	Phlog.vein	Ødegård	36.44	8.70	3.66	0.98	21.11	9.55	0.76	3.92	0.01	8.20	3.18	96.31	0.98	***0.00***	***0%***	1712.4	5318	65357
KB12A.91	Phlog.vein	Ødegård	49.96	15.17	1.38	3.10	12.42	4.02	5.62	1.87	0.01	0.81	2.99	97.36	0.60	***2.50***	***81%***	1712.4	5318	65357
KB12G.91	Phlog.vein	Ødegård	49.30	16.28	1.22	3.48	10.63	4.12	6.57	2.25	0.01	1.18	2.40	97.44	0.63	***2.85***	***82%***	1712.4	5318	65357
KB12H.91	Phlog.vein	Ødegård	28.58	5.43	3.20	29.02	14.85	5.10	0.25	0.98	0.01	2.35	5.68	95.44	0.49	***28.53***	***98%***	1712.4	5318	65357

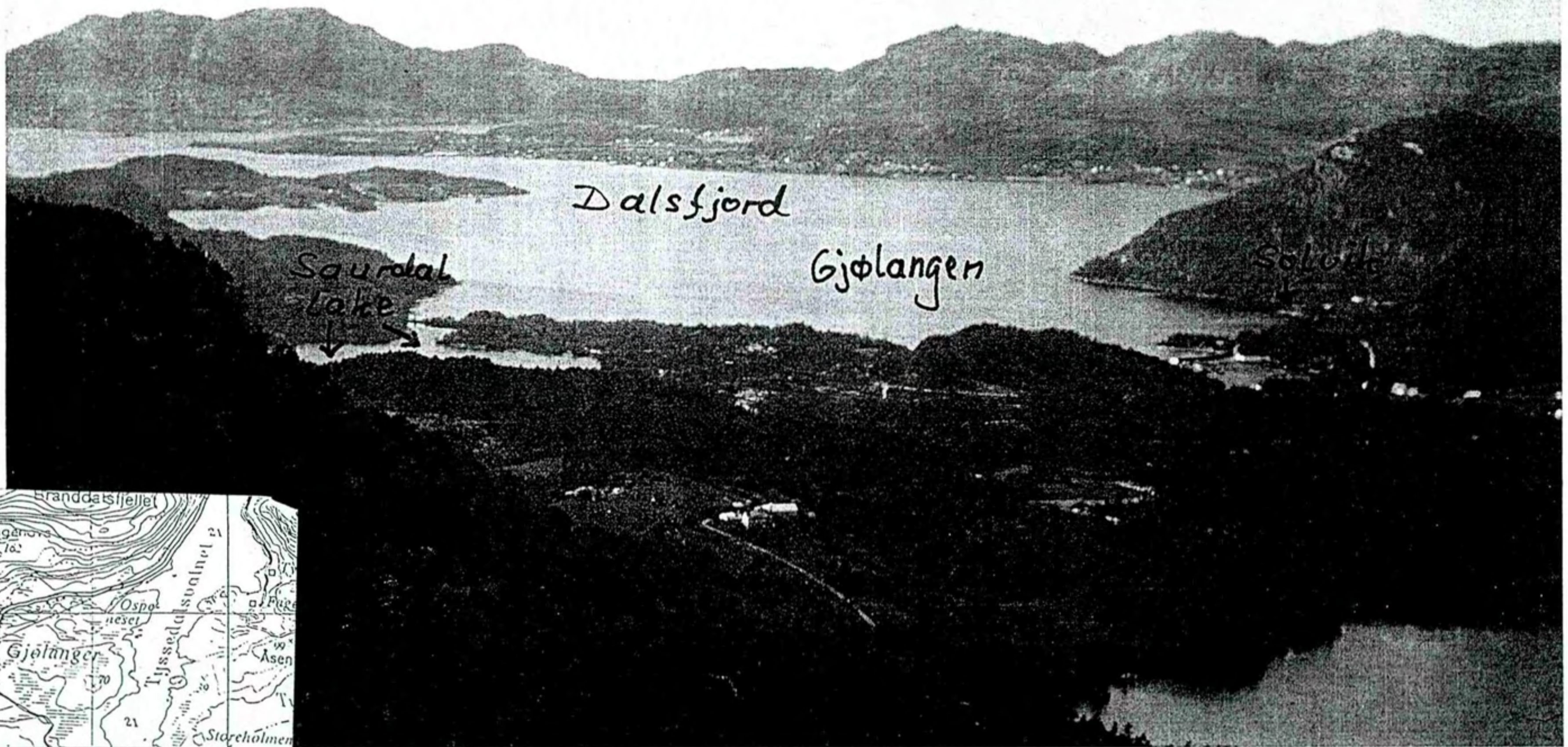
			SiO2	Al2O3	Fe2O3	TiO2	MgO	CaO	Na2O	K2O	MnO	P2O5	Gl.t.	Sum	TiO2	Rutile	*Rel.% rutile*	Map	UTM-X	UTM-Y
GRANITES AND GNEISSES																				
KB6A.91	intermediate	Gruvetjønn	71.42	12.68	3.65	0.76	0.80	2.96	6.15	0.34	0.02	0.16	0.54	99.48	0.80	***-0.04***	***-5%***	1612.1	4978	65148
KB46.91	mangeritic	Størdalsvatnet	64.87	14.26	6.68	0.76	0.80	3.21	3.27	4.36	0.10	0.23	0.20	98.73	0.79	***-0.03***	***-4%***	1612.2	5035	64996
KB5I.91	granitic gn.	Fone	73.68	13.62	1.94	0.24	0.43	1.42	3.64	4.66	0.04	0.06	0.28	100.01	0.24	***0.00***	***0%***	1612.1	5040	65224
KB32A.91	granitic gn.	Farsjø	75.68	12.36	1.39	0.14	0.24	1.08	3.39	4.11	0.02	0.03	0.24	98.67	0.12	***0.02***	***14%***	1712.4	5191	65343
KB40.91	granite	Grøtvatnet	75.43	12.75	1.39	0.15	0.24	1.13	3.62	3.89	0.02	0.03	0.36	99.01	0.12	***0.03***	***20%***	1712.4	5161	65312
KB8C.91	granitic gn.	Krefjell	67.01	13.70	4.55	0.70	1.13	2.43	3.57	5.06	0.08	0.30	0.29	98.82	0.64	***0.06***	***9%***	1612.2	4957	65082
KB45.91	granite	Størdalsvatnet	70.52	13.30	2.30	0.41	1.29	0.97	2.00	6.54	0.01	0.08	1.38	98.78	0.21	***0.20***	***49%***	1612.2	5039	64999
KB47.91	granite	Grimstad	71.47	13.91	1.71	0.31	0.62	0.87	3.68	5.17	0.02	0.09	0.86	98.70	0.05	***0.26***	***84%***			
KB10A.91	granite	Laget	73.69	14.52	0.73	0.62	0.31	0.91	7.77	0.78	0.01	0.04	0.25	99.62	0.26	***0.36***	***58%***	1612.2	5044	65046
METASEDIMENTS																				
KB43B.91	Phlog.-coord. gn.	Gjerstadvt.	51.10	15.64	7.98	2.66	13.58	1.89	0.68	2.42	0.02	0.57	2.40	98.93	0.53	***2.13***	***80%***	1612.1	5035	65244
KB43C.91	Phlog.-coord. gn.	Gjerstadvt.	49.24	15.34	9.32	3.29	13.42	2.34	0.47	2.38	0.03	0.53	2.24	98.61	0.51	***2.78***	***84%***	1612.1	5035	65244
KB43A.91	Phlog.-coord. gn.	Gjerstadvt.	46.19	17.49	10.05	3.59	13.81	3.05	0.43	2.15	0.04	0.72	1.78	99.29	0.51	***3.08***	***86%***	1612.1	5035	65244
KB30A.91	quartzite	Niksjå	93.08	3.27	0.78	0.11	0.86	0.04	0.10	1.02	0.01	0.01	0.61	99.79	0.06	***0.05***	***45%***	1612.3	4882	65004
KB30B.91	quartzite	Niksjå	72.40	13.10	3.59	0.48	1.69	0.81	1.80	3.46	0.02	0.07	1.56	98.98	0.31	***0.17***	***35%***	1612.3	4882	65004
KB30C.91	Phlog.-coord. gn.	Niksjå	56.24	15.73	8.55	1.57	9.66	2.50	0.55	1.88	0.08	0.31	2.43	99.50	0.75	***0.82***	***52%***	1612.3	4882	65004
KB37B.91	Phlog.-coord. gn.	Ødegård	52.30	17.97	6.87	1.65	10.29	0.63	0.32	4.74	0.01	0.34	3.89	99.00	0.76	***0.89***	***54%***	1712.4	5312	65349
KB37C.91	Phlog.-coord. gn.	Ødegård	50.72	17.45	7.42	2.17	12.35	0.89	0.40	3.05	0.03	0.37	4.18	99.03	0.40	***1.77***	***82%***	1712.4	5312	65349
KB37A.91	Phlog.-coord. gn.	Ødegård	47.88	17.73	7.71	2.35	13.35	1.05	0.36	3.65	0.03	0.46	4.25	98.80	0.45	***1.90***	***81%***	1712.4	5312	65349
KB37D.91	Phlog.-coord. gn.	Ødegård	52.24	17.25	5.96	2.96	9.01	1.52	0.24	4.64	0.01	0.70	4.31	98.84	0.61	***2.35***	***79%***	1712.4	5312	65349
KB42C3.91		Sannidal	67.72	10.89	2.63	0.63	9.87	1.09	0.51	2.94	0.01	0.19	1.87	98.36	0.55	***0.08***	***13%***	1612.1	5126	65272
KB42C1.91	All KB42-	Sannidal	68.08	11.06	3.12	0.65	9.49	0.77	0.48	2.86	0.01	0.18	2.18	98.88	0.54	***0.11***	***17%***	1612.1	5126	65272
KB42B1.91	samples:	Sannidal	89.39	3.02	0.71	0.25	3.12	0.06	0.10	0.78	0.01	0.02	0.99	98.36	0.12	***0.13***	***52%***	1612.1	5126	65272
KB42C2.91		Sannidal	74.32	8.85	2.01	0.60	7.18	0.97	0.54	2.21	0.01	0.12	1.38	98.18	0.47	***0.13***	***22%***	1612.1	5126	65272
KB42B3.91	quartz-rich	Sannidal	83.84	5.72	1.17	0.32	4.40	0.09	0.10	0.95	0.01	0.04	1.69	98.20	0.15	***0.17***	***53%***	1612.1	5126	65272
KB42A3.91	coordierite-	Sannidal	92.56	2.65	0.21	0.23	1.85	0.21	0.10	0.11	0.01	0.04	0.65	98.59	0.02	***0.21***	***91%***	1612.1	5126	65272
KB42A2.91	bearing	Sannidal	92.11	2.90	0.28	0.26	2.15	0.23	0.10	0.16	0.01	0.04	0.59	98.80	0.04	***0.22***	***85%***	1612.1	5126	65272
KB42B2.91	gneisses	Sannidal	76.28	7.59	2.52	0.58	6.65	0.15	0.15	2.42	0.01	0.04	1.79	98.18	0.34	***0.24***	***41%***	1612.1	5126	65272
KB42A1.91		Sannidal	88.96	3.27	0.36	0.34	3.01	0.22	0.10	0.38	0.01	0.05	1.22	97.86	0.09	***0.25***	***74%***	1612.1	5126	65272

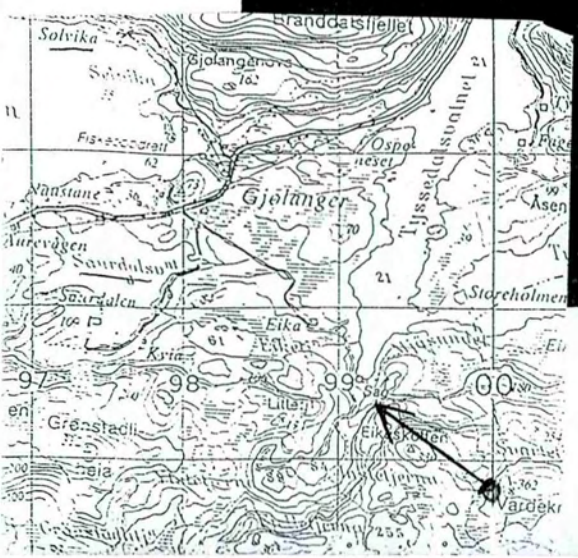
			SiO2	Al2O3	Fe2O3	TiO2	MgO	CaO	Na2O	K2O	MnO	P2O5	Gl.t.	Sum	TiO2	Rutile	*Rel.% rutile*	Map	UTM-X	UTM-Y
PEGMATITES																				
KB11F.91	pegm	Lindvikkollen	69.14	19.26	0.17	0.02	0.01	0.98	10.16	0.97	0.01	0.01	0.33	101.00	0.01	***0.01***	***50%***	1712.4	5214	65254
KB3D.91	pegm	Ringsjø	74.75	14.97	0.20	0.02	0.10	0.91	5.76	2.88	0.01	0.01	0.42	100.02	0.01	***0.01***	***50%***	1712.4	5306	65352
KB5H.91	pegm	Fone	64.17	18.68	0.31	3.04	0.27	1.41	10.65	0.25	0.01	0.14	0.35	99.29	0.10	***2.94***	***97%***	1612.1	5042	65229
KB6E.91	pegm	Gruvetjønn	75.82	14.12	0.27	0.06	0.12	1.52	6.74	0.55	0.01	0.02	0.88	100.10	0.05	***0.01***	***17%***	1612.1	4978	65148
KB36.91	pegm	Ødegård	72.89	13.05	1.13	0.22	0.24	0.87	3.63	5.77	0.01	0.05	0.63	98.47	0.10	***0.12***	***55%***	-	-	-
KB4C.91	pegm	Ødegård- W	69.78	17.43	0.40	0.19	0.28	2.22	8.98	0.26	0.01	0.18	0.99	100.73	0.06	***0.13***	***68%***	1712.4	5307	65356
KB9A.91	pegm	Haukåsen	55.19	14.49	5.19	1.03	8.68	6.14	4.87	1.05	0.04	1.16	1.49	99.33	0.32	***0.71***	***69%***	1612.2	4940	65052
KB9B.91	pegm	Haukåsen	60.20	18.49	1.55	3.22	2.09	4.21	6.97	1.08	0.01	0.72	0.85	99.38	0.31	***2.91***	***90%***	1612.2	4940	65052
KB9C.91	pegm	Haukåsen	55.93	16.67	0.88	12.36	1.26	2.34	5.95	1.90	0.01	0.03	1.55	98.86	0.16	***12.20***	***99%***	1612.2	4940	65052
SCAPOLITIZED METAGABBRO (ØDEGÅRDITE) FROM ØDEGÅRDEN																				
KB51A.91	scap. metag.	Ødegård-NE	52.33	15.40	2.58	3.98	6.30	7.06	7.01	0.63	0.01	0.73	1.85	97.89	0.47	***3.51***	***88%***	1712.4	5321	65360
KB51C.91	scap. metag.	Ødegård-NE	53.14	17.85	1.22	3.92	5.76	4.66	7.99	0.92	0.01	0.40	1.97	97.83	0.30	***3.62***	***92%***	1712.4	5321	65360
KB51B.91	scap. metag.	Ødegård-NE	52.44	17.02	1.96	4.08	5.59	6.70	7.64	0.61	0.01	0.51	1.20	97.75	0.26	***3.82***	***94%***	1712.4	5321	65360
KB51D.91	scap. metag.	Ødegård-NE	52.01	17.17	1.82	4.19	5.74	6.80	7.64	0.57	0.01	0.35	1.43	97.73	0.24	***3.95***	***94%***	1712.4	5321	65360
KB52E.91	scap. metag.	Ødegård-SW	56.37	15.90	2.58	2.05	6.64	5.92	6.50	0.60	0.01	0.34	1.38	98.29	0.20	***1.85***	***90%***	1712.4	5318	65357
KB52A.91	scap. metag.	Ødegård-SW	50.07	16.81	3.19	3.05	7.37	8.53	6.57	0.54	0.02	0.39	0.92	97.46	0.52	***2.53***	***83%***	1712.4	5318	65357
KB52B.91	scap. metag.	Ødegård-SW	49.98	17.39	2.82	3.01	7.44	7.62	6.59	0.73	0.01	0.43	1.50	97.52	0.40	***2.61***	***87%***	1712.4	5318	65357
KB52D.91	scap. metag.	Ødegård-SW	49.88	17.08	3.21	3.11	7.47	7.79	6.53	0.81	0.01	0.45	1.33	97.67	0.43	***2.68***	***86%***	1712.4	5318	65357
KB52C.91	scap. metag.	Ødegård-SW	49.92	17.01	3.12	3.14	7.29	8.18	6.60	0.66	0.01	0.43	1.14	97.49	0.31	***2.83***	***90%***	1712.4	5318	65357
KB12F.91	sand	Ødegård-SW	27.47	7.18	2.45	1.33	11.98	19.91	1.38	1.81	0.01	16.66	4.18	94.37	0.80	***0.53***	***40%***	1712.4	5318	65357

Appendix 7:

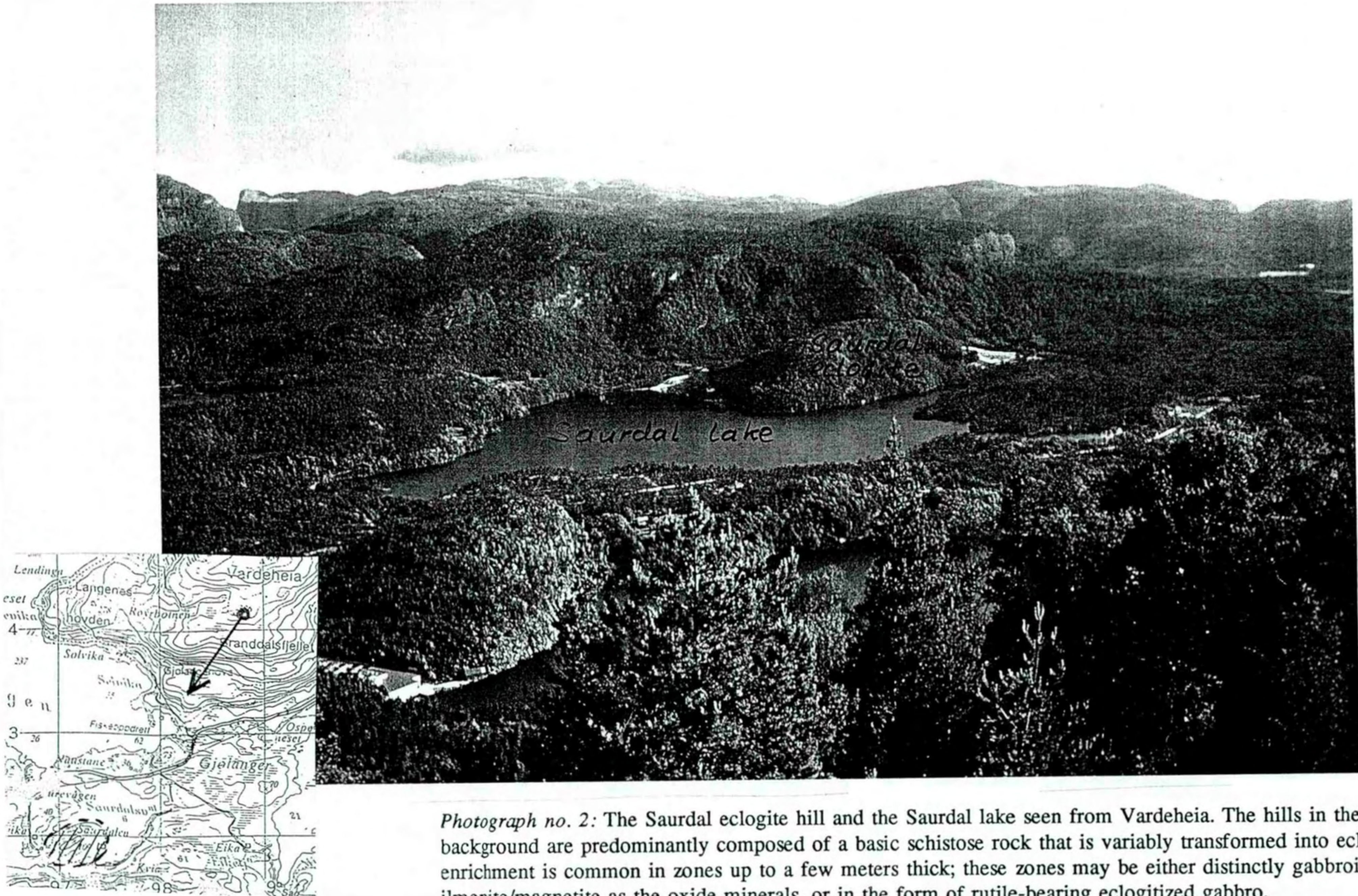
39 black and white copies of colored photographs from the Dalsfjord region, Sogn og Fjordane.

The original color copies are sent to DuPont.

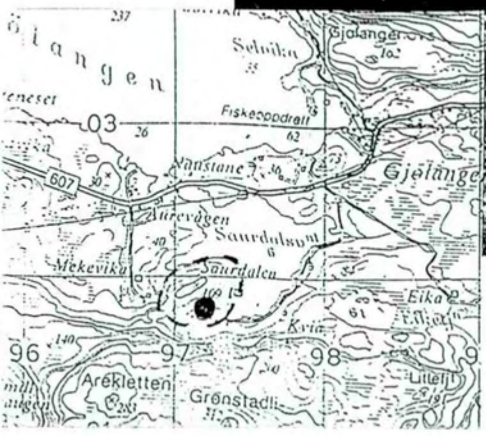




Photograph no. 1: Gjølangen bay seen from Vardeknolten.

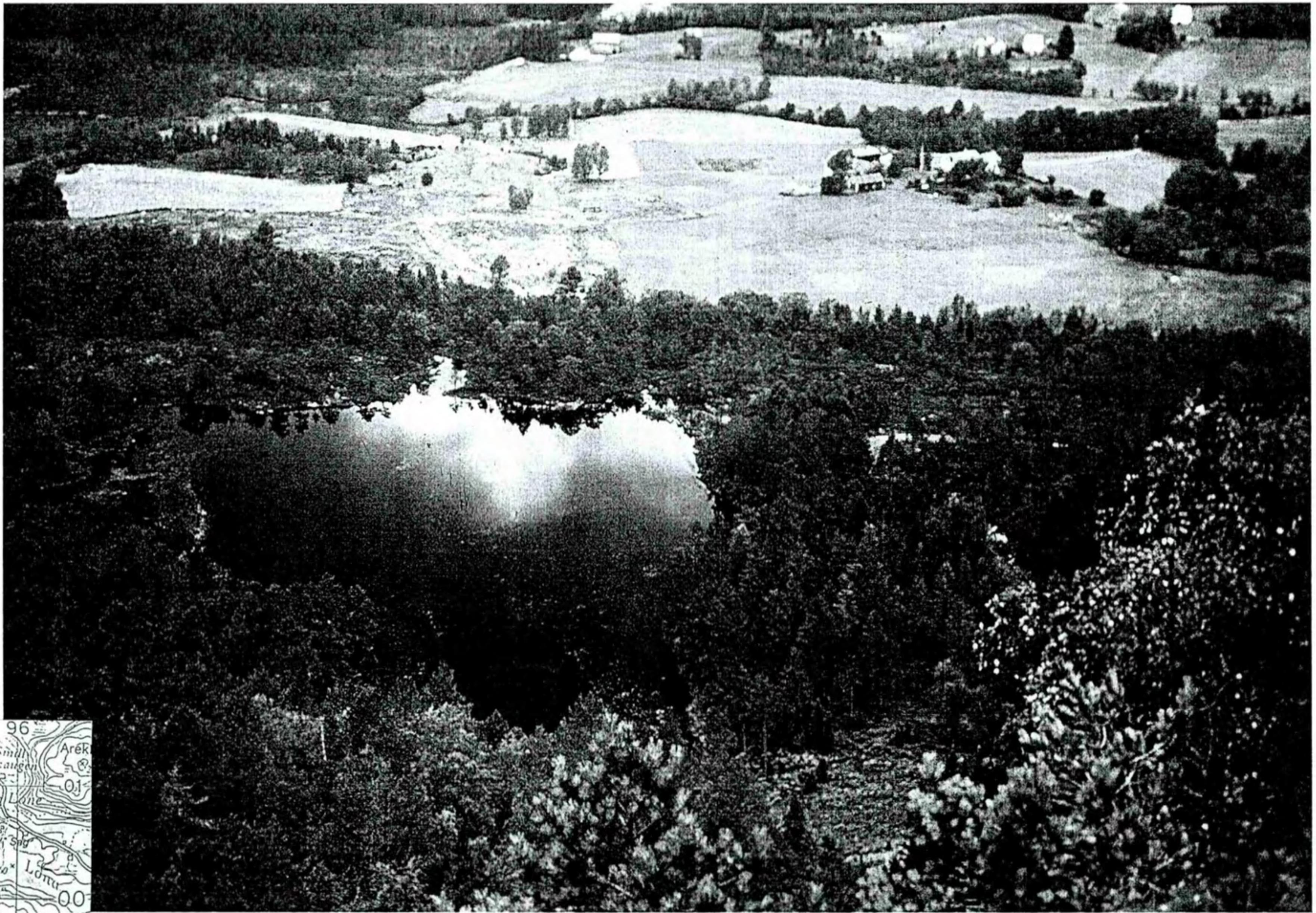


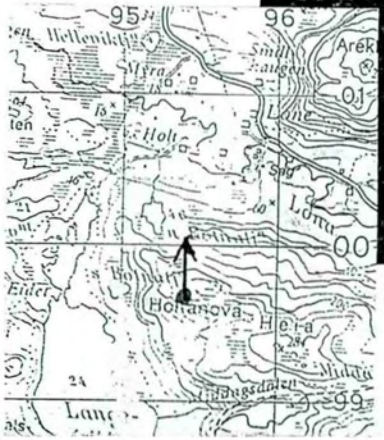
Photograph no. 2: The Saurdal eclogite hill and the Saurdal lake seen from Vardeheia. The hills in the background are predominantly composed of a basic schistose rock that is variably transformed into eclogite. Ti-enrichment is common in zones up to a few meters thick; these zones may be either distinctly gabbroic, with ilmenite/magnetite as the oxide minerals, or in the form of rutile-bearing eclogitized gabbro.



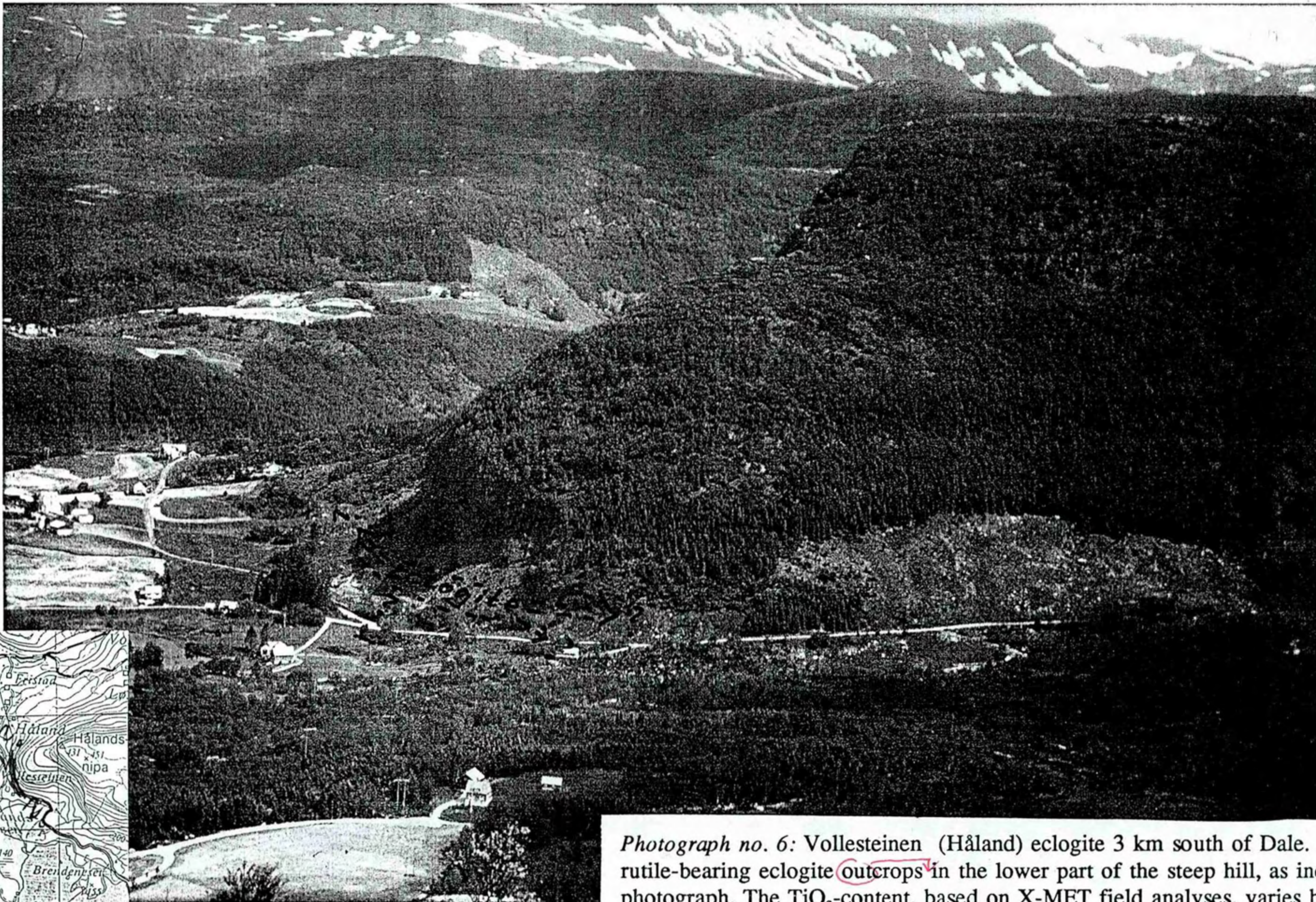
Photograph no. 3: The Saurdal block-stone quarry. The quarry contains a white-mica-rich variety of the Saurdal eclogite mined for 3-4 years for ornamental/polished-stone purposes. The eclogite, however, is very fractured and production of sufficiently-sized eclogite blocks proved difficult; the mining activity ceased in 1992.

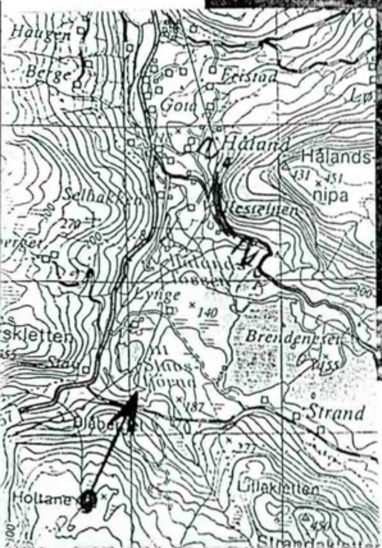
Photograph no. 4: The northern end of Langsjøen lake seen from the Holtanova hill. The dominant rock is a coarse, gabbroic to anorthositic rock that is partly transformed into eclogite. The slabs to the left of the small lake in the foreground are low-Ti coronitic variations of the eclogite. This type of eclogite is often very resistant to erosion and tends to stand out on the landscape; eclogites rich in iron and titanium are often more easily eroded. The titanium mineralization characterized by rutile/ilmenite is very inhomogeneous. X-MET field analyses indicates values varying from less than 1% to 5-6% TiO_2.



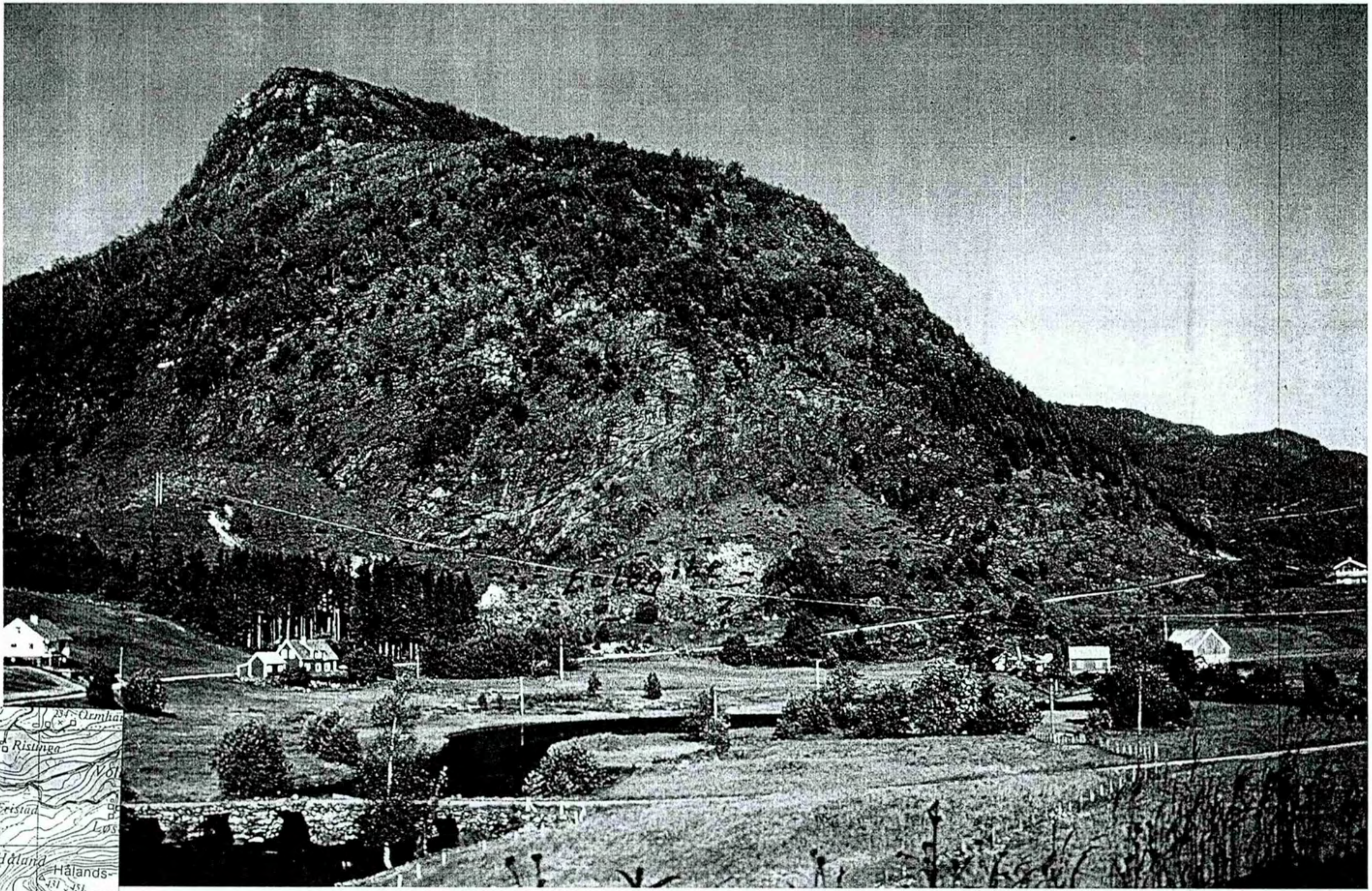


Photograph no. 5: Botnatjønn lake seen from Holtanova. The rocks in this area are equivalent to those to the west/northwest of Holtanova (see the text in Photograph no. 4).



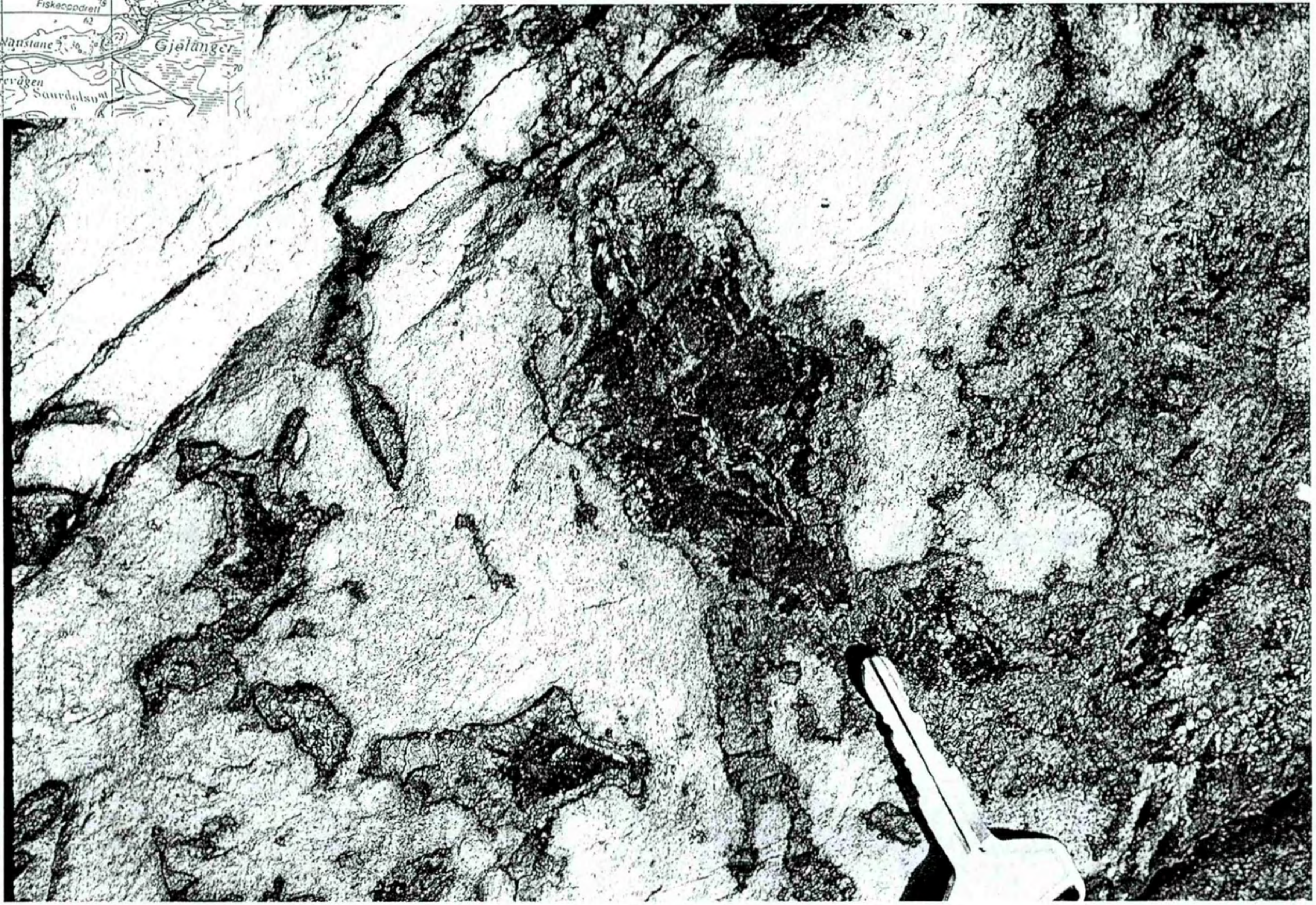


Photograph no. 6: Vollesteinen (Håland) eclogite 3 km south of Dale. A zone of rutile-bearing eclogite outcrops in the lower part of the steep hill, as indicated on the photograph. The TiO_2-content, based on X-MET field analyses, varies between 1 and 5-6%. The rutile/TiO_2 ratio is unknown. The surrounding hills, especially southwards towards Flekke, contain numerous small lenses/layers of a rutile- and garnet-rich eclogite rarely exceeding 2-3m in width. This type of eclogite is frequently found in boulders along rivers and in till in this area. See also Photograph no. 7.

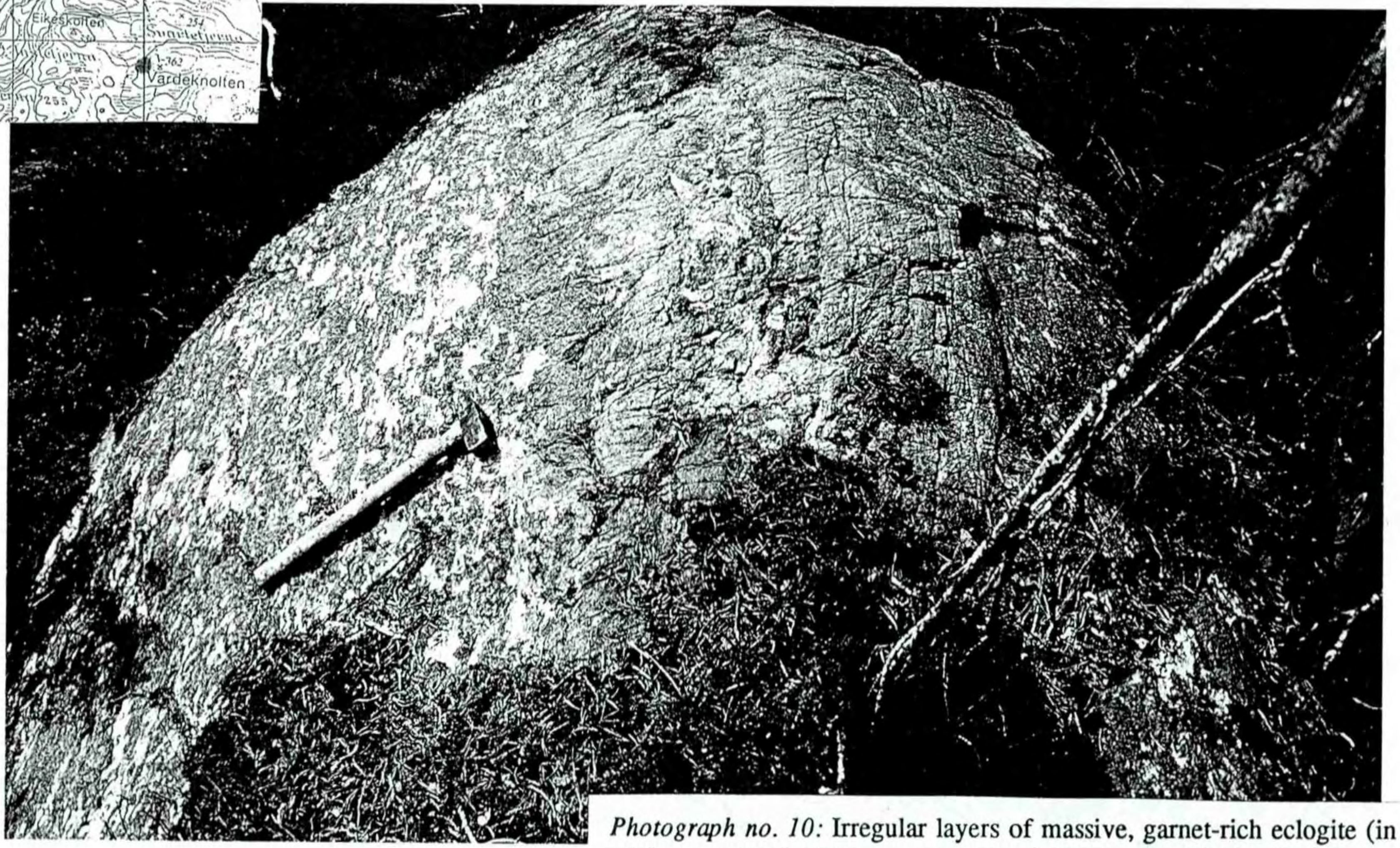


Photograph no. 7: The Vollesteinen eclogite seen from the NW. See also Photograph no. 6.

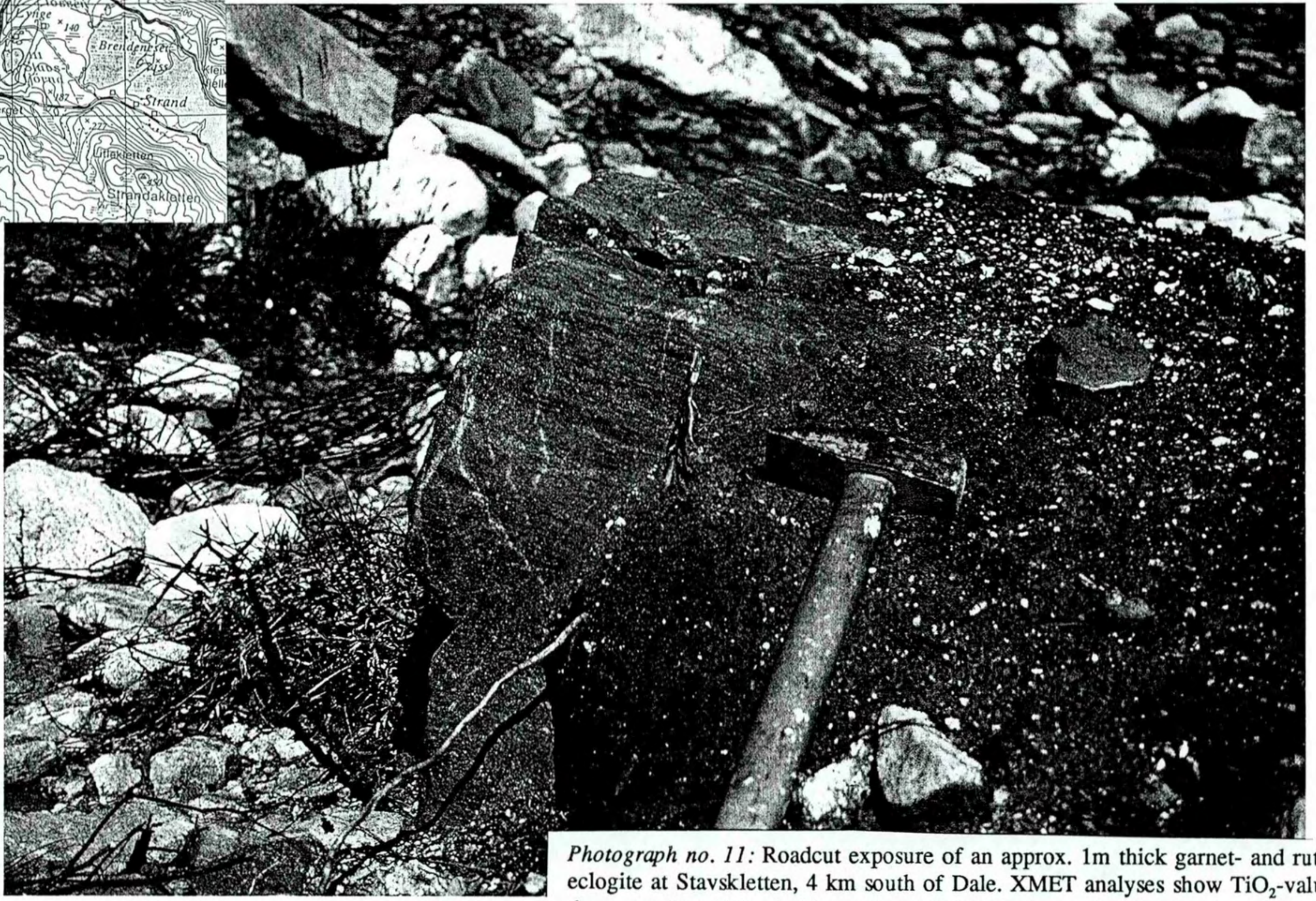
Photograph no. 8: Boulders along an old road near Lonedalstjønn 2 km SE of of Saurdal. Boulders may be inspected when searching for new rutile-rich eclogites since rock-types present in-situ in an area may be reasonably reflected in composition of the boulders.



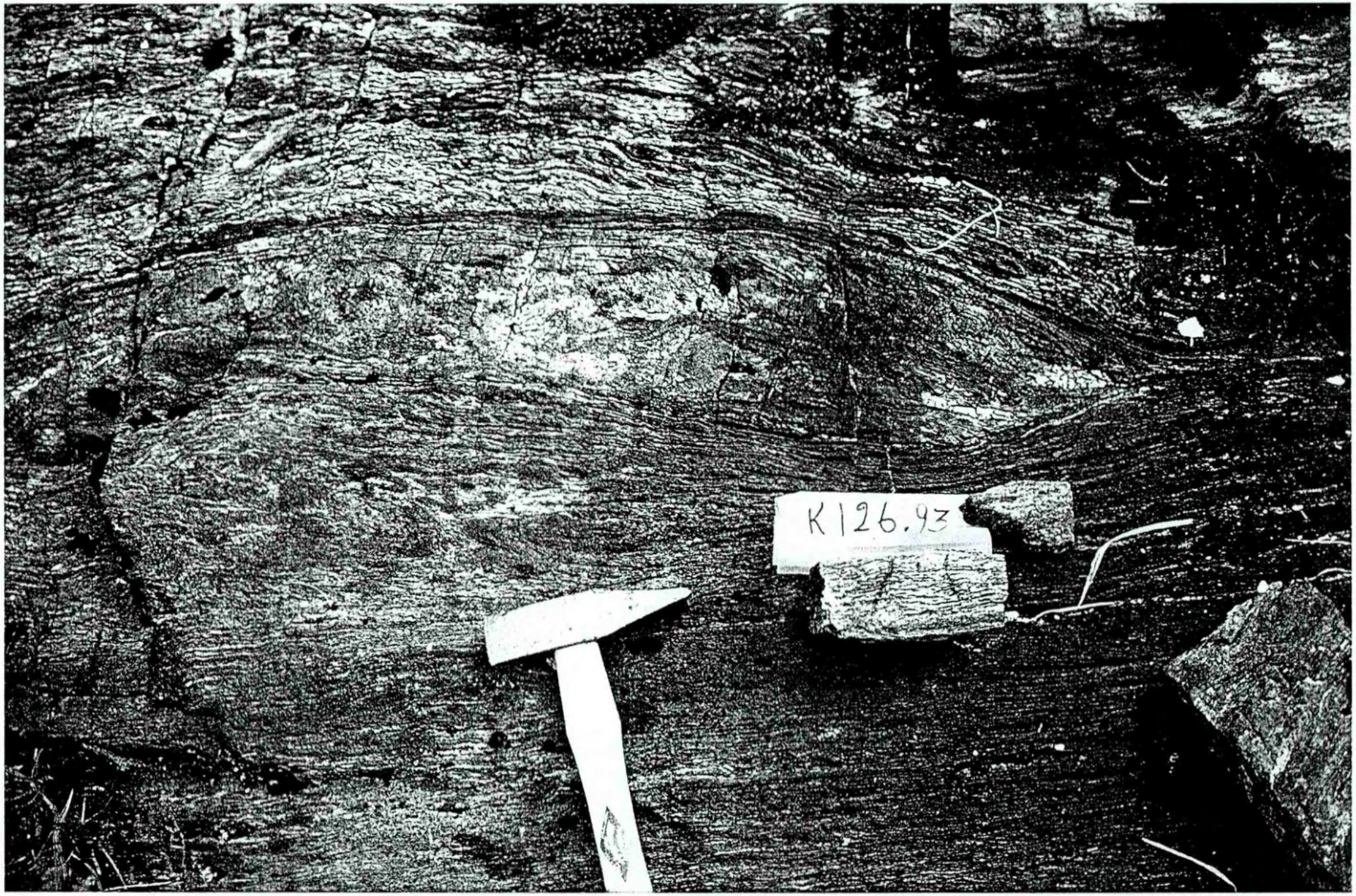
Photograph no. 9: Very coarse variety of a coronitic eclogite at Solvik, Gjølanger. Variations of coronitic eclogites are frequently found in the Gjølanger area; the Hovden eclogite 2 km NW of Saurdal, is the most significant eclogite of this type.



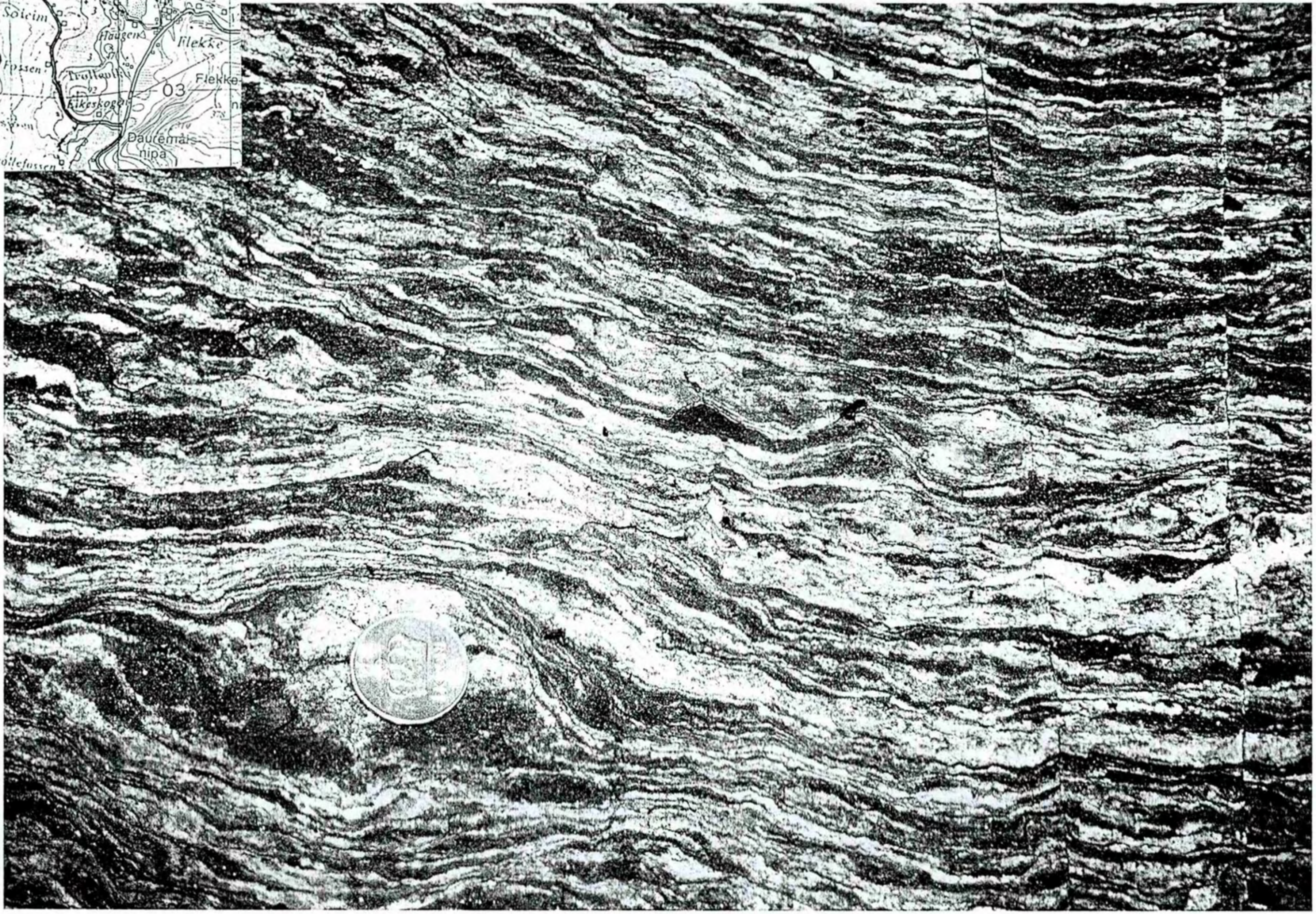
Photograph no. 10: Irregular layers of massive, garnet-rich eclogite (in the right part of the exposure) within a coronitic eclogite (to the left) in the hills south of Saurdal. The garnet-rich eclogite is also distinctly rutile-rich (4-5% rutile and more). Such rutile-rich eclogites are frequent in the area and have thicknesses up to a few meters. They are believed to represent iron- (and titanium-) rich layers in a original layered gabbroic intrusion. In some cases such Fe-Ti rich eclogites have cross-cutting relationships to the layering in the surrounding metagabbro/eclogite indic… originally intrusive origin.



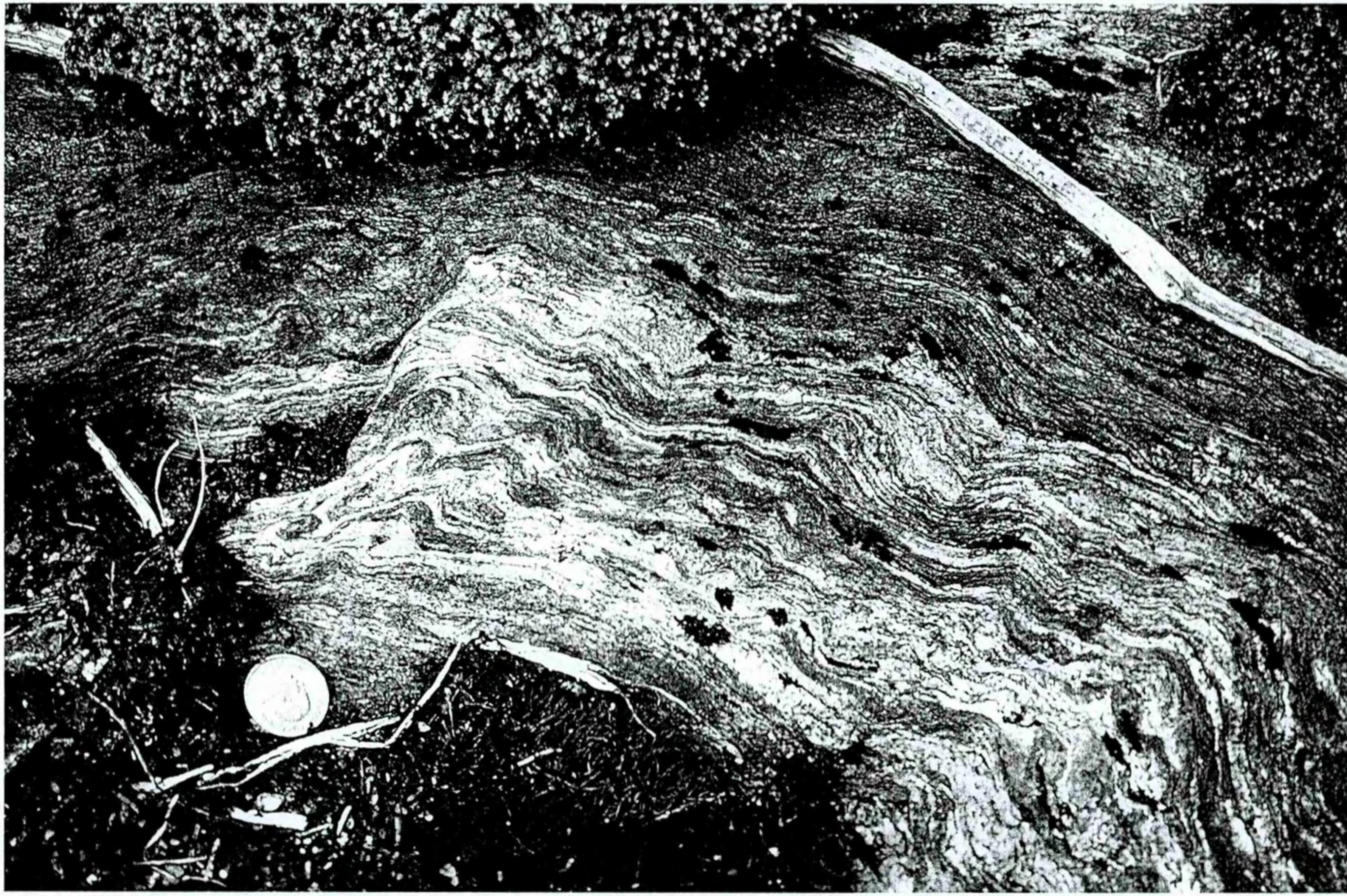
Photograph no. 11: Roadcut exposure of an approx. 1m thick garnet- and rutile-rich eclogite at Stavskletten, 4 km south of Dale. XMET analyses show TiO_2-values in the range 5 to 10%. A thin-section (K117.93) shows that the titanium occurs as rutile with only traces of ilmenite. This type of rutile-rich eclogite is widely distributed in the Dalsfjord region as layers, lenses or dykes in various eclogitized rocks, and as loose boulders.



Photograph no. 12: Sheared, partly eclogitic, gabbroic rock with a lens of garnet-rich, rutile-bearing eclogite east of Flekke (loc. K126.93). This appearance is characteristic for the basic rocks in the Gjølanger - Flekke area (called metabasite by Simon Cuthbe 1985

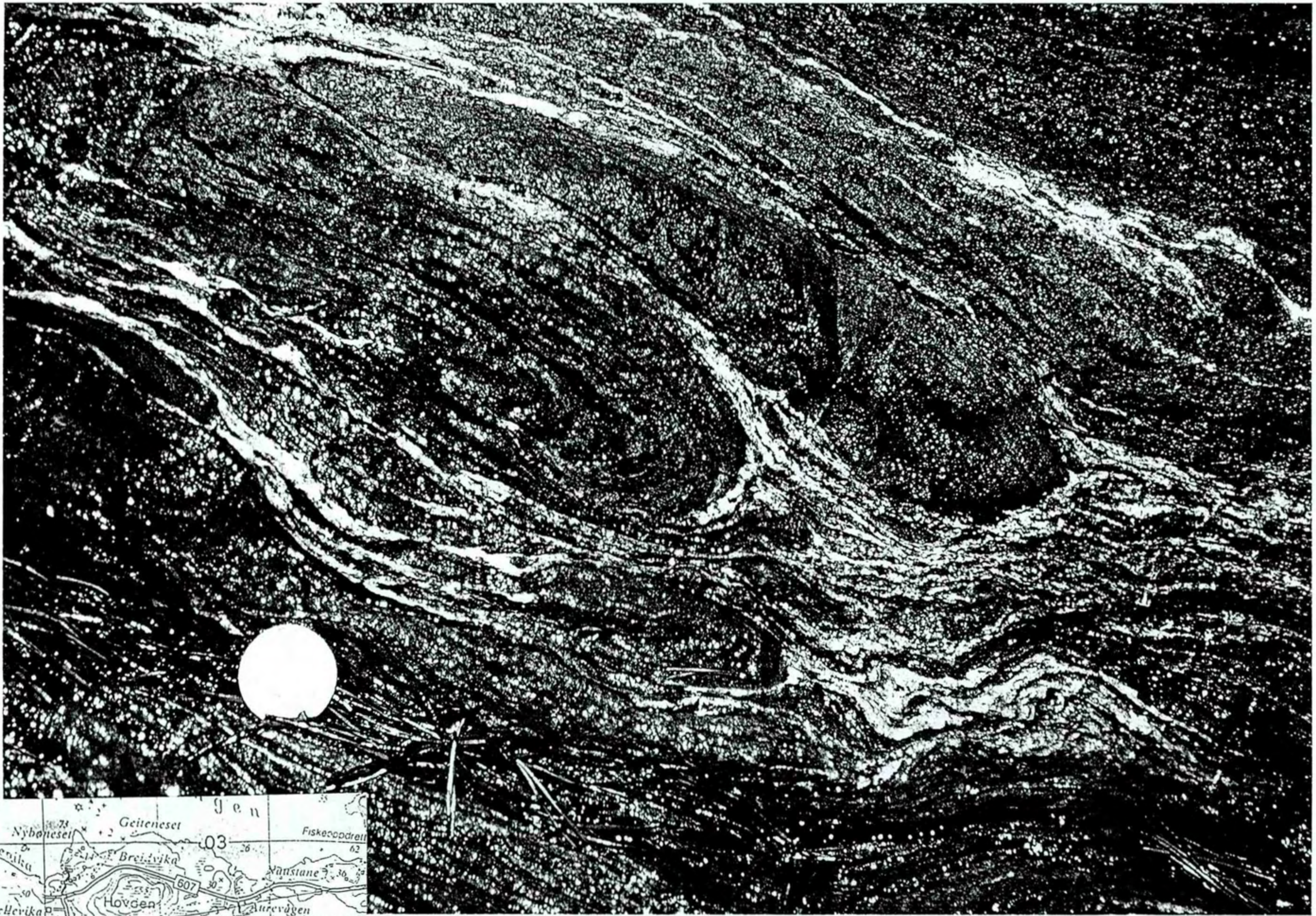


Photograph no. 13: Sheared gabbro (metabasite) well-exposed along a new road (not indicated on the map) in the eastern slope of Håheia (locality K170.93). Such rocks frequently show transitions into eclogite.

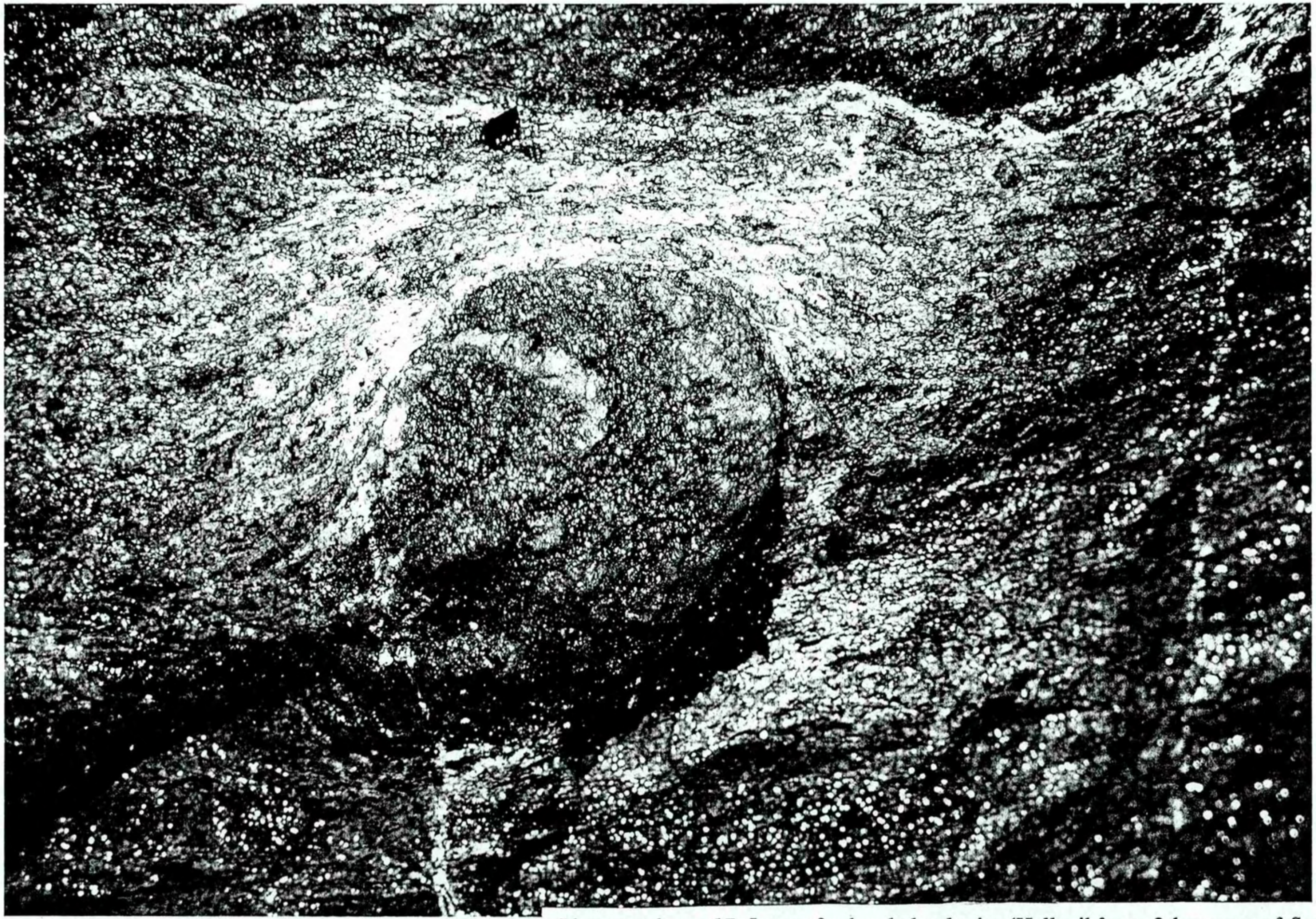


Photograph no. 14: Folded, compositionally banded eclogite east of Flekke.

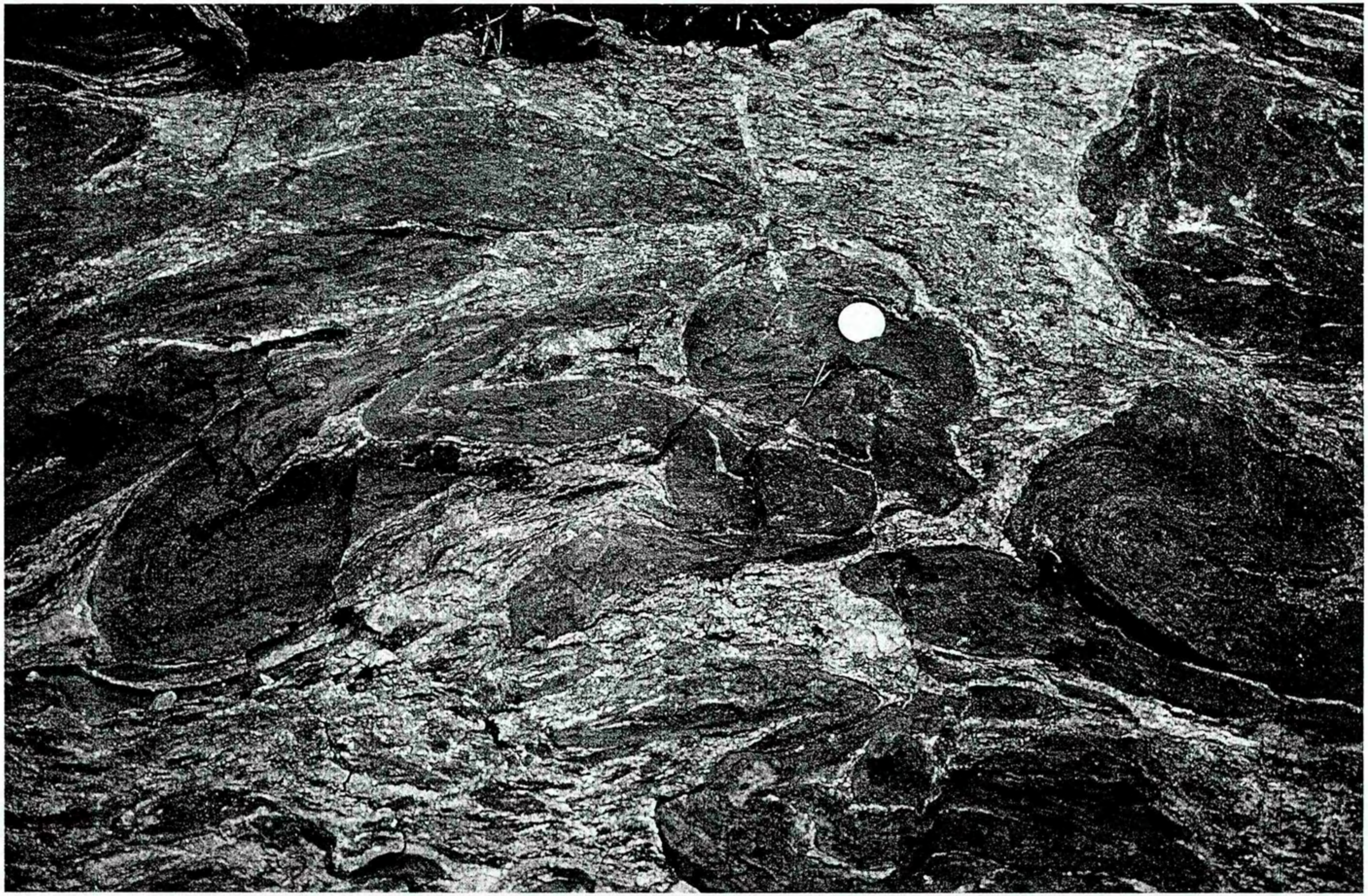
Photograph no. 15: Folded, banded eclogite east of Flekke.



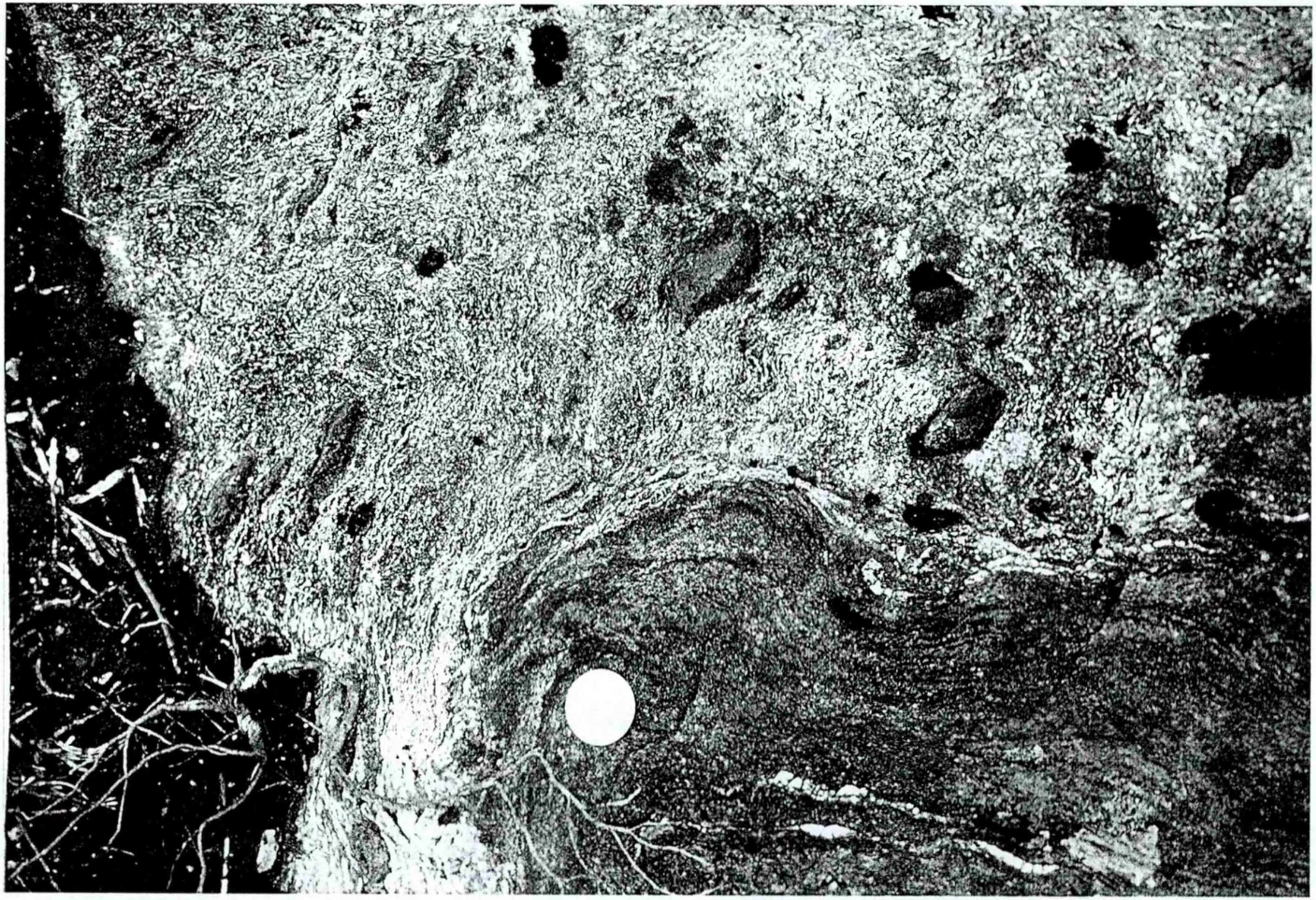
Photograph no. 16: Folded eclogite infiltrated by a quartz-rich, felsic rock at Hellevikåsen, Gjølanger area.



Photograph no. 17: Lens of a banded eclogite (Hellevikåsen, 2 km west of Saurdal) surrounded by a fairly felsic rock. The felsic unit is a variety of the tonalitic rock frequently found in the eclogite terrains south of Dalsfjord and on both sides of Førdefjord.

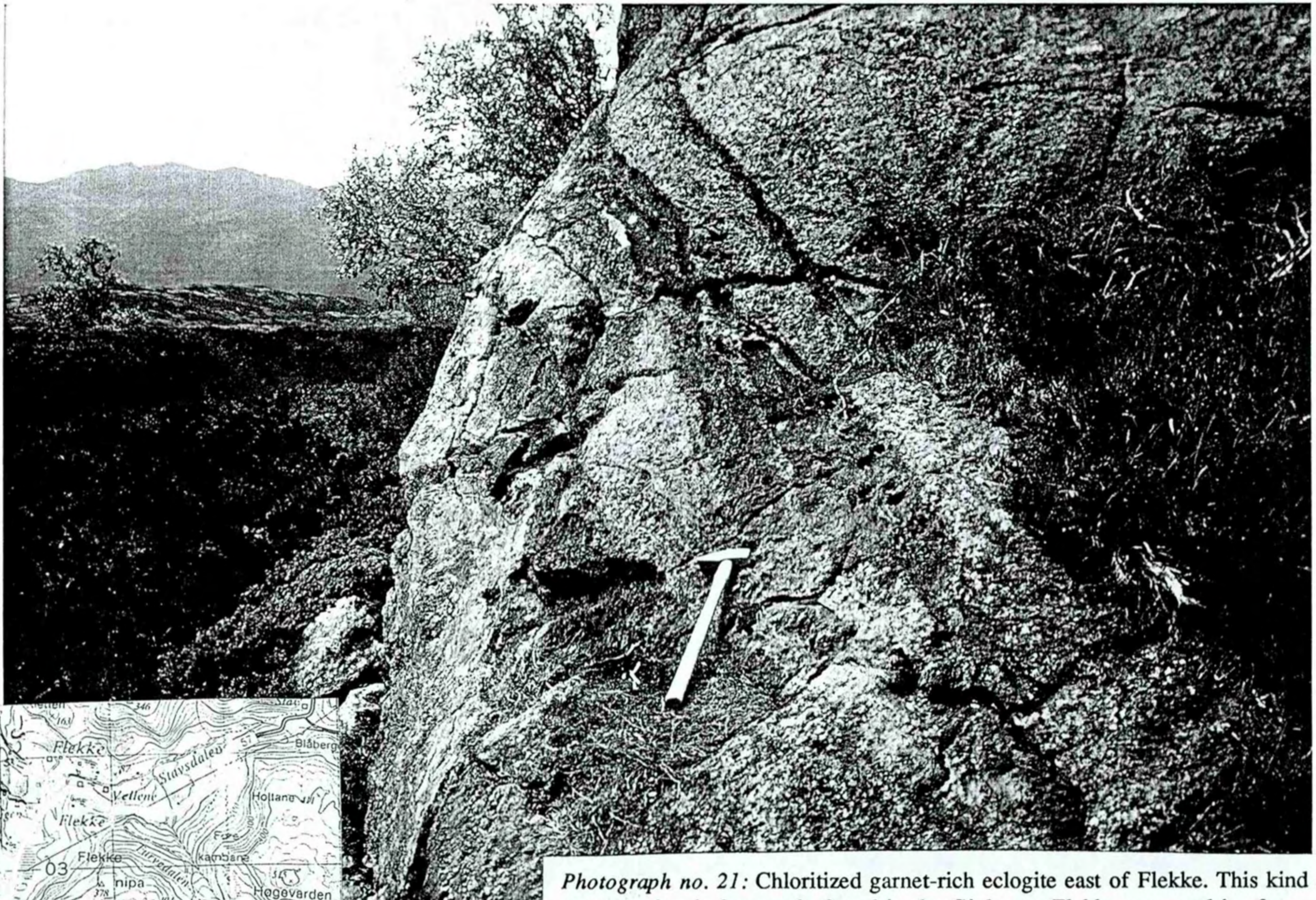


Photograph no. 18: Eclogite infiltrated by a quartz-rich felsic rock at Furevik, Førdefjord.

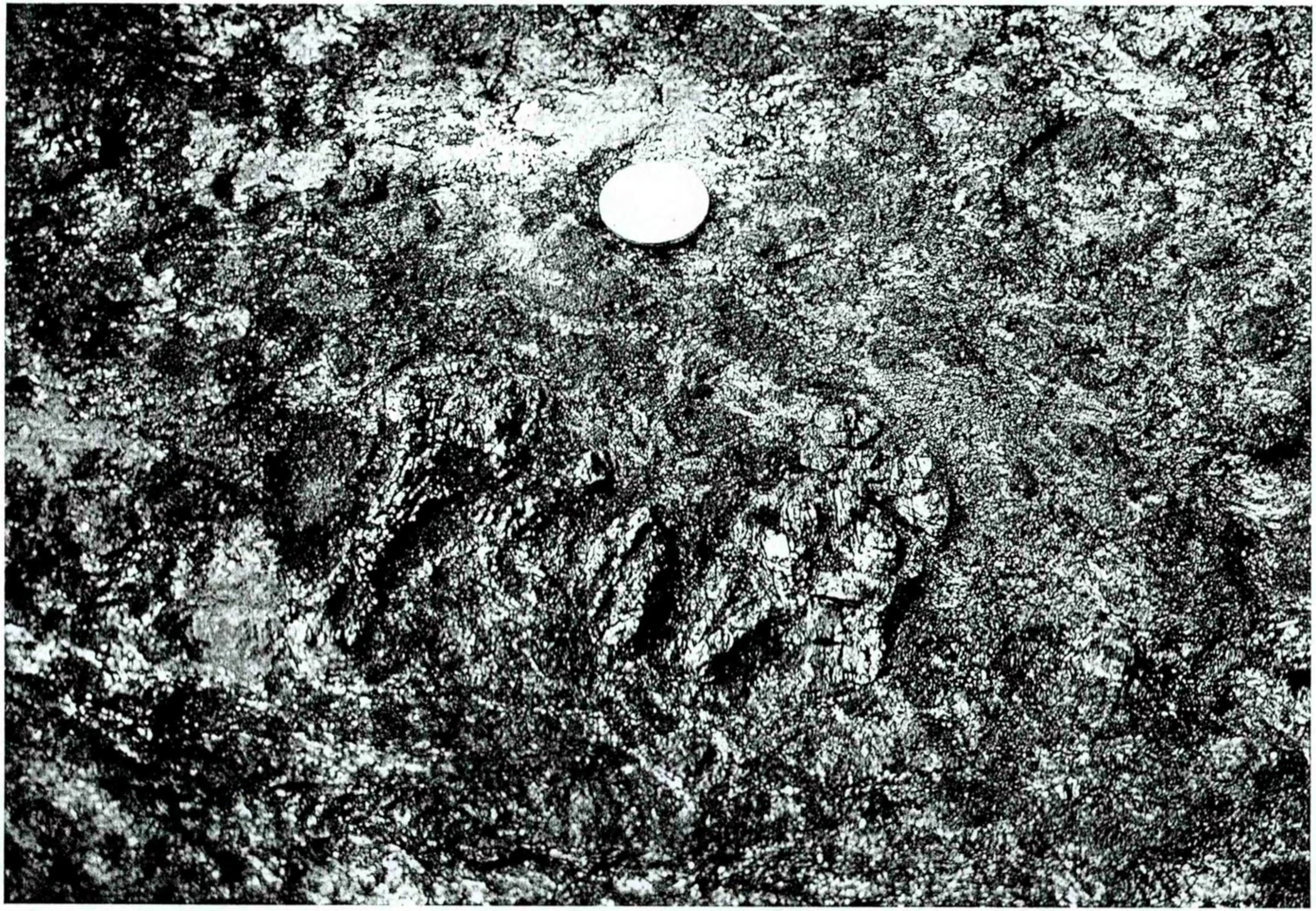


Photograph no. 19: Eclogite intruded by a felsic rock, east of Flekke. This felsic rock is believed to have intruded before or under the eclogitization event. Similar felsic rocks are very common in the Gjølanger-Flekke area.

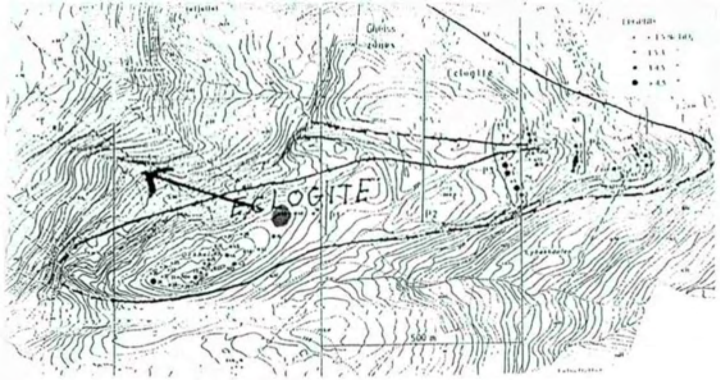
Photograph no. 20: Lens of folded eclogite within a quartz-rich felsic rock at Hellevikåsen, Gjølanger area.

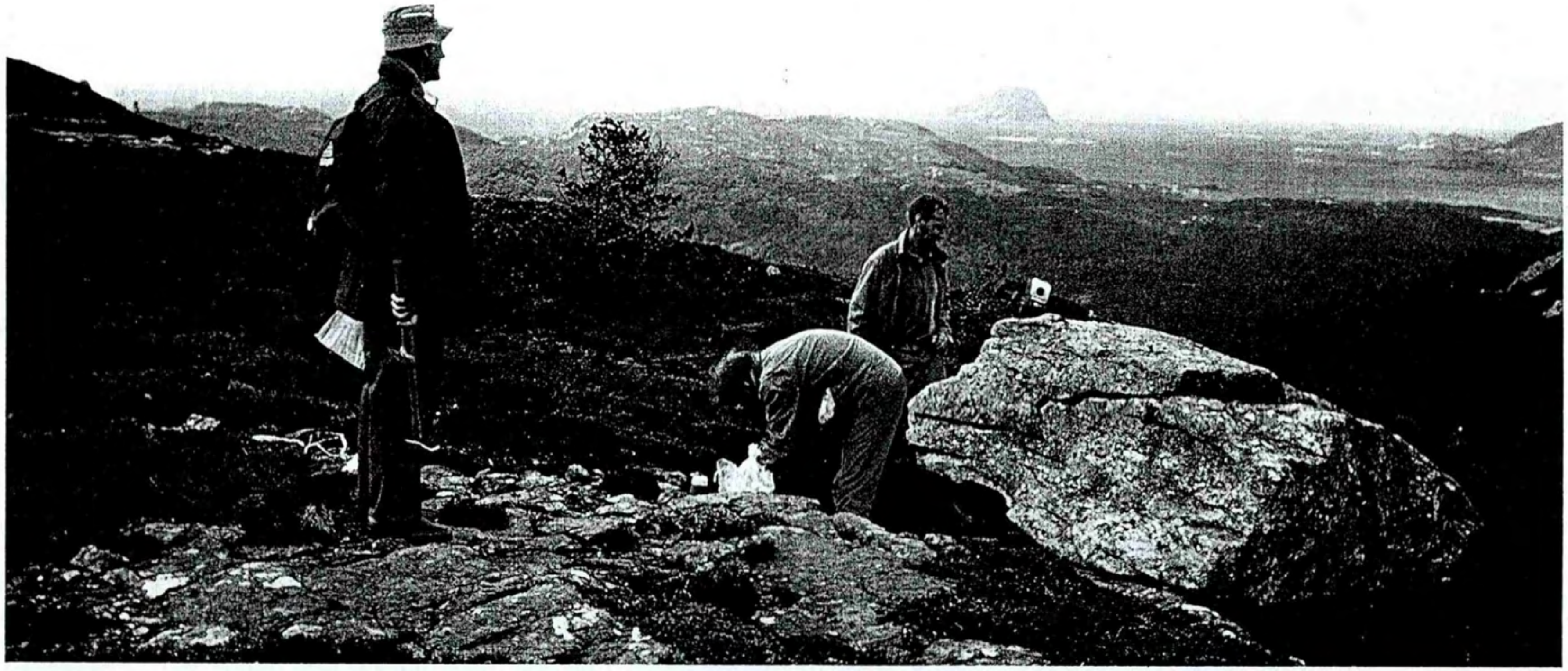


Photograph no. 21: Chloritized garnet-rich eclogite east of Flekke. This kind of retrogression is frequently found in the Gjølanger-Flekke area, and is often accompanied by the formation of secondary magnetite. Therefore, such rocks are strongly magnetic. A distinct magnetic anomaly at Flekke (aeromagnetic map Måløy 1:250000) is caused by such extensive chloritization and accompanying formation of

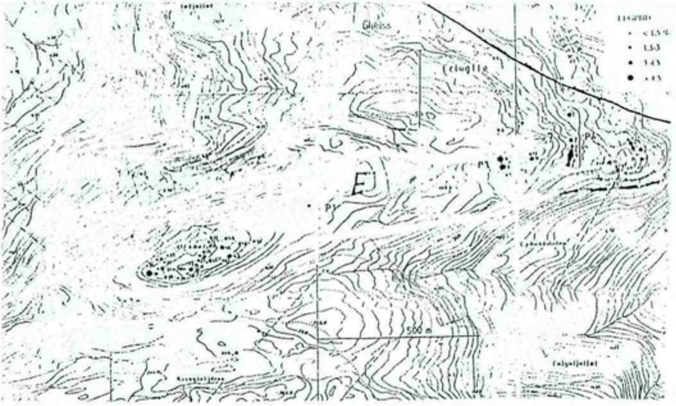


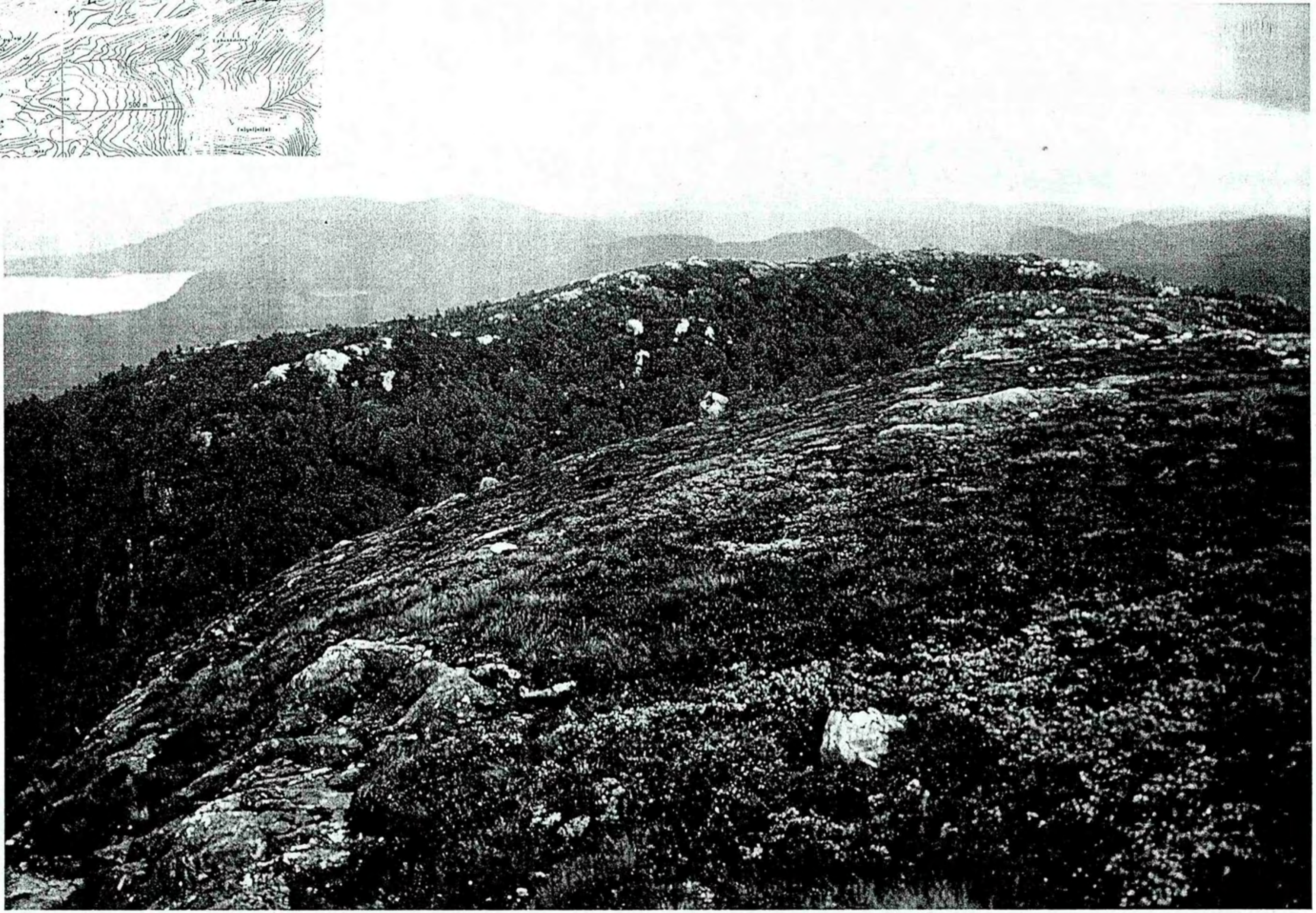
Photograph no. 22: Garnet relics in the chloritized eclogite east of Flekke. See also Photograph no. 21.



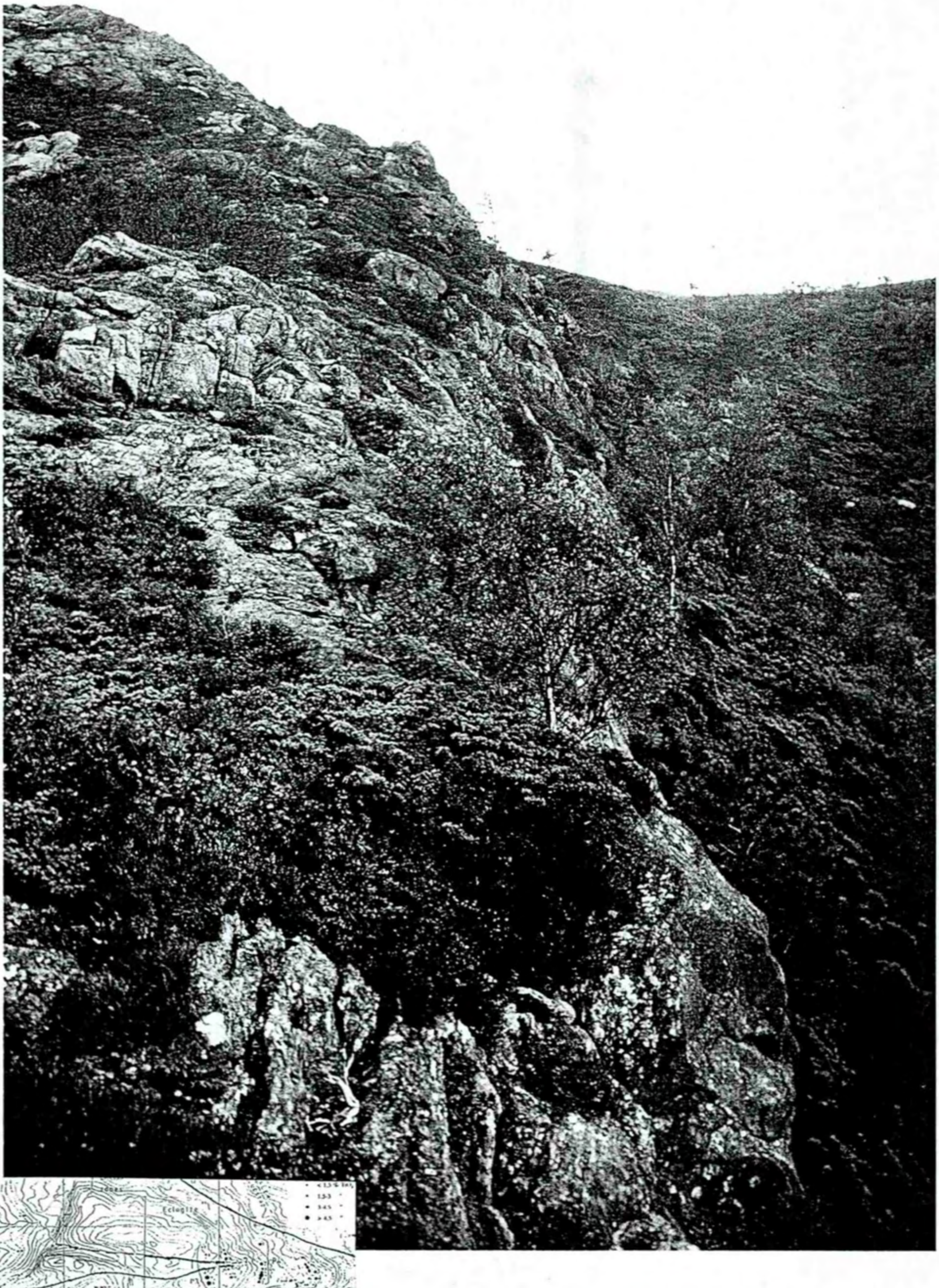


Photograph no. 23: View from Orkheia towards the northwest, with Magnus Garso, Svein Parr and Leif Furuhaug in the foreground.



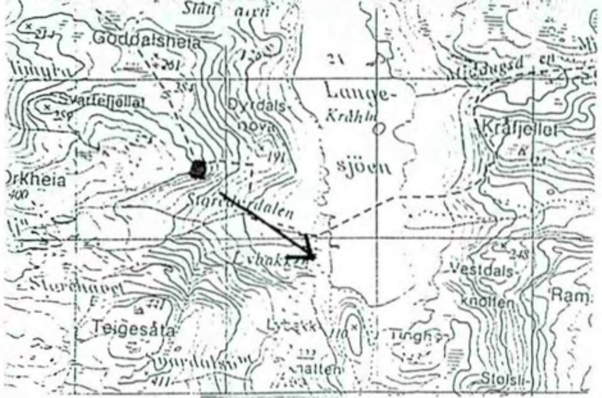


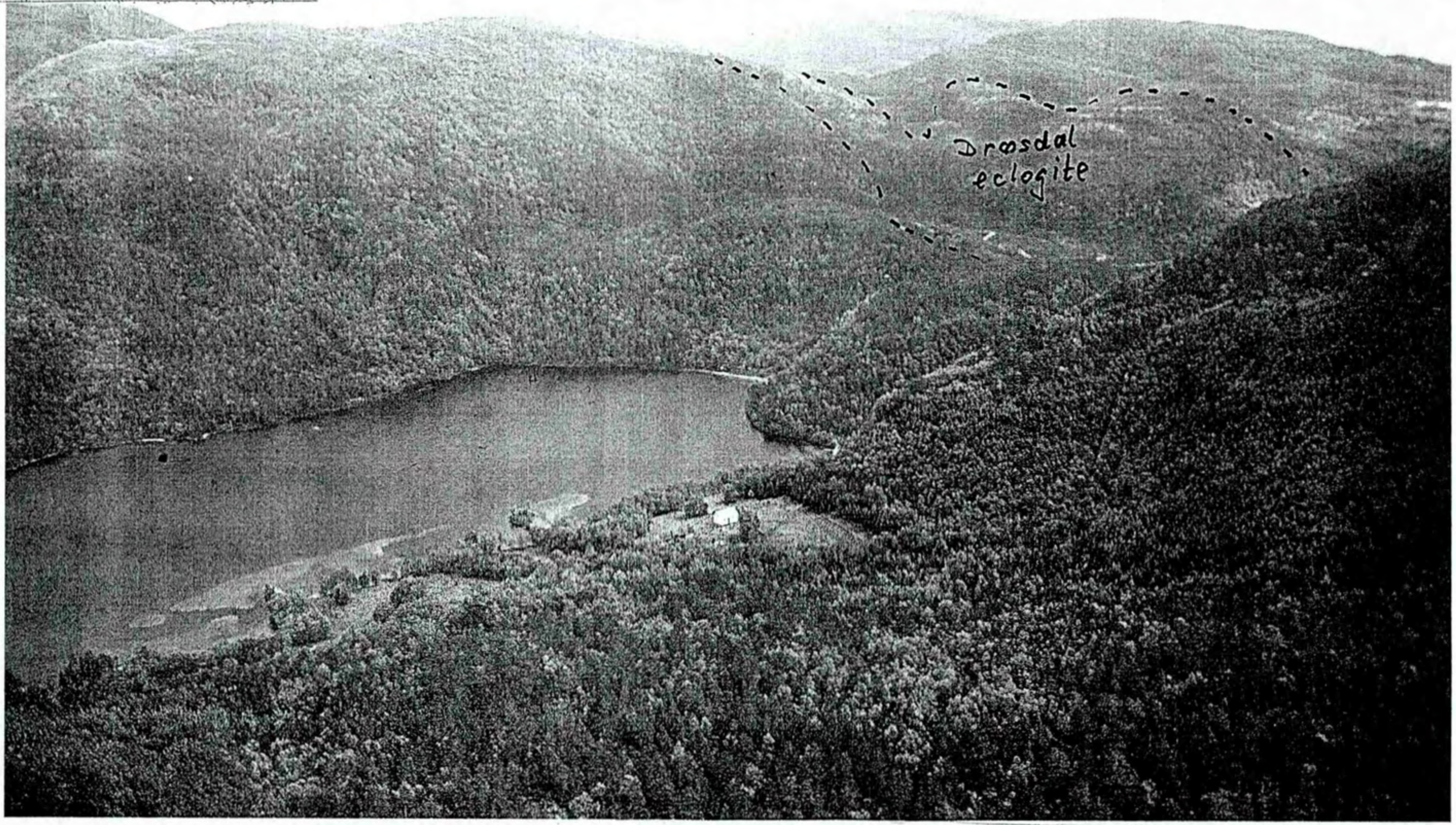
Photograph no. 24: View from the ridgetop at Orkheia.



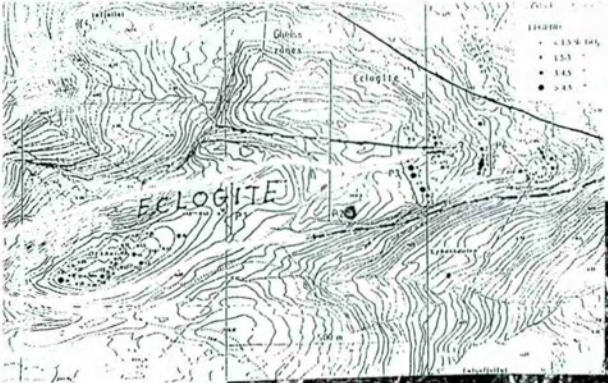
Photograph no. 25: Southwestern margin of the Orkheia eclog

Photograph no. 26: View from Orkheia towards Langsjøen lake with Holtanova, Hellevikåsen and Gjølangen in the background.

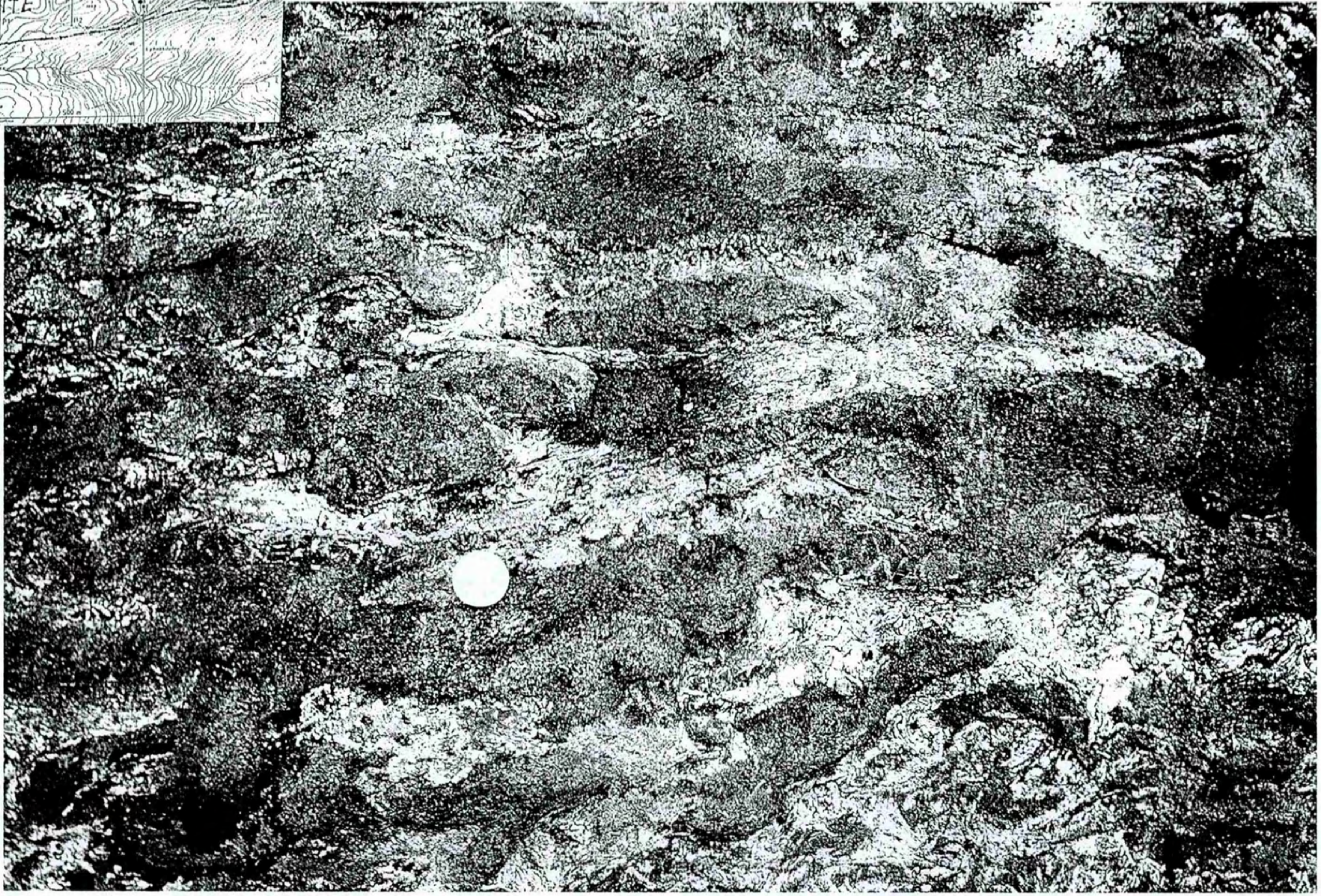




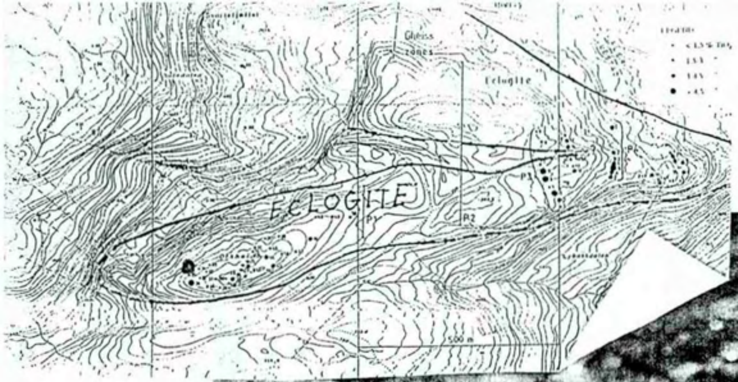
Photograph no. 27: View from the eastern continuation of the Orkheia eclogite towards the southern end of Langsjøen lake, with the Lybakk farm (abandoned; now used as a hut by a family living in Bergen) in the foreground and the Drøsdal eclogite in the background.

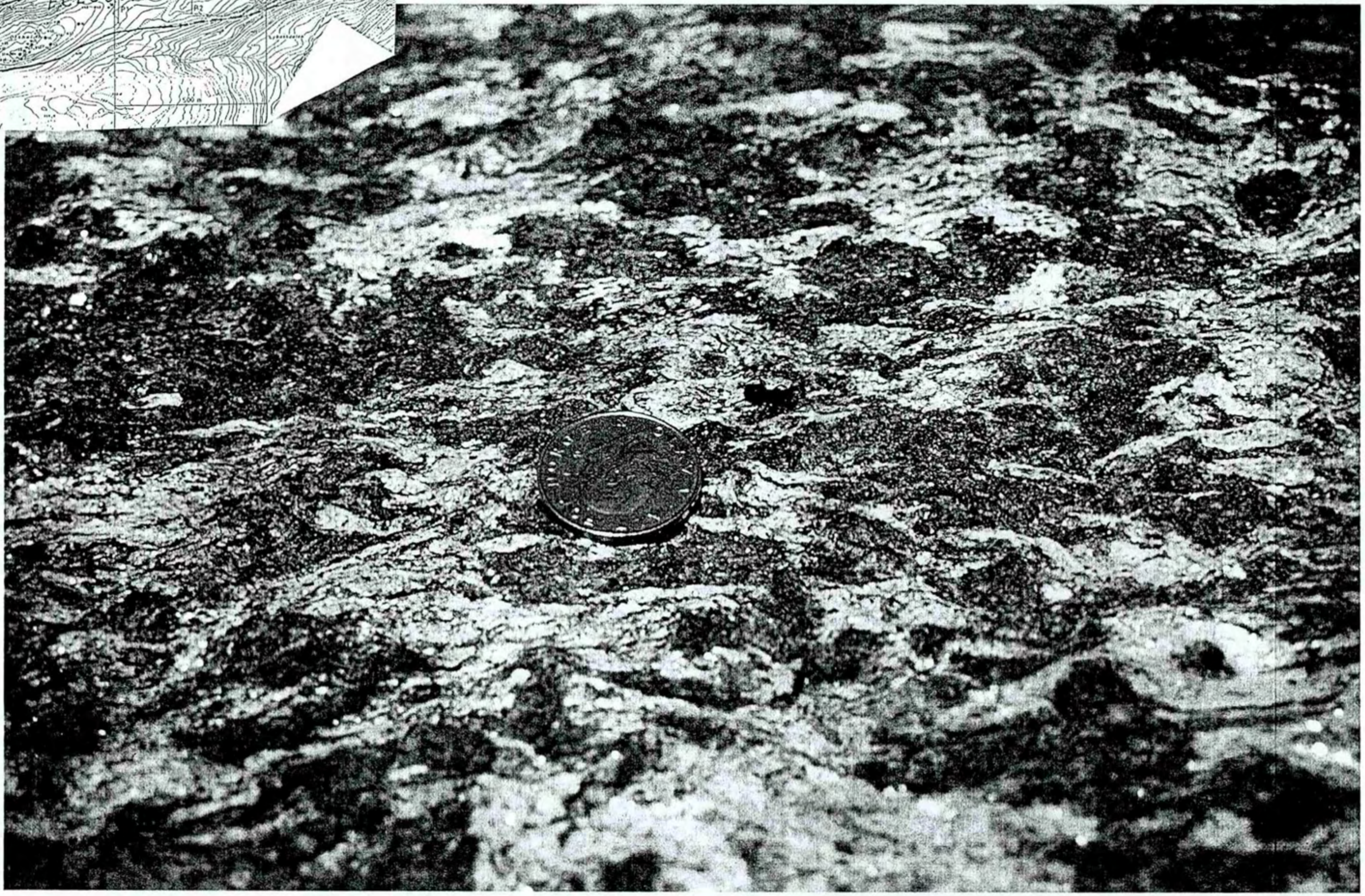


Photograph no. 28: Drill-dust sampling at Orkheia.

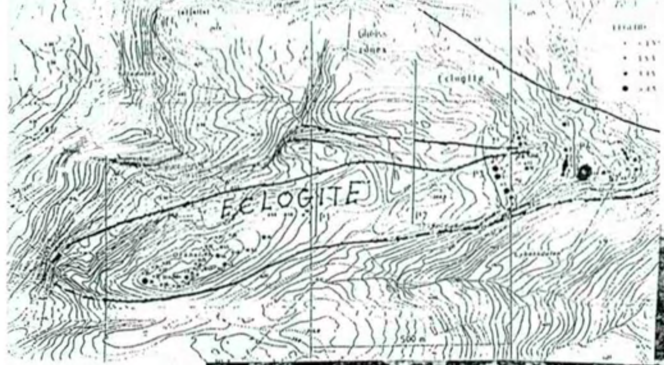


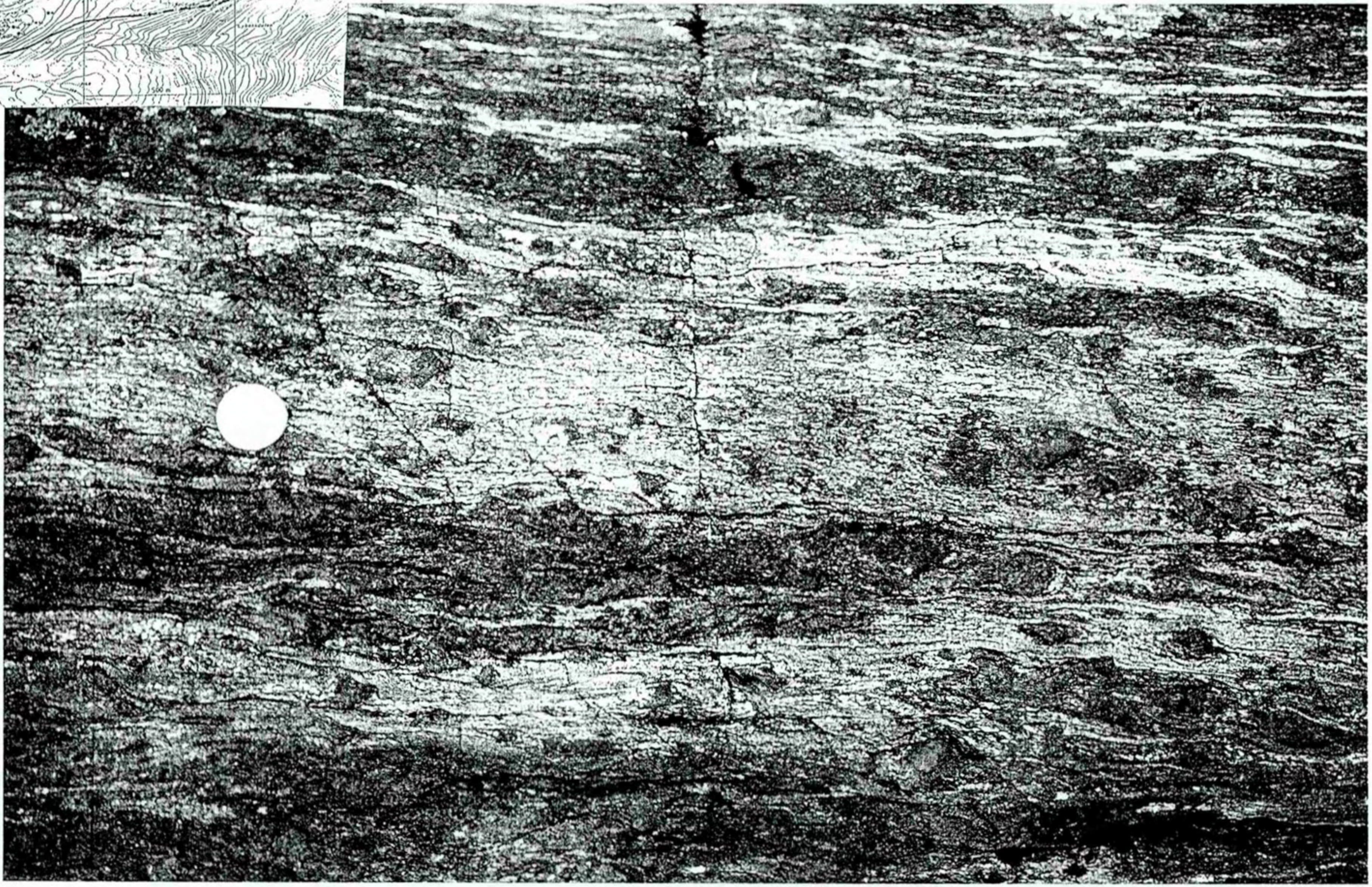
Photograph no. 29: Eclogitized gabbro at Orkheia. The white patches are alteration products after plagioclase composed mainly of clinozoizite, white mica, quartz and some kyanite. The dark parts are eclogite with garnet, omphacite and barroisitic amphibole.





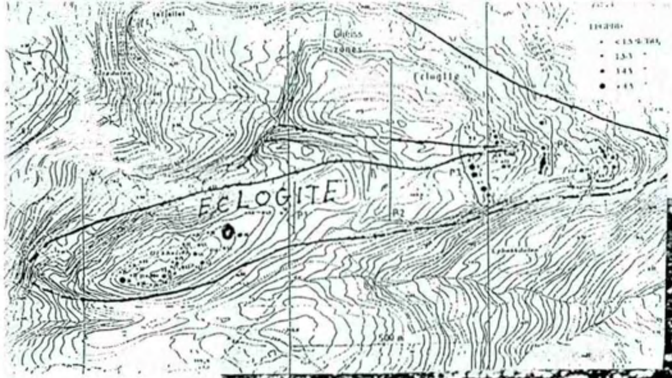
Photograph no. 30: Coronitic eclogite, western part of Orkheia.

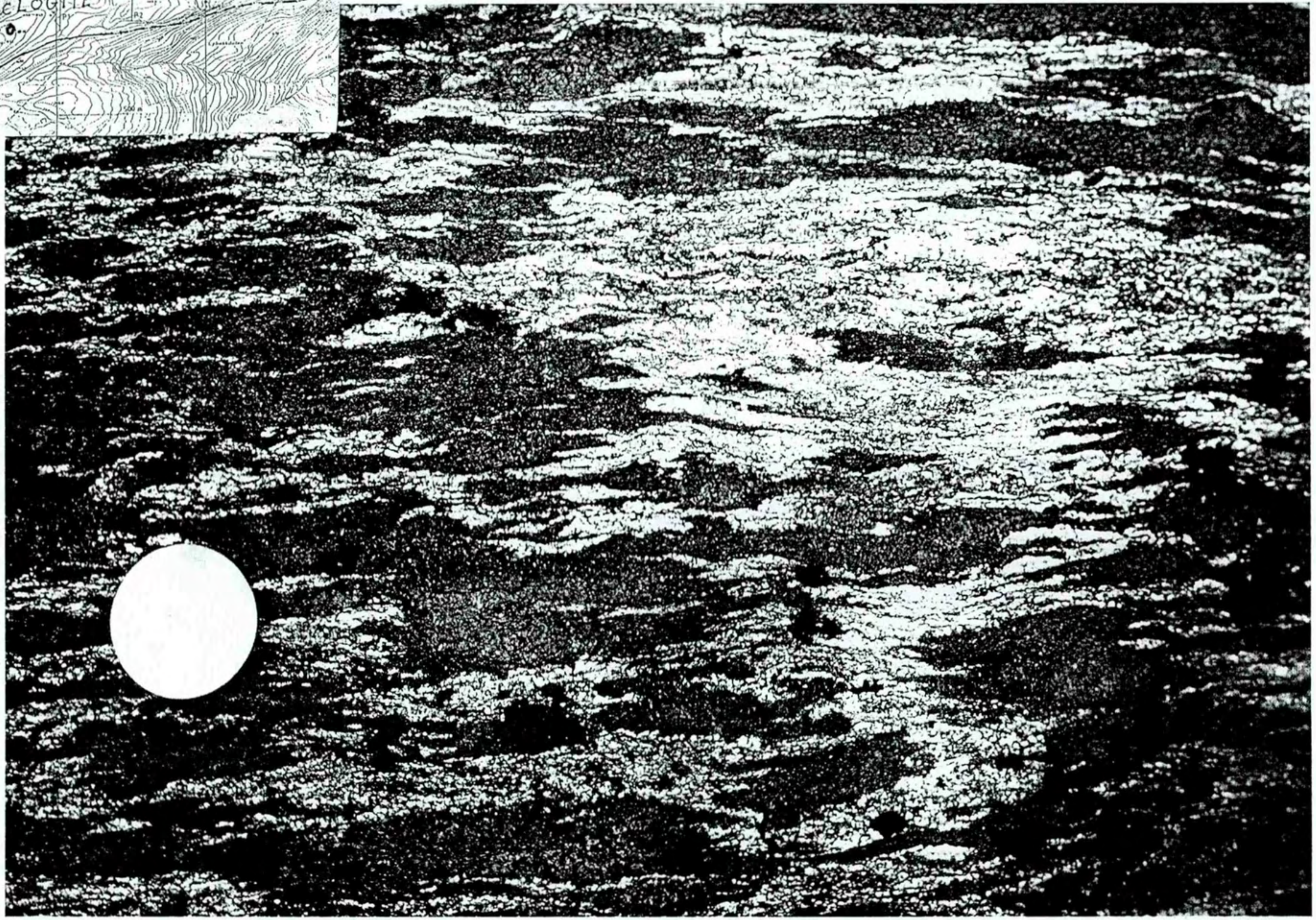




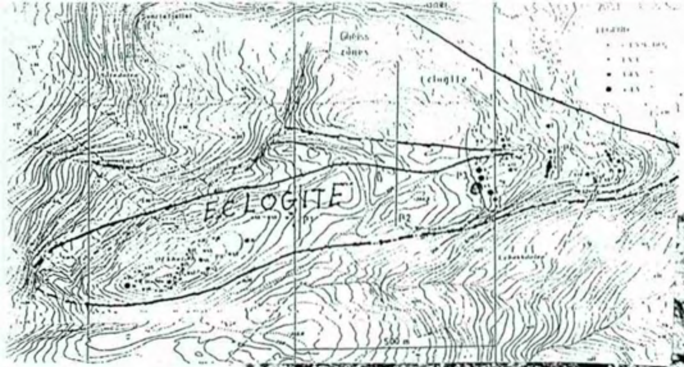
Photograph no. 31: Eclogitized sheared gabbro with light-colored layers of originally anorthositic composition, Orkheia

Photograph no. 32: Eclogitized sheared gabbro, Orkheia.





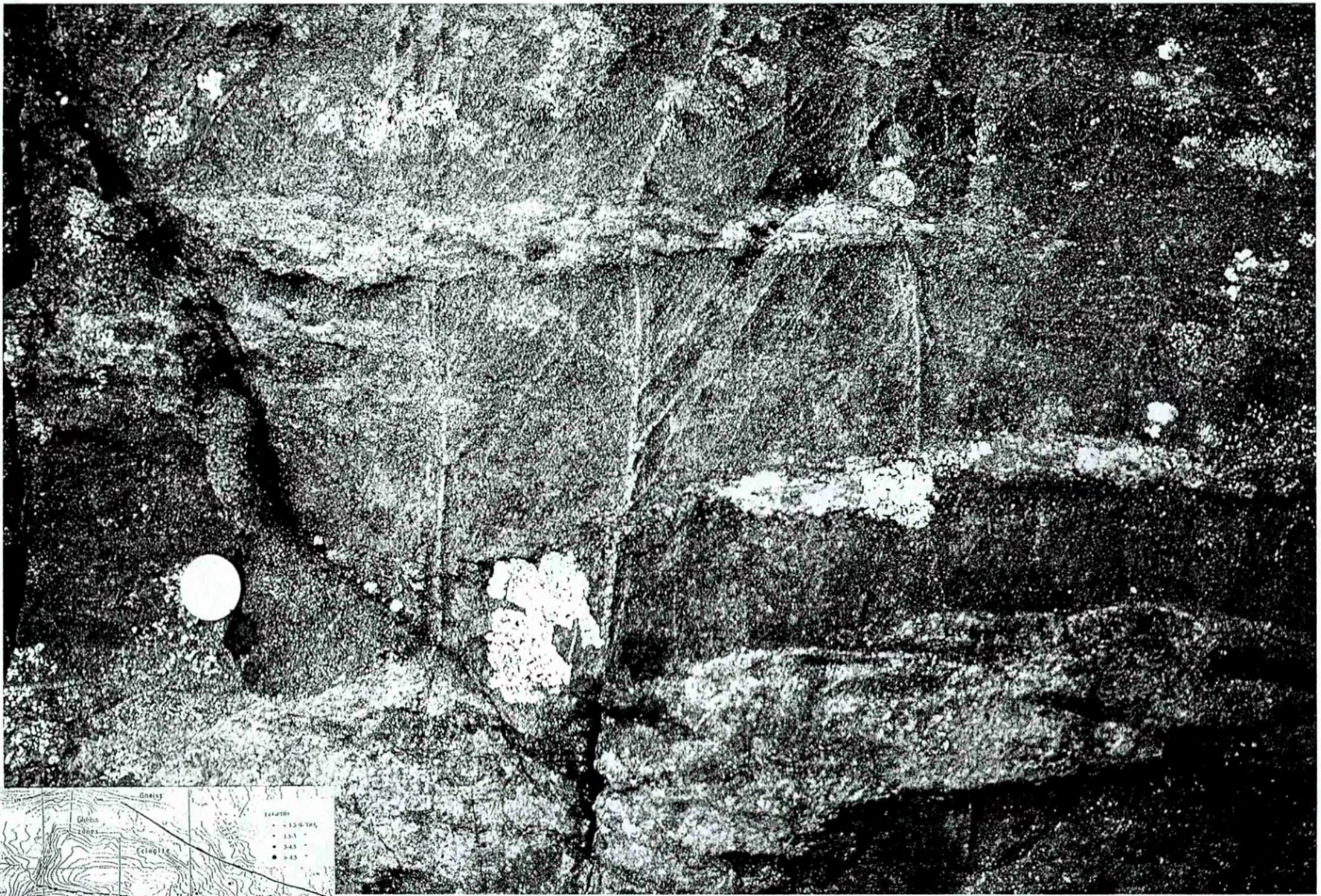
Photograph no. 33: Eclogitized sheared gabbro, Orkheia.

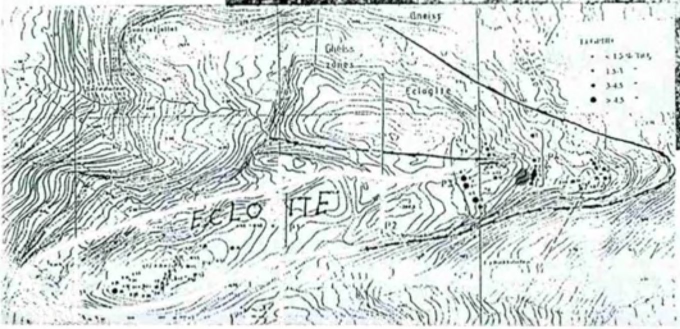


Photograph no. 34: Alternating mafic (eclogitic, Ti-enriched) - felsic (Ti-depleted) layers; presumably metamorphosed after gabbro-anorthositic layers in the original layered intrusion (Orkheia eclogite).

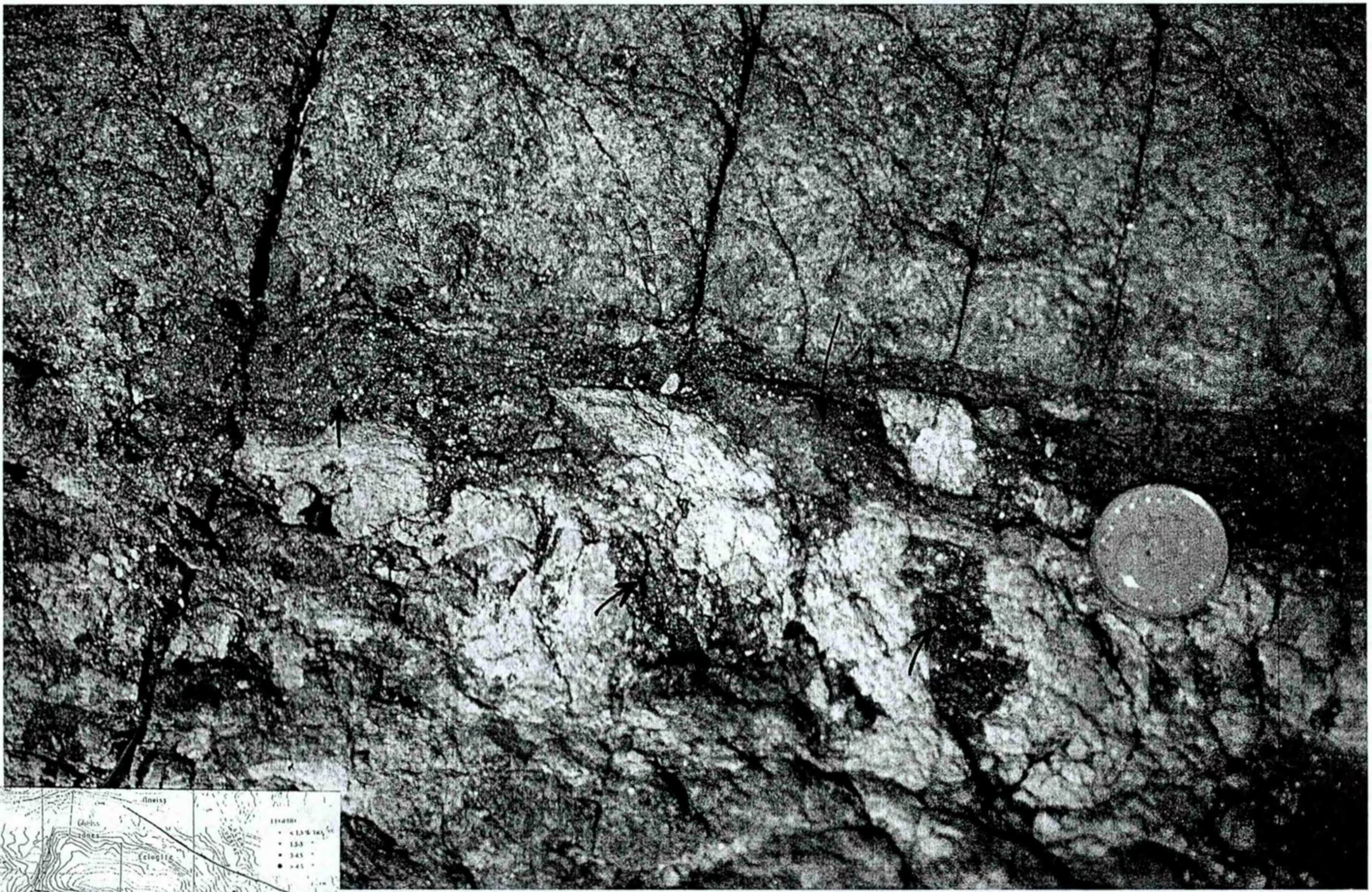
Photograph no. 35: Garnet- and rutile-rich, massive eclogite layer within a slightly banded, less Ti-rich eclogite, Orkheia. This garnet-rich eclogite is practically identical in mineralogy and rutile content to the dyke-eclogite shown in Photograph

Photograph no. 36: Alternating mafic/felsic layers, Orkheia eclogite.

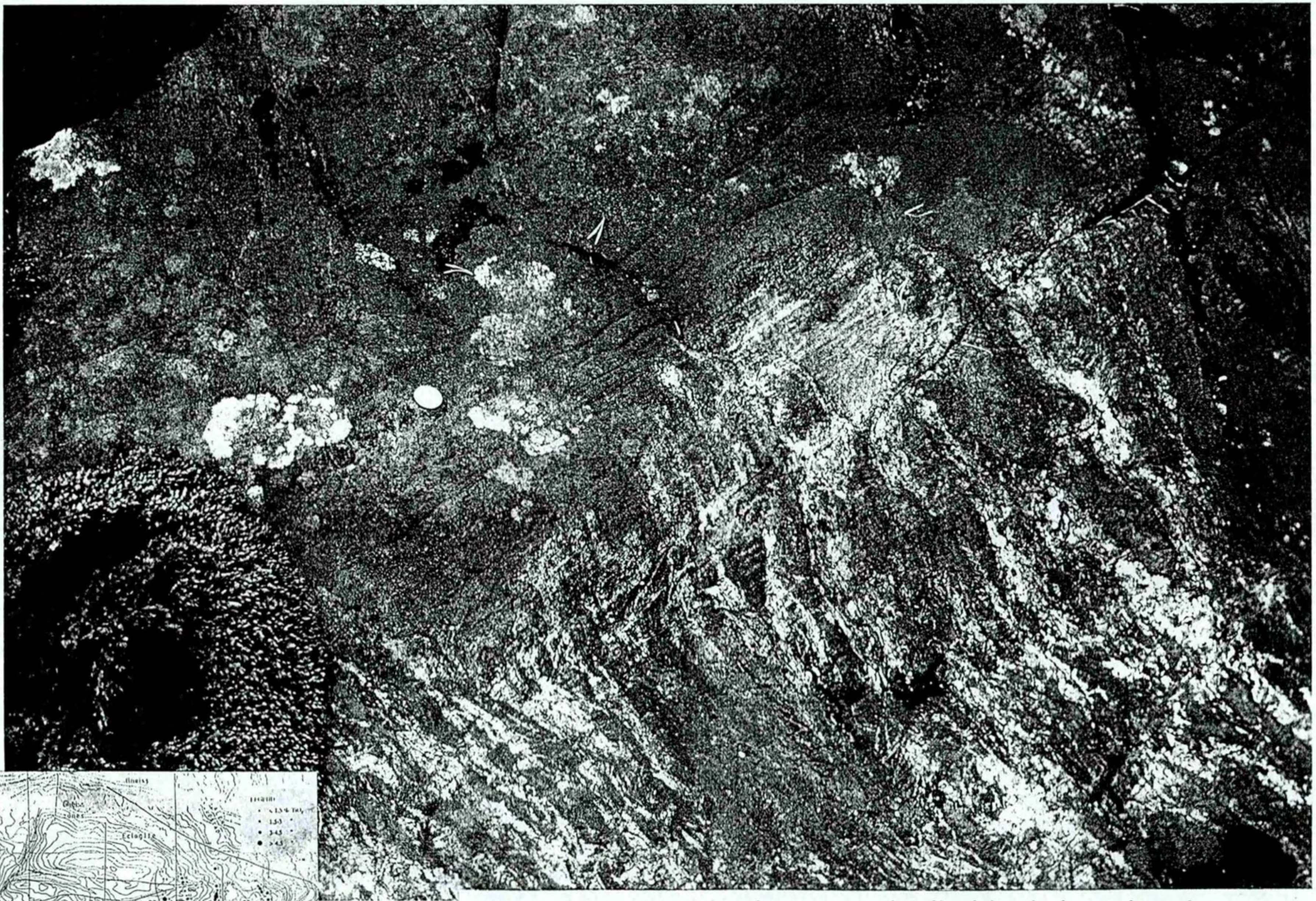




Photograph no. 37: Omphacite-rich layers within a garnet- and rutile-rich variety of the Orkheia eclogite.

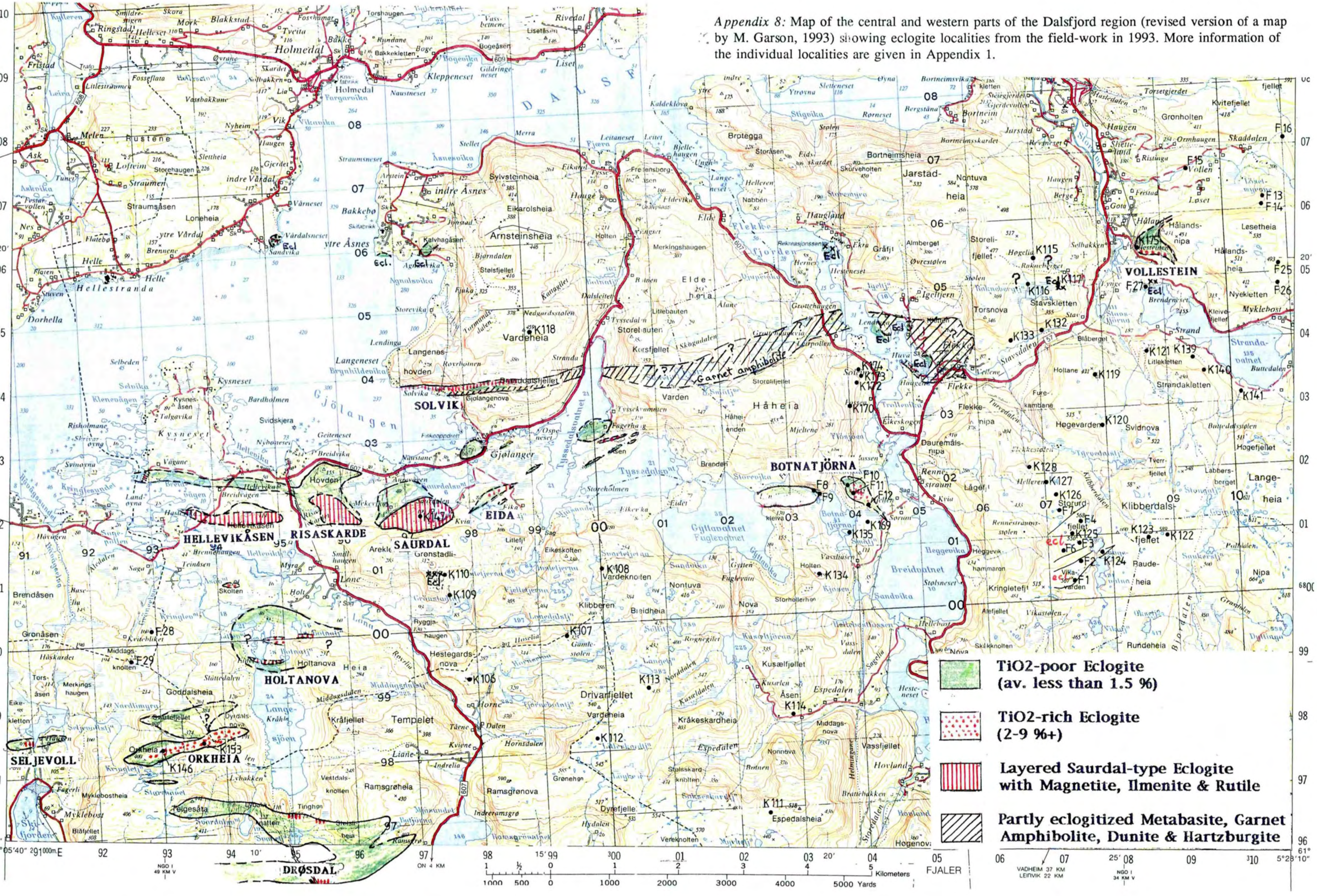


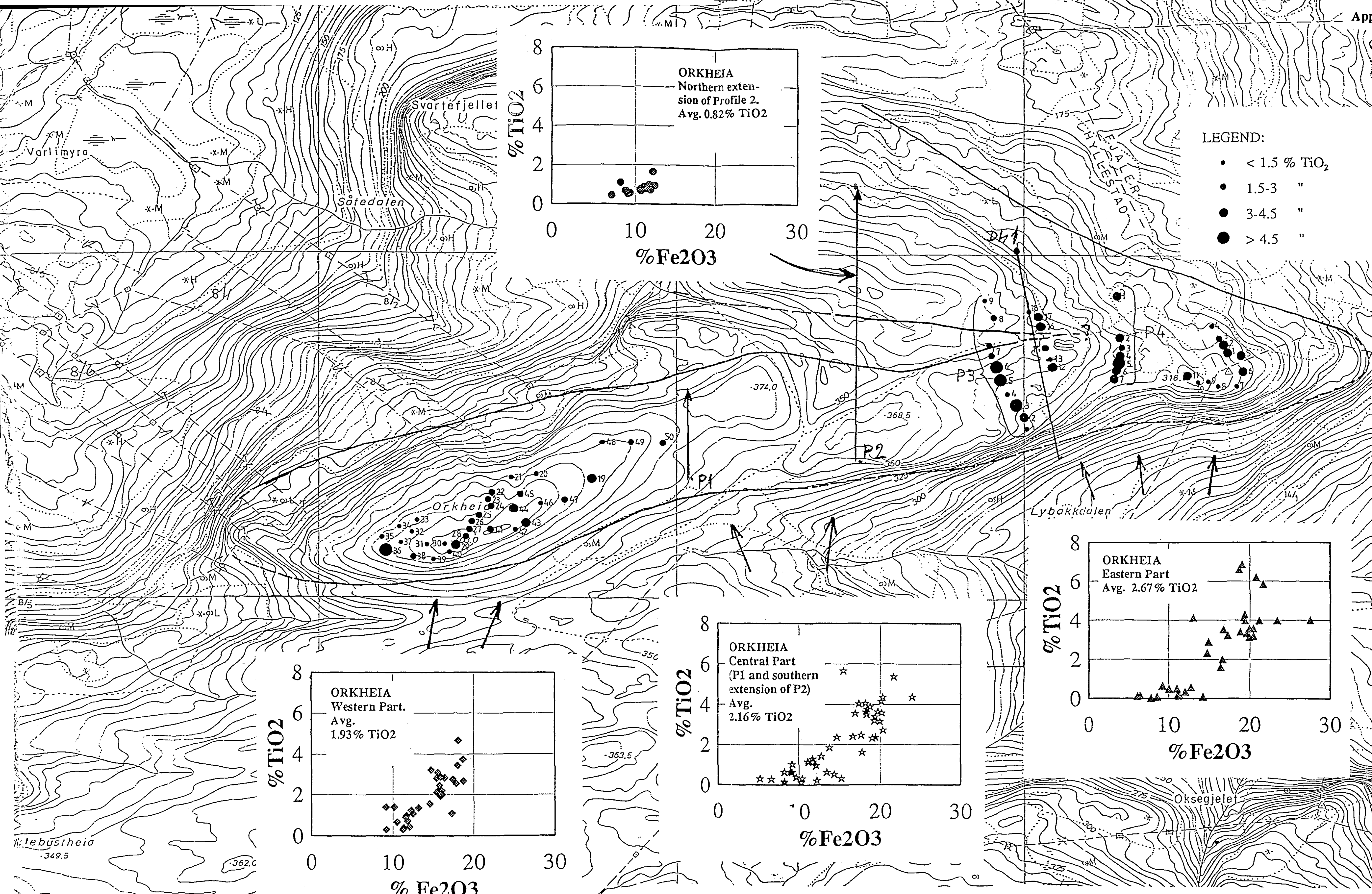
Photograph no. 38: Rutile aggregates (marked by arrows), Orkheia eclogite.



Photograph no. 39: Dyke of a garnet- and rutile-rich eclogite cutting a less garnet-rich, slightly banded eclogite variety, Orkheia. This garnet-rich eclogite is mineralogically very similar to the garnet-Ti rich eclogites that are frequently found in the Gjølanger - Flekke area and elsewhere in the Dalsfjord region, and is also fairly similar to Ti-rich eclogites in the Førdefjord area.

Appendix 8: Map of the central and western parts of the Dalsfjord region (revised version of a map by M. Garson, 1993) showing eclogite localities from the field-work in 1993. More information of the individual localities are given in Appendix 1.





Appendix 9: Drill-dust sampling results, Orkheia eclogite. The samples are taken with DuPont's gasoline drill. The samples from Profile 1 and 2 are analysed by the XMET portable XRF in the field; the rest are analysed by DuPont in USA.