



# Bergvesenet

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## Rapportarkivet

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Tittel Brief summary of the Core Logging Bh 4 at Rørvatn, in Gjersvik Area, Grong District				
Forfatter Haitian, Sun	Dato 15.06	År 1991	Bedrift (Oppdragsgiver og/eller oppdragstaker) Norsulfid Grong Gruber AS	
Kommune Gjersvik	Fylke Nord-Trøndelag	Bergdistrikt	1: 50 000 kartblad 19241	1: 250 000 kartblad Grong
Fagområde Boring Geologi	Dokument type	Forekomster (forekomst, gruvefelt, undersøkelsesfelt) Rørvatn Gjersvikfeltet		
Råstoffgruppe Malm/metall	Råstofftype Cu,Zn			
Sammenheng, innholdsfortegnelse eller innholdsbeskrivelse Beskriver borloggingen av Bh 4, lengde 374,2 meter der Sun logget 0-290 meter og Reinsbakken 290- 374,2 meter. Bergartstyper og deres fordeling i hullet rapporteres. Bergartenes magnetisme oppgis, sammen med hydrotermale endringer og mineralisering. Sterkeste mineralisering ved 317-325 og 359- 360,5 meter, ellers ofte svake mineraliseringer. Vedlagt kjernelogg og opptegning i skisse til 290 meter.				

**Brief Summary for The Core  
Logging Bh 4, at RORVATN,  
in Gjersvik Area, Grong District**

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**June 15th, 1991**

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Enclosure: a legend of the original core logging with descriptions

## **Brief Summary for The Core Logging Bh 4, at RORVATN, In Gjersvik Area, Grong District**

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### **1 Introduction**

This work is a part of the Gjersvik research project, a Grong Gruver A/S - Department of Geology and Mineral Resources Engineering, NTH. INST. united project, funded jointly by NTNF and GRONG GRUVER A/S.

The summary is based on results of the core logging Bh 4 from 0 to 290 m made by Sun Haitian, and from 290 to 374.2 m in depth by Arne Reinsbakken, combined with the identification of 21 thin sections and 9 polished thin sections under microscope for the specimen collected from different levels of the drill hole covered from 290 to 374.2 m in depth.

### **2 Background**

The logged drilling core Bh 4 has well been preserved in the Grong Gruver. The background concerning it is delineated in follow.

- (1) Name of hole: Bh 4
- (2) Location of hole: about 1050 m in the northeast of the RORVATN, at the Gjersvik area, and about 550 m in the west of the major N.E.- striking fault
- (3) Stratigraphic sequence covered by the drilling: metamorphosed volcano-stratigraphic succession of the Gjersvik Group
- (4) Completion depth: from 0 meter on the surface to 374.2 m towards depth
- (5) Angle relative to the horizontal: about 60 at angle ?
- (6) Direction: towards the east

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- (7) For whom the hole is being drilled: Grong Gruver A/S
- (8) Drilling company: Grong Gruver A/S ?
- (9) Purpose of the core drilling: extending knowledge in geology, stratigraphy, lithology, alteration and mineralization known from the mapping on the surface
- (10) Date of drilling: 1988 ?
- (11) Name of the loggers:
  - from 0 to 290 m in depth logged by Sun Haitian
  - from 290 to 374.2 m in depth logged by Arne Reinsbakken

### 3 Summary

#### Types of the rocks and their distribution in the core

The stratigraphic succession covered by the drilling core consist of metavolcanic rocks of the Gjersvik Group. Thus, types of the rock should correspond with that of the Gjersvik Group.

Three types of the rocks, i.e. pale greenstone, dark greenstone and felsic rock, have been distinguished within the core. The dark greenstone dominates the length of the drilling rods ( about 92% in length ) only with minor amounts of felsic rocks ( about 7% ) and pale greenstone ( about 1% ). The dark greenstone has been subdivided into several subtypes of epidote-bearing, biotite- and stilpnomelane-bearing and chlorite-dominating greenstones. In general, the felsic rock and pale greenstone are clear in contact with their wall rocks, whereas subtypes of the dark greenstone are transitional in contact each other.

The felsic rock occurs at 32.5 - 33.5 m, 37.5 - 40 m, 113.2 - 113.8 m, 129.4 - 129.8 m, 191 - 193 m, 213.8 - 215.8 m, 221 - 224.4 m, 240.2 - 242.2 m, 267.8 - 269 m, 274.2 - 279.4 m, and several places below 290 m in depth and tends to increase towards the depth. They vary largely between 0.5 - 3 m, occasionally up to 5 m wide. The pale greenstone has been distinguished to occur as thin layers ranging from 0.5 to 1.5 m wide at levels of 48.8 - 50.2 m, 101.8 - 103 m, 135 - 136.5 m, and 247 - 247.8 m in depth. Subtypes of the dark greenstones tend to present in different levels of the drilling core. The epidote-bearing greenstone is predominantly associated with chlorite-dominating greenstone and they occur mainly in upper and lower two parts, from 0 m on the surface to 165 m and from 285 m to the 374.2 m in the end of the drilling core, respectively, whereas the biotite- and stilpnomelane-bearing greenstone presents at middle-lower level between 165 m and 285 m in depth. Sometimes, the biotite- and stilpnomelane-bearing greenstone also contains epidote.

#### Lithologies

## Felsic rock

The felsic rocks are associated with the dark greenstones. It seems that they can be subdivided into two types. First, the felsic rock is pale-white grey, hard, very massive and fine-grained, very homogeneous, and slight magnetite, as well as has a clear contact with dark greenstones. It consists of quartz, albite with a small biotite and chlorite. Sometimes, the albite porphyritic crystal can be recognized by the megascopy from the core specimen. This sort of felsic rock has been considered mainly to represent felsic sills or dykes. Second, this kind of the felsic rock is generally similar with the first one, but different in its non-homogeneous feature, and transitional contact with the wall rocks. For example, the felsic rock occurring at 274.2 to 279.4 m in depth is pale green-grey, fine-grained, hard, non-homogeneous and weak magnetite, and gradually grades into the dark greenstone in both sides. It consists of quartz, albite, chlorite, epidote, biotite, stilpnomelane and carbonate, in which mafic minerals are non-homogeneous in occurrence and much more in content than the first one. This kind of the felsic rock was probably formed by hydrothermal alterations of the dark greenstone. Thus, primary type of the felsic rocks found within the drilling core are largely felsic sills or dykes, but some of them are probably product of hydrothermal alterations of the dark greenstone.

The features under microscope show that metafelsic rock consists predominantly of albite, quartz and chlorite with minor amounts of biotite, stilpnomelane, sericite and carbonate, of which the felsic minerals range from 60 to 80 per cent in content. It is characterized by typical porphyritic texture that comprises largely porphyritic albite, usually less 30 per cent in content, with few biotites setting in matrix consisting of allotriomorphic, and fine-grained, generally less 0.05 mm in size, felsic minerals being probably albite or quartz which are too fine to be distinguished each other under microscope. The porphyritic albite crystal are mainly euhedral, tabular with obvious twins, ranging either from 0.1 to 0.3 mm ( e.g., Sections No. 21538, 21539, 21542 ) or from 0.2 to 0.6 mm ( seeing Sections No. 21558, 21562, 21563 ) in size and almost of them are oriented along direction of the schistosity, and some of them are obviously surrounded by the schistosity ( e.g. Sections No. 21562, 21563 ). Biotites are allotriomorphic or euhedral, about 0.1 - 0.5 mm in size, and some of them are wholly or partly replaced by chlorite. Biotite occurs only in certain specimen, for example, Sections No. 21538, 21539 and 21542, but seldom in the others. Chlorite is mica-like, but oriented along direction of the schistosity. Sericite, carbonate and some of quartz probably belong to the altered minerals.

In general, the felsic rocks are often associated with sparsely disseminated pyrite mineralization.

## Pale greenstone

It is pale greenish, fine-grained, homogeneous, massive to schistose, carbonate-rich, and no-magnetite, consisting of chlorite, albite, actinolite, and carbonate. No obvious mineralization

can be recognized. Contact between pale and dark greenstones is usually clear.

### Dark greenstone

The dark greenstone is dark-black to moderate green-grayish, massive to schistose, fine-grained, homogeneous to non-homogeneous, and strong to no magnetism. It is often but non-homogeneously associated with sulphide mineralization and hydrothermal alterations, and consists of chlorite, albite, epidote, biotite, and stilpnomelane plus altered minerals, such as carbonate, quartz and sericite, and sulphides. The epidote-rich and chlorite-dominating greenstone are characterized by massive to schistose structure, whereas the biotite- and stilpnomelane-bearing greenstone is generally massive to compact massive. The epidote occurs mainly either as small, rounded amygdales varying between 1 to several mm in diameter and thin veins or as altered disseminated crystal and aggregate within the epidote-bearing and chlorite-dominating greenstones and, occasionally, in biotite- and stilpnomelane-bearing greenstone. The biotite and stilpnomelane occur mainly as disseminated, small scaly or needle and short prismatic crystal in the greenstone. Megascopic features of the biotite- and stilpnomelane-bearing greenstone appear to be very similar with those that were found on the surface in the east of the major N-E striking fault.

Microscope identification shows that the dark greenstone comprises predominantly chlorite and albite with minor amounts of epidote, biotite, stilpnomelane and muscovite, and, at places, of quartz and carbonate which occur as later hydrothermal altered minerals. Chlorite is usually over 60 per cent in content, sometimes, concentrates over 90 per cent to constitute bands of the chlorite in the rock. Epidote is non-homogeneous in content, either less 10 per cent or disappearance in different specimen, and occurs mainly as two styles: one is of allotriomorphic, fine-grained individual or aggregate of epidote crystal, about 0.05 - 0.2 mm in size; the other occurs as amygdales that are predominantly round, lessly ellipse with generally 0.1 - 1 mm, occasionally 3 mm in diameter, and consist mainly of crystalline individual or aggregate of epidotes, occasionally of mineral assemblages of epidote + quartz or epidote + chlorite + quartz ( e.g. Section No 21560 ). The amygdales set in matrix of the schistosity chlorite and are all surrounded by the schistority. Albite is euhedral, tabular crystals with obvious albite-like twins, ranging from 0.1 to 1 mm in size, and occurs largely as porphyritic crystal of albites setting in matrix, consisting predominantly of chlorite and felsic minerals which are too fine, generally less 0.05 mm in size, to be distinguished under microscope. Occasionally, glomeropheric albites present ( e.g. Section, No.21546 ). The porphyritic albites is usually less 40 per cent of all felsic mineral in content.

The dark greenstones often exhibit porphyritic and amygdaloidal textures. The porphyritic texture comprises mainly porphyritic crystal of the albite about 0.1 to 0.5 mm in size ( usually less 15 % in content ) setting in matrix. Almost porphyritic crystal are oriented in direction along and surrounded by the schistority. The amygdaloidal texture is extensive but limited to occur in certain portion of the drilling core. Meanwhile, it seems that the amygdaloidal texture becomes more obvious in the stratigraphic levels where the porphyritic texture occurs.

Structure and texture features associated with different subtypes of the dark greenstone probably illustrate the difference of their primary rocks. For example, massive to schistose epidote-bearing and chlorite-dominating greenstone characterized by porphyritic and amygdaloidal textures represents a sort of vesicular basaltic lava, whereas massive biotite- and stilpnomelane-bearing greenstone with less epidote and without obvious porphyritic texture were most probably produced by thick basaltic lava flow. There is a kind of the schistose chlorite-dominating ( with less epidote ) greenstone which differs from other dark greenstone in association with neither meta-amygdaloidal nor metaporphyritic ( or very less metaporphyritic ) textures but with some amounts of muscovite. It is only located in certain levels of the drilling core such as 313 - 334 m in depth, and has been proposed to belong, perhaps, to a metamafic tuff.

### **Magnetism of the rocks**

Magnetism is one of the important features associated with the rocks in the Gjersvik Group. Magnetism of the rocks covered the drilling core was determined in terms of a magnet bar. The result indicates that the pale greenstone is associated without magnetism, felsic rocks with weak magnetism, and dark greenstone without or with variety of the magnetism. The reason leading variety of the magnetism is, perhaps, due to present and contents of magnetite in different types of the rocks.

The variety of magnetism associated with the dark greenstones seems to be related to the lithologies. Generally, the altered dark greenstone is characterized by non-magnetism, whereas the dark, massive biotite- and stilpnomelane-bearing greenstone is generally associated with strong magnetism, but occasionally in places without or with only weak magnetism, such as at level between 258.5 - 267.5 m in depth. The dark, massive to schistose epidote-bearing and chlorite-dominating greenstones are associated with or without magnetism. For example, the epidote-bearing and chlorite-dominating greenstones are characterized by non-magnetism at levels in 0 - 45 m, 83.5 - 85 m, 87.5 - 91 m, and 105.5 - 107.5 m in depth, but they are generally associated with strong magnetism at other places above 160 m in the drill core. No any boundaries between the dark greenstones with and without magnetism can be distinguished, and, strictly speaking, no difference in lithologies can be recognized on megascopy between the two. What is reason leading variation of the magnetism in the dark greenstones is not clear until now.

However, one possibility is that the variety of magnetism in the dark greenstones was probably caused by concentration and decomposition of magnetite in the rocks during circulating processes of hydrothermal solution within ocean floor hydrothermal system, but much more study are needed to certify this proposal.

Nevertheless, it is important to mention that magnetism of the rocks must be carefully used in determining subtypes of the dark greenstones.

### **Deformation**

The deformation of the rocks in the drill core is generally not intensive. The schistosity of the rocks is generally vertical or keeps a slight angle, varying between 0 - 10 degrees, relative to the drilling core. However, the deformation becomes sometimes relatively strong and the angle between the schistosity and the drilling core can in places reaches into about 40 degrees. For example, the angle between the schistosity and the drill core at level between 150 - 180 m in depth is about 40. Otherwise, some evidences related to late tectonic activity, e.g., quartz veins, tectonoclastic zones and tight fold have been recognized. Five quartz veins varying between 0.5 - 2 m wide have been recognized at levels about 65.9 - 66.8 m, 141.5 - 143.8 m, 150 - 151.4 m, 170 - 170.8 m, and 171.8 - 174 m, four of them being concentrated between 140 - 175 m in depth. The tectonoclastic zones, varying generally between 0.5 - 1 m wide, have been recognized in 27 m, 57 m, 65 m, 101.4 m, 102.6 m, 151.4 m, 172 - 174 m, and 181 - 183 m in depth, which are characterized by small pieces of the core specimen broken by the tectonic processes.

It is interesting and important to notice that the level of the drilling core between 150 - 180 m in depth appears to be occupied by a fault evidenced from that in where the angle between schistosity and drilling core is relatively bigger, and there are an obvious concentration of the quartz thin veins and tectonoclastic zones in occurrence as well as some apparently tight fold in places occur. On the other hand, a boundary of the lithology between the epidote-bearing and chlorite-dominating greenstone and biotite- and stilpnomelane-bearing greenstone just lies in about 175 m in depth.

#### **Hydrothermal alteration and mineralization**

The hydrothermal alteration and mineralization are extensive, non-homogeneous, and linear-type within the rocks covered by the drilling core. It seems that they are mainly associated with the dark greenstones, only weakly but extensively disseminated pyrite mineralization with the felsic rocks, whereas no obvious alteration and mineralization with the pale greenstone. The intense mineralization are often associated with relatively strong alterations.

The massive to schistose epidote-bearing and chlorite-dominating greenstone is generally associated with relatively strong hydrothermal alterations and mineralization than the massive biotite- and stilpnomelane-bearing greenstone in which although they do also occur. For example, a relative wide hydrothermal alteration zone associated with weak mineralization occurs in chlorite-dominating greenstone at level between 120 m to 155 m in depth, and thin veined and disseminated pyrite mineralization ranging usually between 1 - 3 mm wide have been frequently associated with the epidote-bearing and chlorite-dominating greenstone at level above 110 m, whereas relatively intense and extensive alterations and mineralization are, in places, present in the chlorite-dominating greenstone at level below 300 m in depth. In comparison to alteration and mineralization at different levels, on the other hand, the strongest mineralization with concentration of the sulphide minerals up to 30 per cent in content occur at levels of 317 - 325 m and 359 - 360.5 m in depth, while relative weak mineralization widespreadly occur in different levels of the drilling core, such as about 2 m, 6.5 m, 21 m, 36 m, 46 m, 48 m, 51 m, 77 m, 93 m, 97 m, 99 m, 103 m, 304 m, 334 m, 340 m and so on in depths, in where the sulphide mineralization occur mainly either as thin veins about one to

several mm wide or as linear-type disseminated forms that the sulphides are less 10 per cent in content. The alteration and mineralization associated with the massive biotite- and stilpnomelane-bearing greenstone in middle-lower part of the drill core is weak relative to the epidote-bearing and chlorite-dominating greenstone, but thin veined and disseminated sulphide mineralization associated with weak alterations do occur in several places at different levels such as 185 m, 196.2 m, 198.2 m, 226.4 m, 251.6 m and 280.6 - 282.2 m in depth, which each ranges from 2 - 6 m wide with less 10% sulphides.

The alteration and mineralization occur mainly as interconnected thin veins and linear-type disseminated styles within the greenstones. The interconnected thin veins and veinlets, ranging generally from 0.5 to 2 cm wide, are generally clear in contact with the dark greenstone. They, sometimes, are alternated with the dark greenstones, which constitutes bands alternating slight with dark color. The linear-type disseminated veins range generally from several millimeters to several or tens centimeters wide but are not clear in contact with their wall rocks. These features appear to show that the thin veined and veinlet hydrothermal alterations and mineralization were probably formed mainly by the filling along cracks or fissures, whereas the alterations of linear-type disseminated styles result mainly from metasomatism of the greenstone.

The types of the alterations are largely silicification, carbonitization and chloritization with, lessily and locally, albitization and sericitization. The veined and disseminated hydrothermal alterations consist predominantly of quartz, carbonate and chlorite with small sericite or muscovite, and albite plus sulphides, which vary from 40 to 90 per cent in content. The altered quartz and carbonate occur mainly as thin veins or replace the greenstone in linear-type disseminated style, while the altered chlorite are associated either with the quartz and carbonate alterations or with greenstone. The altered chlorite can be distinct from that constituting major rock-forming mineral in the greenstone in crystal size and degree of chlorite concentration.

The mineralization occur predominantly as very fined veins or linear-type disseminated styles. The veined mineralization, generally less 2 mm in width, are obviously controlled by fissures, being associated usually with chloritization and silicification, while the disseminated mineralization are predominantly formed by replacement of mineralized solution along the fissures and often associated with silicification, carbonitization, albitization and chloritization. The mineralization are mainly composed of pyrite with or without minor amounts of chalcopyrite, sphalerite and magnetite. The pyrite occurs widespreadly in the portions where mineralization occur, and is usually about 90 per cent of the metallic minerals in content in addition to individual specimen, e.g. Section No. 21552, in which the pyrite is about 70 per cent. In some specimen, such as Sections No. 21554, 21558, the mineralization is only composed of pyrite. The pyrite is euhedral or hypidiomorphic-granular individual or aggeragate of crystals, ranging generally from 0.05 to 0.5 mm in size, and spatially very related with chloritization. The chalcopyrite also exists widespreadly in most places where the mineralization occurs, but is low in content which is usually less 10 per cent of metallic minerals, with the exception of the Section No. 21552. which is about 20 per cent. The chalcopyrite is allotriomorphic granular, and occurs generally along cracks or edge of the pyrites in where the pyrites are replaced by chalcopyrite. The sphalerite is often associated spatially with chalcopyrite, but usually less 5 per cent in content of metallic minerals. The

magnetite, with less 5 per cent of metallic minerals in content, has been recognized to occur in some specimen, such as Sections No. 21551, 21552 and 21554, and is mainly euhedral acicular individual crystal, each about 0.1 mm long, which it is oriented along the direction of schistosity.

#### **Comparison in geology to the results of the mapping on the surface**

In comparison with the result taken from the surface mapping on the scale 1:5000 in the area, the drill hole is located in the west of the major NE - SW striking fault about 550 m, which separates the dark greenstone into two regions, the epidote-bearing and chlorite-dominating greenstone in the western part of the fault and the biotite- and stilpnomelane-bearing greenstone in the east. The direction of the drill core goes towards the east ( or towards the fault ) with the angle relative to the surface about 60 degrees. The dark greenstone near the fault dips towards the west with angle varying 25 - 35 degrees on the surface.

The results revealed by the drill core in geology has indicated that the rocks covered by the drilling hole are dominated by the dark greenstone consisting epidote-bearing and chlorite-dominating greenstone and biotite- and stilpnomelane-bearing greenstone. The massive to schistose epidote-bearing and chlorite-dominating greenstones occur mainly in upper and lower parts of the drilling core at above 175 m and below 285 m in depth, which are comparable in lithology to those in the west of the fault on the surface. The massive biotite- and stilpnomelane-bearing greenstone lies at level between 175 - 285 m in depth, which corresponds to that in the east of the fault. On the other hand, there seems is a tectonic zone to occupy within the drilling core at level about 150 m - 175 m, which is characterized by relatively big angle between schistosity and the drilling core, relative concentrations of quartz veins and tectonoclastic zones and tight folds. Thus, an apparent change of the lithologies and tectonic features seems to indicate that the drill hole has, perhaps, passed the major fault at level between 150 - 170 m in depth of the drilling core.

#### **4 Major conclusions**

##### **(1) Types of the Rocks and Lithologies**

The rocks covered the drilling core Bh4 have been distinguished into three types, i.e. pale greenstone, dark greenstone and felsic rock. The dark greenstone dominates the length of the drilling rods only with minor felsic rocks plus few pale greenstone. The dark greenstone has been subdivided into several subtypes of epidote-bearing, biotite- and stilpnomelane-bearing and chlorite-dominating greenstones.

The pale greenstone has been distinguished to occur as thin layers ranging from 0.5 to 1.5 m wide at three levels.

The felsic rocks as thin layers ranging from 0.5 to 3 m wide occur at different levels in the core and tends to increase towards the depth. The rocks are the pale-white greyish, hard, very

massive and fined-grained, very homogeneous, and slight in magnetism, consisting predominantly of albite, quartz with minor amounts of chlorite, biotite, stilpnomelane, sericite and carbonate, of which the felsic minerals range from 60 to 80 per cent in content. They are characterized by typical porphyritic texture that comprises largely porphyritic albite, usually less 30 per cent in content, with few biotite setting in matrix. Sometimes, the albite porphyritic crystal can be recognized by the megascopy from the core specimen. The felsic rocks have been proposed to be formed by thin sills and dykes or by alteration of the dark greenstone.

Subtypes of the dark greenstone are present in different levels. The epidote-bearing and chlorite-dominating greenstones chlorite-dominating greenstone occupy in upper and lower two parts, from 0 m on the surface to 165 m and from 285 m to the end of the drilling core, respectively, whereas the biotite- and stilpnomelane-bearing greenstones are located at middle-lower level between 165 m and 285 m in depth. The former is characterized by massive to schistose structure, whereas the latter is generally massive to compact massive.

The dark greenstone is dark-black to moderate green-grayish, massive to schistose, fine-grained, homogeneous to non-homogeneous, and strong to no magnetism, consisting of chlorite, albite, epidote, biotite, and stilpnomelane plus altered minerals, such as carbonate, quartzs and sericite, and sulphides. Chlorite is usually over 60 per cent in content, sometimes, concentrates over 90 per cent to constitute bands of the chlorite in the rock. Epidote is non-homogeneous in content, generally less 20 per cent and associated mainly with epidote-bearing greenstone. The dark greenstones often exhibit porphyritic and amygdaloidal textures. The porphyritic texture comprises mainly porphyritic crystal of the albite ( usually less 15 % in content ) setting in matrix.

Structure and texture features associated with different subtypes of the dark greenstone probably illustrate the difference of their primary rocks. For example, massive to schistose epidote-bearing and chlorite-dominating greenstone characterized by porphyritic and amygdaloidal textures represents a sort of vesicular basaltic lava, whereas massive biotite- and stilpnomelane-bearing greenstone with less epidote and without obvious porphyritic texture were most probably produced by thick basaltic lava flow. There is a kind of the schistose chlorite-dominating ( with less epidote ) greenstone which differs from other dark greenstone in association with neither meta-amygdaloidal nor metaporphyritic ( or very less metaporphyritic ) textures but with some amounts of muscovite. It is only located in certain levels of the drilling core such as 313 - 334 m in depth, and has been proposed to belong, perhaps, to a metamafic tuff.

## **(2) Magnetism of the rocks**

Magnetism of the rocks covered the drilling core was determined in terms of a magnet bar. The result indicates that the pale greenstone ia associated without magnetism, felsic rocks with weak magnetism, and dark greenstone without or with variety of the magnetism.

Generally, the altered dark greenstone is characterized by non-magnetism, whereas the dark,

massive biotite- and stilpnomelane-bearing greenstone is associated with strong magnetism. The dark, massive to schistose epidote-bearing and chlorite-dominating greenstones are associated with or without magnetism, within which it seems that no any difference in lithologies can be recognized between the two. What is reason leading variation of the magnetism in the dark greenstones is not clear until now. However, it is probably important to mention that magnetism of the rocks must be carefully used in determining subtypes of the dark greenstones.

### **(3) Hydrothermal alteration and mineralization**

The hydrothermal alteration and mineralization are extensive, non-homogeneous, and linear-type within the rocks covered by the drilling core. It seems that they are mainly associated with the dark greenstones, only weakly but extensively disseminated pyrite mineralization with the felsic rocks, whereas no obvious alteration and mineralization with the pale greenstone. The intense mineralization are often associated with relatively strong alterations.

The hydrothermal alterations and mineralization are more extensive in association with the massive to schistose epidote-bearing and chlorite-dominating greenstone than with the massive biotite- and stilpnomelane-bearing greenstone in middle-lower part in which although they do occur. The strongest mineralization with concentration of the sulphide minerals up to 30 per cent in content occur at levels of 317 - 325 m and 359 - 360.5 m in depth.

The alteration and mineralization occur mainly as interconnected thin veins and linear-type disseminated styles within the greenstones. The interconnected thin veins and veinlets, ranging generally from 0.5 to 2 cm wide, are generally clear in contact with the dark greenstone. They, sometimes, are alternated with the dark greenstones, which constitutes zones alternating slight with dark color bands. The linear-type disseminated veins range generally from several millimeters to several or tens centimeters wide in the drilling core but are not clear in contact with their wall rocks.

Types of the alterations are largely silicification, carbonitization and chloritization with, lessly and locally, albitization and sericitization. The veined and disseminated hydrothermal alterations consist predominantly of quartz, carbonate and chlorite with small sericite or muscovite, and albite plus sulphides, which vary from 40 up to 90 per cent in content.

The mineralization occur predominantly as very fined veins or linear-type disseminated styles. The veined mineralization, generally less 2 mm in width, are obviously controlled by fissures, being associated usually with chloritization and silicification, while the disseminated mineralization are predominantly formed by replacement of mineralized solution along the fissures and often associated with silicification, carbonitization, albitization and chloritization. The mineralization are mainly composed of pyrite without or with minor amounts of chalcopyrite, sphalerite and magnetite.

The alteration and mineralization found in the drilling core are generally comparative with those in the dark greenstone exposed on the surface in the Gjersvik Group. The latter is usually

characterized by extense, non-homogeneous alteration and mineralization, which probably result from extensive bleaching and metasotism of ocean floor basalt by heated circulating solution in the connecting hydrothermal system. However, the mineralization and alteration at level between 290 - 370 m in depth are much stronger, which can be considered as a possibility to represent a part of or closed to the feeder zone underlying directly massive sulphides. This is a valuable clue in prospecting new ore bodies.

In a word, The alteration and mineralization found in the drilling core are comparative with those in the dark greenstone exposed on the surface in the Gjersvik Group. The latter is generally characterized by extense, non-homogeneous alteration and mineralization, which probably result from bleaching and metasomatism of ocean floor basalt by heated connecting solution in the circulating hydrothermal system. However, the most intensive mineralization at level between 317 - 360 m in depth is an obviously anomalous relative to normal mineralization in the dark greenstone, which can be considered as a possibility to represent a part of or closed to the feeder zone underlying directly massive sulphides.

#### **(4) Comparison in geology to the results of the mapping on the surface**

In comparison with the result taken from the surface mapping in the area, the drill hole is located in the west of the major NE - SW striking fault about 550 m, which separates the dark greenstone into two regions, the epidote-bearing and chlorite-dominating greenstone in the western part of the fault and the biotite- and stilpnomelane-bearing greenstone in the east.

The results revealed by the drill core has indicated that the rocks covered by the drilling hole are dominated by the dark greenstone consisting epidote-bearing and chlorite-dominating greenstone and biotite- and stilpnomelane-bearing greenstone. The massive to schistose epidote-bearing and chlorite-dominating greenstones occur mainly in upper and lower parts of the drilling core at above 175 m and below 285 m in depth, which are comparable in lithology to those in the west of the fault on the surface. The massive biotite- and stilpnomelane-bearing greenstone lies at level between 175 - 285 m in depth, which corresponds to that in the east of the fault. There seems is a tectonic zone to occupy within the drilling core at level about 150 m - 175 m, which is characterized by relatively big angle between schistosity and the drilling core, relative concentrations of quartz veins and tectonoclastic zones and tight folds. Thus, an apparent change of the lithologies and tectonic features seems to indicate that the drill hole has, perhaps, passed the major fault at level between 150 - 170 m in depth of the drilling core.

**Enclosures: a legend of the original core logging with descriptions**

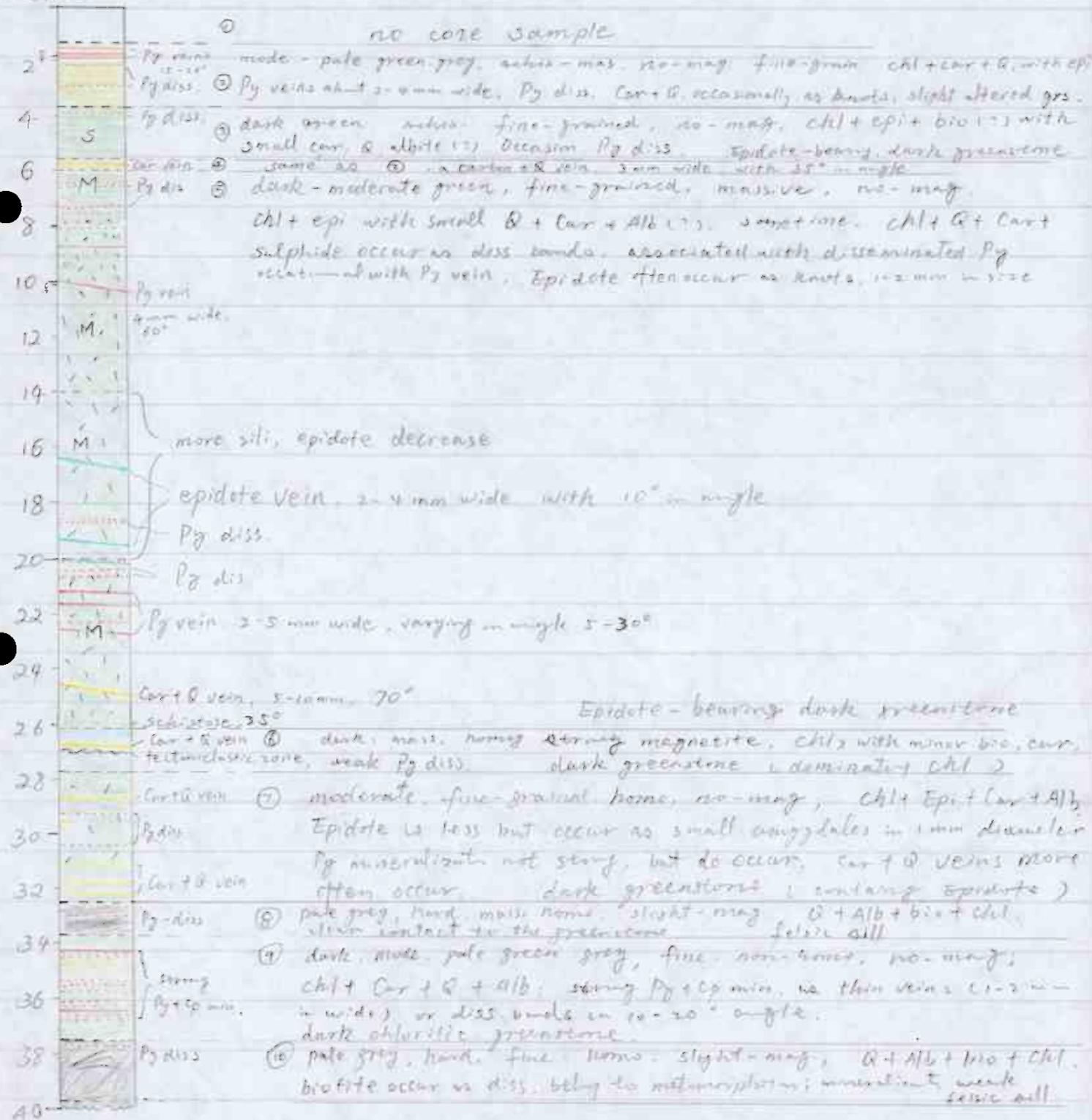
May 27 1991.

Logging of the drilling core 4#, Rqyvutnet

Scale 1:200

1 cm = 2 m

meters



NOTE: 7. collected sample and locations





meters	Stratigraphic Unit	Notes
140	Δ CA	① These fragments set in matrix of dark greenstone. They look like tectonic fragments in altered greenstone.
142		② Q + (Car) vein
144		③ moderate green-grey, fine-grained, schistose, schistosity at about 40°, no-mag; chl + Alb + Epi + (Car + Q); the thin veins (looks like bands) consisting of (Car + Q + Epi), about 2-6 mm alternate with greenstone at about 40°. Mineralization is weak but do assoc with alternate altered greenstone
146	S	Py vein
148		Car + Q + (Epi) rich (+ Py)
150		④ Q + (Car) vein
152	S	⑤ moderate-pale green-grey, non-homogeneous, schistose no-mag; Car + Q + (Epi) + (Alb + Ser) occur as thin veins at about 40°; the core, in places was broken into small pieces with Q vein, or strongly folded. altered greenstone
154		Car + Q rich
156		⑥ dark, black green-grey, massive, fine, homo, strong magnetite. Sulphide mineralization is not obvious, but Py, in places, occur to be associated with (Car + Q + (Alb)), in places. Epidote and Biotite occur. Biotite as small scaly crystals, Epidote as amygdales or small knots, 1-2 mm in size. chl + Alb + (Epi + Bio + (Car))
158	M	Car + Q + Py rich
160		
162		
164		Epi + Bio rich
166		
168		Bio rich
170	M	
172		⑦ Q + (Car) vein
174		⑧ dark chloritic greenstone
176		⑨ Q + (Car) vein. strong tectonic, almost Q + (Car) vein was broken to small pieces, or lost.
178		Car + Q vein
180		Py diss.
182	M	⑩ In this level, the veins and schistosity almost keep in horizontal or slight angle in occurrence, which is contrast with above, chl + Alb + (Epi) + Bio + Stil/p + (Car + Q) in places, tectonic worse. The Biotite and stilpno-melane to occur as an important feature, which like the bio + stil-bearing greenstone in the east of the major fault. The sulphide mineralization is not strong.
184		Bio + Stil rich
186		Car + Q veins
188		Py diss. with Car + Q
190		Car + Q + Alb + Ser rich
192		
194		
196		
198		
200		dark, bio + stil bearing, chloritic, greenstone (with strong magnetite)

metres

190  
192  
194  
196  
198  
200  
202  
204  
206  
208  
210  
212  
214  
216  
218  
220  
222  
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238  
240

dark, bi-stil bearing, chloritic greenstone  
pale-white gray, hard, very fine, mag-bearing. Very  
massive,  $Qtz + Alb + Bix + (Chl)$ ,  $Alb$  crystal.  $Py$  also  
felted rock  
coarse - moderate green; mass, some fine  
strong magnetite,  $Chl + Alb + Epi + Mn + Stil$   
Biot  
+ (Cpx + Cr)  
Mineralization in veins;  $Bix + Stil$   
Sill  
rich  
- rich - white level, but Epidote limited in  
places, occurring as aggregates  
dark, bi-stil-bearing, chloritic greenstone  
with strong magnetite  
moderate - pale green-gray, fine, non-homogeneous  
mass - adherent, non-magnetite,  $Chl + Alb + Epi + Bix +$   
rich  
 $(Stil) + (Cpx + Cr)$ ,  $Cpx + Cr + (Alb)$  occur as thin veins or  
small lenses, varying 2-5 mm wide; some places associated  
with strong light fold; some texture fragments occur.  
altered greenstone  
moderate - pale green gray, non-homogeneous mass - adherent,  
fine-grained, homogeneous, strong magnetite,  $Chl + Alb + Bix +$   
rich  
 $(Stil) + (Cpx + Cr)$ ,  $Alb$  crystal.  $Py$  also  
felted rock  
pale-white gray, hard, mass, very fine magnetite,  $Qtz + Alb + Bix +$   
rich  
 $(Chl)$ ,  $Alb$  crystal.  $Py$  also  
felted rock  
dark, bi-stil-bearing greenstone  
moderate - pale green gray, non-homogeneous mass - adherent,  
rich  
 $Cpx + Cr + (Alb)$ ,  $Stil$ , as vein - like altered greenstone  
non-mag  
moderate - pale green gray, non-homogeneous mass - adherent,  
rich  
fine-grained, homogeneous, strong magnetite, light  
typical dark bi-stil-bearing greenstone.  
pale-white gray, massive, hard, fine-grained, adherent, light mag  
rich  
 $Qtz + Alb + Bix + Chl$  -  $Qtz + Alb$  porphyritic, especially at base, irregular  
dissemination. Pyrite extensive, present, occasionally in thin  
veins  
dark - moderate green, gray, massive - adherent,  
rich  
fine-grained, homogeneous, strong magnetite,  
 $Chl + Alb + Bix + Stil + Epi + Cpx + Cr$   
Epi  
rich  
Epidote occur in limited level, but biotite or  
 $Stil$  (prominent) present in white section. Sometimes  
rich  
 $Cpx + Cr + (Alb + Stil)$  occur as thin veins, scattered  
or disseminated, obviously, as linear type in occur-  
rence, which seem to be product of replacement  
along cracks or fractures.  
dark, bi-stil-bearing greenstone with magnetite

dark, bi-stil bearing, chloritic greenstone  
pale-white gray, hard, very fine, mag-bearing. Very  
massive,  $Qtz + Alb + Bix + (Chl)$ ,  $Alb$  crystal.  $Py$  also  
felted rock  
coarse - moderate green; mass, some fine  
strong magnetite,  $Chl + Alb + Epi + Mn + Stil$   
Biot  
+ (Cpx + Cr)  
Mineralization in veins;  $Bix + Stil$   
Sill  
rich  
- rich - white level, but Epidote limited in  
places, occurring as aggregates  
dark, bi-stil-bearing, chloritic greenstone  
with strong magnetite  
moderate - pale green-gray, fine, non-homogeneous  
mass - adherent, non-magnetite,  $Chl + Alb + Epi + Bix +$   
rich  
 $(Stil) + (Cpx + Cr)$ ,  $Cpx + Cr + (Alb)$  occur as thin veins or  
small lenses, varying 2-5 mm wide; some places associated  
with strong light fold; some texture fragments occur.  
altered greenstone  
moderate - pale green gray, non-homogeneous mass - adherent,  
fine-grained, homogeneous, strong magnetite,  $Chl + Alb + Bix +$   
rich  
 $(Stil) + (Cpx + Cr)$ ,  $Alb$  crystal.  $Py$  also  
felted rock  
pale-white gray, hard, mass, very fine magnetite,  $Qtz + Alb + Bix +$   
rich  
 $(Chl)$ ,  $Alb$  crystal.  $Py$  also  
felted rock  
dark, bi-stil-bearing greenstone  
moderate - pale green gray, non-homogeneous mass - adherent,  
rich  
 $Cpx + Cr + (Alb)$ ,  $Stil$ , as vein - like altered greenstone  
non-mag  
moderate - pale green gray, non-homogeneous mass - adherent,  
rich  
fine-grained, homogeneous, strong magnetite, light  
typical dark bi-stil-bearing greenstone.  
pale-white gray, massive, hard, fine-grained, adherent, light mag  
rich  
 $Qtz + Alb + Bix + Chl$  -  $Qtz + Alb$  porphyritic, especially at base, irregular  
dissemination. Pyrite extensive, present, occasionally in thin  
veins  
dark - moderate green, gray, massive - adherent,  
rich  
fine-grained, homogeneous, strong magnetite,  
 $Chl + Alb + Bix + Stil + Epi + Cpx + Cr$   
Epi  
rich  
Epidote occur in limited level, but biotite or  
 $Stil$  (prominent) present in white section. Sometimes  
rich  
 $Cpx + Cr + (Alb + Stil)$  occur as thin veins, scattered  
or disseminated, obviously, as linear type in occur-  
rence, which seem to be product of replacement  
along cracks or fractures.  
dark, bi-stil-bearing greenstone with magnetite



Description	for the core logging, Bk4	May 21-31, '51
1.22 m	No samples. drilling core disappeared	
2-2 m general mineral struc min	Medium greyish, green-greyish, schistose, no magnetite consisting of chl. epidote. felsic min. occur as bands where felsic min and epidote but no obvious contact between the two. It is transitional. Showing metasomatic mineralization occur, mainly	fine-grained, homogeneous, no obvious massive felsic minerals (quartz, carbonates). disseminated or spotted setting the matrix become less, the dark grey <sup>bands</sup> are formed. as veining in several levels, in 1.23 m, 1.36 m, 1.55 m, 1.65 m, and 1.75 m, a few disseminated
in 1.55 m	min mainly pg, 0.2-0.5 cm wide. generally 15-20° angle. there is a vein of quartz or carbonate, 0.3 cm wide, 45° angle. It is obviously cut by pyrite vein	min mainly pg, 0.2-0.5 cm wide. generally 15-20° angle. there is a vein of quartz or carbonate, 0.3 cm wide, 45° angle. It is obviously cut by pyrite vein
encl -3 m	altered (medium) greenstone	with pg mineralization of olivine, veinage
general dark color in 2-2.15 m, consist of of chlo. others felsic min (quartz, carbon-	Medium greyish, - dark greyish dark color in 2-2.15 m, consist of of chlo. others felsic min (quartz, carbon-	fine-grained, no magnetite, mass. 2.51-2.54 m, and 2.78-2.83 m. medium color, composed of chlorite and albite). <del>the</del> the contact between the two, dark is original, grey is altered
mineral struc min	dark consistency of chlorite epidote sometimes, epidote occur as in 2.90-2.93 m. about 2-4 mm diameters	grey chlorite, quartz carbonate, epidote spotted, amygdaloidal structure
min con 3-3.07 m 3.07-4 m	slight disseminated pg: in mainly slight-medium altered disappearing	2.21-2.24 m, 2.96-2.97 m. greenstone
3.07-3.71 m	looking like above	
general struc mineral min con 3.71-4 m	medium - pale greyish, schistose 3.18-3.25 m, 3.49-3.71 m dark consistency mainly of chl. with chl. felsic min (quartz, carbon) slight pg. dissin. mainly associated with a thin vein of pyrite about 2 mm wide occurs in 3.33 m, with 20° angle medium - slight altered greenstone with mineralization	fine-grained, no magne. massive more dark greyish, others pale greyish few epidote but pale greyish of chl. with pale greyish - especially in 3.25-3.33 m. but in 3.90-3.92 m. more obvious dissin.
general mineral min.	dark green, schistose chl. epid. bio (?) slight disseminated pg.	fine-grained, no magne. homoge. but in 3.90-3.92 m. more obvious dissin.

con	schistose dark green stone with slight mineralization
4 - 4.95 m	
general	dark-medium green-greyish, homogeneous, no magne. mass
minerals	chl. epi. with a few felsic minerals. quar. albite, carbon.
second	some carbonate as irregular disseminated thin veinlet or spot occur. looks like white spot setting in the dark matrix.
min	slight py mineralization
conc	epi. barely dark greenstone with slight mineralization.
4.95 - 5 m	disappears.
5 - 6 m	
5 - 5.37 m	same as 3.71 - 4 m
5.37 - 6 m	
general	Medium green-greyish, more schistose, homogeneous schist
minerals	schistose about 35-40° fine-grained, no magne.
min	mainly chlorite, some carbonate, quartz
second	slight disseminated py, but obvious in 5.69-5.71 m
conc	a carbonate vein occurs in 5.70-5.73 m, about 0.3 cm wide 35° in angle, sharp contact with wall rocks
	slight altered greenstone with slight mineralization
6 - 7 m	
general	medium-grey, grey-white, non-homogeneous, non-magnetite, fine-grained, schistose
structure and mineral	grey-white, occur as disseminated bands in 6.07-6.08 m, 6.42-6.48 m, 6.52-6.55 m, consisting of chl., quar., carbonate and pyrite
min	others medium green, consist of chl. epi. py mineralization occur mainly as disseminated with the carbonate quartz. Pyrite is fine-crystalline, about 1 mm in size.
second	grey-white, that is, mineralized grey bands is 40° in angle. epidote, sometimes, occur as spots about 1 mm size
	no sharp contact occur between dark (medium) and grey
7 - 8 m	
general	same as 6-7 m
minerals	chl. epi. a few quartz, carbonates
min	some levels, py mineralization occur as disseminated or irregular veinlets
	py min. often associated with carbonate and quartz, mainly in 7.11-7.15
	7.35-7.38 m, 7.45-7.70 m. (discontinuous)
second	epidote often occur as spots (amygdaloid) about 1-2 mm in size especially in 7.18-8 m.

8-14 m

general medium greenish, homogeneous  
mineral chl epi. minor albite  
min occurring as irregular thin  
thin vein about 2 mm wide  
these mineralized seams  
no obvious quartz and corals

no magnetite, no obvious schistosity  
carbonate massive  
veinlet in 8.02-8.11 m., and  
in 8.62, with 60° in angle  
associated with chlo or epidote, but  
white

second whole level, epidote occurs  
some Epidote-bearing greenstone  
Pg vein in 10m 4mm wide

as some spots about 1-2 mm in size  
with local, slight mineralization (Pg)  
with 60° in angle

14-20 m

general: same as 8-14m but lt  
rease, moderate green. ma

seems silica increase, epidote dec.  
ssive ~~not~~

mineral: chl + epi + silica  
min.: no obvious mineralization, but

occasionally, Pg disse. in 18.76-18.83 m

second: epidote occurs sometimes,  
in 16.53 m, 19.32 m with  
folded.

irregular thin veins, 2-4 mm wide  
10° in angle. the epi veins are obviously  
folded.

con: Same as 8-14m epi-bearing greenstone

showing a slight magnetite

19.5-20 m

showing a slight magnetite

20-26.1 m

same as 8-14m

general  
mineral

Dark-moderate green,  
chl + epi. characterized by  
epidote occurs as irreg-  
ular knots about several mm to 1 cm  
in 20.54-20.67 m,  
with 35° in angle.

massive fine-grained, no mag  
netite. characterized by epidote rich, with cor. + Q  
irregular knots about several mm to 1 cm  
in 20.54-20.67 m, 22.35 m, or as thin vein in 20.11 m.

min

Sometimes, Pg + chl min  
occur as disse. in 20.20-20.27 m,  
20.31-20.40 m, 20.76-

occur as disse. in 20.20-20.27 m,  
20.81 m, 21.47-21.51 m. the dissemi-  
nated min. often associated with carbonate + Q

second

Occal. lg. Pg veins occur  
21.57, 21.65, 22.45, 22.50, with angles 5°-30° variate  
Car + Q vein occur,  
wide, obvious folded  
in 26-26.10 m, schis-  
tose 35° in angle

or 2.5 mm in wide, in 21.05,  
21.57, 21.65, 22.45, 22.50, with angles 5°-30° variate  
e.g. in 24.57-24.7 m, 5-10 mm  
about 70° in angle

26/10-27.80 m

general  
minerals

dark green-grey, massive,  
chl, minor biotite +  
weak disseminated Pg, but good crystallization.

homogeneous, strong magnetite  
carbonate

min

Car + Q vein, 3mm

in wide with 25°, in 26.65 m

second

	<p>tectoniclastic zone in greenstone (dominant of chlorite) It must be noted that this band of dark greenstone i.e. strong magnetite</p>	<p>26.72 - 26.82 m.</p>
27.80 - 32.54 m	<p>general mineral moderate green, greyish, epidote-decrease but occur Chl + Epi + Car + Alb not strong, but several places occur as disseminated, in 29.31 - 29.33 m, 30.55 m</p>	<p>massive, fine-grained, no mag as amygdalites about 1 mm in size mainly Py</p>
32.54 - 33.62 m	<p>second Epi + Car + Q veins <math>\frac{5}{6}</math> disseminated bands in 28.15 - 28.23 m Car + Q veins 28.69 m, 31.20 m in 10°. 31.63 - 31.68 m, 32.06 m (epi-bearing) dark greenstone.</p>	
33.62 - 37.64 m	<p>general mineral pale grey, fine-grained, Q + Alb + bio + chl not strong, but Py diss. occur the contact between this and greenstone is clear, sharp, felsic intrusion (?)</p>	<p>in 32.92 m in 50°</p>
37.64 - 39.87 m	<p>general mineral dark, moderate - pale green, grey, fine-grained, Chl + Car + Q + Alb strong mineralization Py + Cp, interconnected vein-veinlet and diss. veins 34.20, 35.7; 36.40; diss or diss bands 34.37 - 34.41 m 35.33 - 35.61; 35.67 - 35.75 m; 36.10; 36.25; 36.68 - 36.74; 36.84, vein and bands to keep in 10 - 20° The mineralization often associated with car + q.</p>	<p>34.64 - 34.66, 34.84 - 34.87; 37.70; 37.76 m in 20° mineralized, dark chloritic greenstone</p>
39.87 - 45.61 m	<p>general mineral pale-grey, fine, basal Q + Alb + bio + chl, biotite not strong but occur felsic sill</p>	<p>homo. slight mag occur as diss. obviously belong to metamorphism as diss. e.g. in 37.74 m</p>
45.61 - 47.87 m	<p>general mineral same as 33.62 - 37.64 m, Chl + Car + Q + Alb not strong, but Py diss. occur 42.10 m,</p>	<p>e.g. in 40.68, 40.77 m;</p>
47.87 - 49.87 m	<p>alteral Carbonized and Silicified strong, occur as veinlet or diss</p>	

e.g. Car + Q veins in 40.74 m (10°), 41.07-41.10 (10°),  
41.53, 43.18 (40°), 43.29 (20°), 43.90, 44.20;  
44.39 (10°)

conc mark chloritic greenstone

45.61-48.65m

general dark-matte green grey, mass. fine, string-mag

mineral Chl + Car + Q + Alb.

mis string but non-homo, occur vs diss bands e.g. 45.61-45.64  
46.15, 46.25, 47.10-47.20; 47.41-47.81; 48.15-48.60;

others from last layer. It grade into this layer, there is no obvious con-  
tact between the two. In fact, they both have 120 big difference  
but in magnetite

conc dark chloritic greenstone (magnetite) (as same as 26.10-27.8)

48.65-50.32

● general pale green, Car-rich, homo, no-mag. fine.

mineral Chl + Act + Car + Alb.

min no mineral, int.

others there is a sharp contact with dark greenstone (photo)

conc pale greenstone

50.32-65.76m

general dark-matte green grey, very massive, fine-grained  
homo. string-magnetite

minerals chl (epi) + Alb + Car + (Q)

50.66-50.78m string interconnected Py + cp veinlet at 20° angle.

51.58, 51.62m Py diss.

52.16, 52.48m Car + Q veins, 2-10 mm wide, 5-10°

56.48m Py diss

56.95m tectonoclastic zone

57.18m Car + Q vein, 8 mm wide, 10°

58.40-59.25m Some epidote occur as omygdales or spits 1-2 mm size

59.50-59.81m string interconnected and diss Py + cp mineralized

60-60.18m, 60.78-70.05; 70.35-70.50; and 62.50-62.80m  
epidote occur as an omygdales or spots 1-3 mm

63.10-63.35m no obvious Py diss.

64.80m tectonoclastic zone

conc dark chloritic (some epi-heavy) greenstone  
(string magnetite)

65.76-66.80m Quartz vein

66.50-83.46m	Same as 50.32-65.26 m, fine, very mass. chl + Alb + Cur + (Q) + (Bio)
	i.e. dark chloritic greenstone
67.76 m	Pg diss.
68.48, 68.74	Cur + Q veins 2-2.5 cm wide
69.23 m	Pg diss.
70.20 m	Pg diss.
71.08 m	Cur + Q vein 2 mm in 30° angle
71.15-71.65 m	discontinue to occur in 10-30° at angles, showing carbonate with weak replacement along the cracks or sulphides, as diss. <del>for</del> fissures.
72.35 m	Cur + Q vein 3 mm wide, 20° in angle
73.17-73.21 m	Cur + Q vein 4 cm wide
73.73 m	weak Pg diss.
74.02-75.89 m	biotite occur as individual small crystal, less 1 mm cubit or 5
74.40 m	Cur + Q vein 2 mm, showing folded
76.35 m	Pg diss.
76.65 m	" "
77.02 m	Pg diss.
77.21-77.33 m	Cur weak Pg diss.
77.50 m	Pg diss.
78.05, 78.36	diss. Pg. with car.
78.48 m	
79.28-80 m	weak magnetite, but do occur.
79.50-79.62	Pg diss with car + Q. diss.
79.81 m	Cur + Q vein 6 mm wide at 10° angle
79.98 m	Pg diss.
80.71-80.78 m	Pg diss. associated with Cur + Q.
81.70 m	" "
82.66-82.72 m	" "
82.90-83 m	Cur as diss
conc.	dark, magnetite-bearing chloritic greenstone.
83.46-84.68 m	
general minerals	dark, black green, grey, massive, fine-grained, no-magnetite chl + Alb + (Cur + Q) + (Bio)
84.20 m	Pg diss. associated with Cur, 0.5 cm wide
84.60 m	Obvious Pg diss. Pyrite occur as perfect crystal, about 1 mm size, associ. with Cur + Q (disseminated)
others	In fact, except no magnetite. It has no difference to

above layer

conc

dark chloritic greenstone (without magnetite)

84.68 - 87.76 m

general

dark, black green or grey, very mass homo. fine-grained, strong magne.

minerals

chl + Alb + (Bio) + Car + (Q)  
carbonate occur along the cracks as diss bands, often associated with Pyrite

86.08 m

Py diss

86.20 - 86.28 m

min

conc

Biotite occur as scaly crystal less 0.5 mm size mineralization is not strong, but occur dark (magnetite-bearing) chloritic greenstone.

87.76 - 90.75 m

general

dark, green grey, massive, fine-grained, no-mag.

minerals

chl + Alb + Car + (Bio + Q)

88.15 - 88.36

Pyrite and carbonate occur as weak disseminated alteration and mineralization.

~~88.76 - 88.83~~

88.76 - 88.83 m

obviously diss. bands Py + Cp mineralization with Car + Q.

89.39 - 89.46 m

89.61 - 89.71 m

90.20 m

conc

Car + Q Vein 1 cm wide dark (no mag) chloritic

It is similar and transitional with upper lower greenstone layers.

90.75 - 101.40

general

dark green-grey, massive, fine-grained, strong-weak magnetite homo. in fact. It looks no difference to above layer, but in magnetism.

chl + Alb + (epi?) + Car

91.20, 91.40

Car + Q veins (2-4 mm wide) they both deformed

91.72 m

" 5 mm "

91.73 - 91.84 m

slight diss Py is associated with Car + Q, which become pale grey

92.00 - 92.27

weak diss. Py and weak carbonization, they are associated together, occur as disseminated.

92.68 m

Py diss (and Car)

94.22 - 94.33

Car + Q veins about (1-5 mm wide), they are sharply deformed. they assoc. with weak Py mineralization.

95.13 m

Py vein, 5 mm wide.

95.72 m

Car + Q vein associated with diss. Py. 1 cm wide.

96.31 m

Py diss

96.90 - 97.11

strong carbonization, as diss bands or bands, associated with diss. Py + Cp.

98 - 98.24 m	more schistose, associated Lamellar Car. maybe tecton
98.41, 98.58 m	Py dis assoc Car.
99.20, 99.38 m	" " " " about 1 cm wide
100.51 m	Py dis with Car + Q
101.05 m	Car + Q vein 1.2 cm wide
core	dark chloritic greenstone (with magnetite)
101.40 - 102.80 m	general pale grey, fine-grained, homo. Carbonate-rich, no-mag.
101.40 - 101.52 m	102.45 - 102.71 m, two tectonic zone, core are broken.
mineral	Chl + Car + Alb.
min	mineralizati. no present
other	there is no clear contact to dark greenstone.
conclu.	pale greenstone or altered greenstone (sample).
102.88 - 105.20 m	general. dark green, fine, homo. very massive, strong-mag.
	It grades gradually into next layer in magnetite. In fact, they looks no difference, no contact between the two.
mineral	Chl + Alb + (Car + Q)
min	mineralizati. is not strong, but occur as disseminated bands in several pt levels, they tend to be controlled by cracks or fissures. Obviously, they occur as linear type. e.g. in 103.41 - 103.44 m, 103.82 m, 104.35 m and 104.73 - 104.80 m.
core	dark chloritic greenstone (with strong magnetite)
105.20 - 107.20 m	general. dark green, massive. fine-grained, no-magnetite
mineral	Chl + Alb + (Car + Q)
min	mineralizati. is mainly Py disseminated associated with Car + Q in places. more strong. 105.35 - 105.49; 105.66; 106.37 - 106.41 m
core	dark chloritic greenstone (without magnetite)
107.30 - 113.20	general. dark-black green, grey. fine-grained. very massive. Strong magnetite, homogeneous
mineral	Chl + Alb + (Bio)
min	mineralizati. is weak, only in places associated with Car veins or as disseminated bands. e.g. in 107.92 (Car vein + Py) 109.30 and 109.72 (diss. Car + Q + Py) 107.74, 108.84, 109.65 thin Car + Q veins, 2-4 mm wide, deformed, about 40° in angle

110 - 113.20 m	very homo. <sup>obvious</sup> no minerali.	very massive
113.20 - 113.62	dark chloritic greenstone (with magnetite)	
general	pale-white grey, fine.	hard, massive, slight magnetite.
minerals	Qtz + Alb + (Car)	
113.62 - 117.40 m	diss Py can be seen felsic sill.	very weak, the contact clear.
general	dark green, fine, very homogeneous.	very massive
116.18 - 116.20	strong magnetite	
118.52	chl + Alb + Bt	
119.40 - 122.45 m	Py diss. (weak) + diss Car + Q (weak).	
general	a Car + Q thin vein (1-2 mm wide) + Py diss. 70° angle.	
119.50 - 119.82	dark chloritic greenstone (with strong magnetite).	
120 - 121 m	mode - pale grey-green non-homogeneous, fine-grained, sometimes, slight magnetite, massive-schistose	
121.40 - 121.50	It is characterized by well-homo. It is often that white thin bands consist of Car + Q + Ser + (Alb) altered with dark	
122.10 - 122.4	dark green stone, white bands vary from 1-5 mm wide, sometimes Car + Q mixed with greenstone	
124.10 - 124.90	Car + Q + chlorite rich. It seems very schistose.	
124.61 - 124.81	Car + Q mix with chlorite	
125 - 125.35	Q + Alb + Car occur as band with several mm to 2 cm wide	
125.70 - 125.92	white-grey bands occur, which like felsic rock or alteration sample	
128.42 - 128.70	Car + Q rich as thin bands, alternated with dark greenstone	
129.10 - 129.90	Car + Q rich with Py diss	
129.61 - 129.81	Car + Q + Py rich, as disseminated band. Py. diss	
129.45 - 129.55	Car + Q alternated with greenstone, as thin bands (1-5 mm) or small lenses	
129.70 - 129.92	Q + Car occur as bands or disse. rich	
129.45 - 129.55	Car + Q occur as lenses, like fragment.	
129.45 - 129.55	chl + Car + Q	
129.45 - 129.55	mineralization weak	Pyrite is not often associated with
129.45 - 129.55	Car + Q.	carbonatization, silicification, alb. ?
129.45 - 129.55	altered greenstone	seri ?

	white grey. hard. fine felsic sill	slight mag. with small Pg
125.55-125.05	same as 119.90-119.95	
130.05-130.30	altered greenstone Car + Q rich as band	
	It is noted that mineralization is very weak	
135.05-136.92	general pale green. fine lentic. Chl + Alb + Car, no obvious pale greenstone or altered greenstone (sample)	no mag. Car-rich is mineralization
136.52-141.40	very non-homogeneous	fine-grained, schistose no mag.
136.68-138.95	Car + Q as thin veins, lenses, they look like keep in <u>40°</u> angle (sample)	several mm to 3 cm) or small fragments, may be tectonic.
140.50-140.87	same. Like fragment the matrix of greenstone	felsic rock, or Car + Q) setting in
	fragments are general in size,	as small lenses, about 1-3 cm
	Chl + Alb (?) + Car + Q	
	altered dark greenstone!	
140.00-143.72	Q + (Car) vein.	
143.72-149.95	general moderate green, fine-grained, no-magnetite	schistose in about <u>40°</u>
	Chl + Alb + (Car + Q)	
143.72-146.60	relative homogeneous	(looks like thin bands)
146.60-149.75	Car + Q + chlorite + Epi. sometimes. Pg rich	rich as veins, disse, constituting the thin alternating band of white grey and moderate green. <sup>2-6mm</sup>
146.72	Pg vein 1mm wide at <u>40°</u>	
	In general, mineralization is weak	
	altered greenstone	
149.75-151.07	Q + (Car) vein	

151.07 - 155.71

151.07 - 152.31

altered greenstone

152.31 - 153.63

tectonic zone, Q vein core were broken to pieces

152.63 - 155.71

mode - pale grey-green. non-homogeneous, (Car + Q + (Epi))  
occur as bands or lenses in about 40°  
Achistose, non-magnetite.

153.22 - 153.35

Car + Q rich

153.10 - 153.70

very strong tightly fold

154.10 - 154.70

Car + Q rich

Chl + Alb + (Car + (Q))

core

altered greenstone

155.71 - 170.

general

dark green grey, massive, fine, strong mag.  
chl + Alb + (Epi + Car)

156.83 - 156.93

Car + Q rich, associated. diss. Py. alterat.

157.60

Car + Q vein, irregular in 50°, 3 cm wide.

158.20

Car + Q vein 8 cm wide

160.25

Car + (Q) vein 2 cm

161.82

Car vein 0.5 cm

162.10

Car vein 0.5 cm

162.50 - 162.62

Car + Q + Alb rich, assoc. weak diss Py, alterat.

163.44 - 163.69

" " " " Py diss alterat zone

164.02 - 166.70

Biotite rich, as disse. scaly crystal.

164.75 - 166.65

Epidote rich as amygdales, 1-10 mm in size. general  
round, but some like pipes. They often associated with  
Qtz + Car. as filling in vesicles

167.55 - 167.70

Biotite occur as small scaly crystal

core

dark chloritic greenstone (with strong magnetite)

170 - 170.65

Q + Car vein

170.65 - 171.85

dark chloritic greenstone (with strong mag).

171.80 - 174.05

tectonic zone with Q + Car vein

almost core lost. very clastic, catclastic

174.05 - 190.70m

general

dark - black green-grey, ~~very~~ massive, fine grained,  
strong magnetite, homogeneous, almost horizon (chlorite)  
chl + Alb + (Epi) + Bzo + Stilpenomelane + (Car + Q)

174.52

Q + Car vein 2 cm.

- 175.87-175.94 disseminated Py occur with less Car + Q + (Alb).
- 175.30-176. Biotite occur, small scaly crystal, dissemin } Biot + stilp.
- 177.80-178.65 Biotite + stilpennomelun occur
- 178.38-178.43 Epidote occur. ∞ knots about 1-2 mm in diameter.
- 179.20-190.70m Biotite + Stil rich  
dark, chloritic greenstone (with strong magnetite)  
Bio + stil. very obvious, as scaly or length (needle) crystal, distrib  
but with varying direction. looks brown. It is very similar with  
Bio-Stil-bearing greenstone to occur in east of major fault.  
sample (180.48 - 180.63 m)
- 181.00-181.40 tectonic zone. ? sample (lost)
- 182.00-182.50 " " " " " "
- 182.85-183.44 tectonic zone, the core was broken into small pieces.
- 183.57-183.61 Q+(Car) vein,
- 183.78-183.84 Q+(Car) vein,
- 185.10-185.27 Car+Q vein and Py min. Pyrite occur as coarse, good crystal  
about 1mm size.
- 185.96-185.70. Epidote occur as amygdaloids, about 3-5 mm in diameters
- 186.30 Car + Q vein, 4 mm wide
- 186.50-186.75 Epidote occur as amygdaloids, about 3-5 mm in size
- 187.35 Car + Q vein 1 cm wide at 40°
- 188.02-188.27 Car + Q + Alb rich, occurring as veins (bands) or small  
lenses, may be alternating along the cracks
- 188.42-188.76 " " " " " "
- 189.40-189.78 " " " " " "
- 190.00-190.34 " " " " " "
- The schistosity and veins almost keep horizon, or very  
slight angle, which is contrast with above layer.
- same. dark, bio + stil bearing greenstone (with magnetite).
- 190.70-192.80.  
general pale-white gray, hard, very fine, magnetite, very horoz  
massive.  
minerals Q + Alb + Bio + (chl) + (stil), occasionally, Albite crys  
tal can be recognized.  
min disseminated Pyrite widespreadly but weak occur  
conc felsic rock (sill, dyke, ?)
- 192.80-204.20  
general dark-moderate green, massive, homogeneous, fine-grained

strong magnetite,  
chl + Alb + Bio + Stil + Epi. + (Car + Q)

all level. Bio + Stil-bearing or rich.

194.70 - 197.00

Epidote rich. as amygdales about 1-2 mm size.

196.19

Py. diss + Car + Q. vein. 5 mm wide.

198.15

Py. diss veins 2 mm wide, generally, mineralization is weak  
dark. bio + stil-bearing, chloritic greenstone.

204.20 - 212.20

general

moderate-pale green. fine, non-homo, massive to schistose,  
no-magnetite.

chl + Alb + Epi + Bio + (Car + Q)

204.2 - 206.50

Bio + Stil-bearing

204.2 - 205.35

Car + Q + (Alb) occur as laminae, 1-5 mm wide, which alternate with  
greenstone.

204.25

Py. diss. occur, not strong

205.4 - 205.85

several Q + (Car) vein occur. (5 veins) 2-4 cm wide

206.50 - 206.72

obvious fold. (strong tightly)

206.50 - 207.20

Car + Q. rich, as veins (lenses)

208.10 - 208.50

fold, Car + Q rich. It seems they mixed with greenstone.

209.50 - 210.75

Car + Q rich, they occur as tectonic fragments  
occur in different directions, vary from mm to several  
cm in size, not round (with angle).

211.30 - 211.72

tectonic fragment. fragments are Car + Q, and greenstone  
associated with inter connected veinlet and disseminated Py +  
mineralization

211.75 - 212.20

Bio + Stil bearing

It must be emphasized that the mineralization is  
weak

conc

altered greenstone

212.20 - 213.90

dark green, homo. massive-schistose, strong magnetite

chl + Alb + Bio + Stil

213.10

Car + Q + Alb vein vein and schistosity keep at 50°

Bio + stil rich

conc

dark, bio + stil-bearing greenstone

213.90 - 215.70

pale-white grey, very fine-hard, mass. mag.

Q + Alb + Bio + chl + Car  
disseminated Pyrite occur but not increase  
there are clear contact to the greenstone in both  
sides.

conc felsic rock ( sill dyke ? )

215.70 - 215.95

Same as 212.70 - 213.90

215.80  
Car + Q + Py (diss)

conc dark, bio + stil - bearing greenstone

215.95 - 218.55

general

moderate - pale green grey, non-homogeneous, mass-schistose  
Car + Q + (Alb) + (Ser) occur as thin veins, and disseminated

216.11 - 216.21

Car + Q rich as like small fragment

216.50

Py diss + Car + Q vein

216.56 - 216.82

Car + Q + Alb rich as a thin vein or dense diss.

217.25 - 218.40

Car + Q rich, chl + (Ep) rich, they occur as vein, veinlet,  
or disseminated;

mineralized not strong

conc altered greenstone

218.55 - 219.24

general

moderate green grey, massive, fine, <sup>homo</sup> - no-magnetite  
light mineral (Alb + Car + Q?) and dark min is equal

they mix together

conc gabbro

219.24 - 220.67 m

dark-moderate green-grey, massive, homo fine,  
strong magnetite

chl + Alb + bio + stil + (Car) Biotite and stilpnomelane  
occur extensively

conc dark, stil + bio - bearing greenstone

220.67 - 224.42

pale-white grey, very fine-grained, massive, slight  
mag, Q + Alb + bio + chl. Alb and Q porphyritic crystal

can be recognized; disseminated Pyrite is more obvious,  
thin Py vein, 1mm

22.2.52

~~felsic dyke~~

felsic rock has a clear contact to the gneiss in both sides  
felsic dyke

224.42 - 240.50

general moderate-dark green, grey. mass - schistose, homo. fine, string magnetite  
Chl + Alb + Bio + Stil + (Epi) + Car + (Q)

224.53

224.90

Car + Q rich, occur as vein 8 cm and 7 cm

225.40 - 228.15

Bio + Stil rich

225.33 - 225.56

Q + Car + a rich as thin vein or diss

226.37

Pg vein (+ Car + Q)

226.60

Car + Q vein 2 cm

227.56

diss Pg + Car + Q

228.40 - 230.

Epidote rich, or amygdale thin laminae and diss

229.67 - 229.9

Bio + Stil rich

230 - 240.50

very massive, bio + stil rich

232.06 - 232.12

Q + Car vein

237.1 - 238.20

rich Epi, Car + Q, alternate occur along cracks alternating pale-grey with moderate green <sup>bands of</sup> ~~formed~~ formed, varying several mm to cm. mineralization not obvious

conc dark, bio-stil rich, chloritic greenstone.

240.50 - 242.50

pale-white grey. mass. very fine, hard, homo. slight mag. Q + Alb + (Bio + Chl), Alb + Q crystal can be seen. Disseminated pyrite occur but not extensive.

conc felsic rock (sill, dyke?)

242.30 - 246.70

243.05 - 243.20

Car + Q fold vein. MM 2 mm wide

244 - 246.70

Bio + Stil very rich.

243.70 - 245.90

Car + Q rich, as disse. with disseminated Pg

general dark-moderate green, grey, massive, fine, string magnetite rich - Bio + Stil, Chl + Alb + (Epi) + Car + (Q)

conc dark, bio + stil - bearing chloritic greenstone

246.70 - 247.60

general moderate-pale green, grey massive, fine, Car-rich, red-mag. chl + Alb + Car + (Epi) + (Q)

- 24718 - 24744 rich - bio + Stil. like altern -  
 others, white Car + Q (Alb) occur as bioto. thin bands  
 or small lenses. Like very schistose, tectonic.  
 conc pale greenstone or fragments greenstone or  
 altered greenstone.
- 24744 - 258.20  
 general very massive. dark to black green. grey, strong magg  
 fine bio + Stil rich
- 249.50 Q + (Car) vein. 2 cm wide.
- 24744 - 251.10 very massive. Bio + Stil bearing
- 251.20 - 251.65 Epidote rich. as amygdaloides or replacing diss.
- 251.46 Pg thin veins (3) 1 cm wide, associ. with Epi + chl.
- 251.55 - 251.80 Bio + Stil. rich
- 251.85 Car + (Q) vein with diss Pg, 2-4 mm wide, at 15°
- 251.80 - 254.12 very massive, stil + Bio bearing
- 253.55 Epidote vein 2 mm wide.
- 254.12 - 255.44 Epidote rich. mainly in amygdale or associ. with Car + Q  
 magnetite slight.
- 255.44 - 258.18 very massive. bio + Stil rich.
- 258.20 - 267.65 Epidote rich. amygdaloides and replacement  
 weak magnetite
- 258.70 - 258.93 Bio + Stil rich very much  
 Chl + Alb + Epi + Bio + Stil + (Car + Q)  
 mineralized weak  
 epidotized is strong in places.
- ~~258.93 - 259.95 dark bio + stil bearing greenstone without magnetite~~
- 258.93 - 259.95 moderate green fine non-homo. no magg.  
 Chl + Epi + Alb + Bio + Stil + Car + (Q)  
 It is characterized by Epidote rich and non-magnetite  
 non-homogeneous. thin seams. altern. Epidote. Carbon.  
 chl. rich.  
 mineralized weak  
 Biotite + stil. bearing
- 259.95 - 260.95 dark bio + stil bearing greenstone without magnetite  
 weak magnetite
- 259.98 - 260.65 Biotite + stil + melan rich very much

261.15 - 261.95

non-homo, Car + Alb occur as band, like replace-  
ment, very 1-5 cm wide, transitional to greenstone  
Epidote rich, but occur replace, typical color green-yellow  
more homo. non- slight magnetite

261.95 - 267.15

Epidote rich, green yellow of rock. as amygdales or  
replacement.

267.15 - 267.65

Car + Alb + Q + (Ser) increase, (rich) occur as disse-  
minated bands,

general.  
typical.

moderate green-yellow, fine mass-schistose.  
① no or slight mag- netite (most of level, no mag)  
② non-homo. bio + Stil-bearing in all sect. but very rich  
in places; Car + Alb + Q occurs as disseminated bands  
③ Epidote rich, some as amygdales, most belong to rep-  
lace ment

minerals  
conc

④ mineralization weak  
Chl + Epi + Alb + Bio + Stil + Car  
dark. Bio + Stil-bearing Epi-rich greenstone  
(without or weak magnetite?)

267.65 - 268.80

pale-white grey, mass. fine-grained, hard, slight mag  
Q + Alb + Bio + (Stil) + (Chl + Albite crystal can be recognized.  
the contact is not clear to the greenstone in either size.  
conc. felsic rock (or replacement rock)

268.80 - 274.35

general. moderate-pale grey, green non-homogeneous, massive schistose  
fine-grained, weak magnetite, Bio + Stil bearing,  
Chl + Epi + Alb + Bio + Stil + Car + Q; mineralization not obvious

268.80 - 270.50

more massive homo

270.50 - 272

Car + Q + Alb increase (rich). they are disseminated or  
well mixed with greenstone.

271.30 - 271.40

> Epidote rich as thin veins, disseminated.

272.50 - 273

It is different from other sections, Car + Alb + Q + (Ser)  
rich, but occur as disseminated replacement, not veins.  
conc. altered greenstone

274.35 - 277.30

general pale green-grey, fine non-homo, hard, slight-mag,

Q + Alb + chl + Bio + (Stil) + Epi + Cor

H is typical in non-homo. seems that Q + Alb + Cor + Ser replace the greenstone, but dominated by slight microls. Albite crystal can be recognized.

274.52 - 274.60

> chlorite rich

274.68 - 274.77

274.85 - 274.90

Cor + Q vein

275.17 - 275.34

> Cor + Q rich on veins

275.83 - 275.88

275.50 - 275.75

Epidote rich. as disseminated

276.10 - 276.18

276.70, 278.60 - 278.70, 278.05 - 278.20 chlorite rich

277.50 - 277.90

278.55 - 278.70 epidote rich

or

There are no clear contacts to the greenstone in either side

core

felsic rock (altered rock)

279.3 - 283.95

general

dark - moderate green, mag. non-homo. massive fine magnetite.

280.30 - 280.90

chl + Epi + Alb + Bio + Stil + Cor + (Q)

280.50

Cor + Alb + Q + Epi rich

281.01 - 281.48

Py vein 2mm wide

281.18 - 281.50

Bio + Stil very rich

282.00 - 282.20

Py vein (2 veins) - 2mm wide

283.20 - 283.40

Epi rich as amygdaloid or disse

282.22

Py vein (3mm wide)

core

Biotite + Stil. occur in all sections

dark, Bio + Stil - heavy chlorite greenstone (with strong magnetite)

283.95 - 285.85

general

moderate - pale green grey, non-laminar massive - ahistose, fine, no or weak magnetite

Alb + Cor + Q + Ser rich, occurring as disseminated bands. varying 0.5 - several cm wide

Bio + (Stil) occur

284.10 - 284.60

Epi rich, mainly disseminated

285.13

Cor + Q vein 2-5mm wide

chl + Epi + Alb + Bio (Stil) + Cor + (Q)  
 mineralization is not strong  
 altered dark greenstone.

conc

285.85-288.50

same as 279.3-283.95 but Biotite and Stil prominent  
 lens not obvious  
 conc dark, chloritic greenstone

288.50-290.

Same as 283.95-285.85 m, but Biotite + Stil not obvious  
 altered greenstone

end.

in Grand Gruver.

May 21-31, 1991

Sun Haitian