

**Fljotsdalur hydro project. Petrographic
description of thin sections from drill core
samples**

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FLJOTSDALUR HYDRO PROJECT

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DESCRIPTION OF THIN SECTIONS

INTRODUCTION

The thin section studies of thirty samples from drill cores from Fljótsdalsheiði indicate that there are five main rock groups in the lava suites, i.e. tholeiite basalt, olivine basalt, porphyritic basalt, titanaugite basalt and andesite. These rock types are described briefly here below.

The rocks that are described in the thin sections are all extrusive rocks of basaltic to andesitic composition. They are all strictly speaking fine grained and the average and coarse grain size mentioned in the descriptions here below is a relative grain size for this fine grained rock variety.

1. Tholeiite basalt: This is a fine grained basalt with intergranular texture and rich in small magnetite crystals.

2. Olivine basalt: A basalt with an average to coarse grained groundmass and sub-ophitic to ophitic in texture. It has plagioclase of variable sizes and the largest laths could be considered to be phenocrysts. Clusters of olivine and pyroxene phenocrysts and plagioclase laths are common. Individual phenocrysts of olivine and pyroxene are also present. The amount of modal olivine is usually 2% or more.

3. Plagioclase Porphyritic basalt: The porphyritic basalts are usually medium to coarse grained, with an intergranular texture. They have phenocrysts of plagioclase, and may also have a variable amount of pyroxene and olivine phenocrysts. The plagioclase porphyritic rocks called porphyritic basalts in the field core logs.

4. Titanaugite basalt: This basalt variety has an average to coarse grained

groundmass, often sub-ophitic. It contains phenocrysts of pyroxene which has an hourglass extinction, typical for the titanaugite. There is no olivine present, although this rock type is very similar in character to the olivine basalt. This basalt seems to be identified as an olivine basalt in the field core logs.

5. Andesite: This is a very fine grained rock, rich in plagioclase laths that show strong flow orientation. The magnetite content is also rather high. Two varieties of andesites were identified in the thin sections, i.e. basaltic-andesite and also true andesite. The basaltic variety is usually slightly coarser grained.

There is a reasonably good correlation between the field logs and the classification in thin section. The main difference is, that the titanaugite basalts are classified as olivine basalts in the field. One fine grained basalt with high modal pyroxene is logged as olivine basalt in the field, even though it contains no olivine (thin section 1533; FS-33, 154 m). This is, however, most certainly a fairly basic rock.

Alteration: The alteration of the rock is two-fold, i.e. alteration or replacement of primary phases (minerals and glass), and precipitation of secondary minerals into pores (vesicles, fractures and cracks).

The first alteration phase is the hydration of glass to palagonite. The next stage is the alteration of palagonite to brown or green smectite. The smectite is also replacing groundmass olivine and pyroxene. The third stage is the alteration of olivine to reddish iddingsite (hematite and smectite). Increased alteration leads to replacement of olivine by smectite and in some cases also illite. The alteration progresses to the alteration of groundmass pyroxene, which is replaced by brown and green smectite. Pyroxene is also replaced by calcite and a

small amount of hematite. Alteration of plagioclase and pyroxene phenocrysts is hardly visible. The precipitation minerals are zeolites and calcite, as well as smectite (chlorophaeite and celadonite).

The point counting: The accuracy of the point counting is not very high, as only 200 and in some cases 400 points were counted. It is estimated to be about $\pm 3\%$. The difference between 200 and 400 points was found to be 1-2%.

All the primary minerals in the rock samples were counted, except for the opaques. All the opaque minerals were grouped together, that is magnetite, ilmenite and tachylitic glass. A great majority of the opaques are, however, thought to be magnetite. The secondary minerals are grouped into clay (replacement of primary minerals) and zeolites (mostly amygdale minerals).

FS-30: 111.2 m, thin section no. 15224

Description

Olivine basalt rather coarse grained with plagioclase laths of variable size. The bigger laths could be classified as phenocrysts. Ophitic texture is dominating. Alteration: Nearly no alteration, just beginning in cracks of olivine (iddingsite) Photos no. 2.3 and 2.4.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	48
" as phenocrysts	2
Pyroxene	44
Olivine	5
Opaques	1
Total	100

FS-31: 15.4 m, thin section no. 15230

Description

Plagioclase porphyritic basalt of average grain size. The pyroxene is mostly intergranular but ophitic texture is also found. Alteration: The vesicles are mostly empty; only a few are filled with zeolites. Brown smectites are found in the empty pores. The brown smectite is also beginning to replace groundmass pyroxene. Photos no. 1.4 and 1.5.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	45
" as phenocrysts	1
Pyroxene	38

Opaques	7
Zeolites	<1
Clay	7
Pores	1
Total	99

FS-31: 83.5 m, thin section no. 15223

Description

Plagioclase porphyritic basalt rather fine grained with some micro-phenocrysts of olivine. Alteration: Some zeolites (chabazite) in vesicles. Brown smectite is beginning to replace pyroxene and red alteration (iddingsite) is beginning in olivine. Photos no. 2.1 and 2.2.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	39
" as phenocrysts	9
Pyroxene	42
Olivine	2
Opaques	3
Zeolites	1
Clay	4
Total	100

FS-31: 87.4 m, thin section no. 15229

Description

Plagioclase porphyritic basalt rather fine grained with intergranular texture. The magnetite, often elongated, is more like magnetite in olivine basalt, and small amount of olivine is found. Alteration is beginning in cracks olivine and plagioclase phenocrysts. There is also some alteration to brown smectite beginning in groundmass pyroxene especially at the edge of the crystals. Photos no. 1.6 and 1.7

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	40
" as phenocrysts	4
Pyroxene	51
Olivine	<1
Opagues	2
Zeolites	1
Clay	2
Total	99

FS-31: 146.2 m, thin section no. 15231

Description

Plagioclase porphyritic basalt of average grain size with some glass in the groundmass.

Alteration: A considerable part of the glass has turned to brown smectite.

Photos no. 2.11 and 2.12

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	46
" as phenocrysts	2
Pyroxene	42
Opagues	2
Glass	4
Clay	4
Total	100

FS-31: 192.4 m, thin section no. 15228

Description

Tholeiite basalt, rather fine grained with micro-phenocrysts of pyroxene which have hourglass extinction which indicates to titan-augite.

Alteration: Brown smectite occurs around vesicles and in the glassy groundmass.

Photos no. 1.1 and 1.2.

Point counting of 400 points

Mineral name	%
Plagioclase in groundmass	51
Pyroxene	39
Opagues	6
Clay	3
Pores	<1
Total	99

FS-32: 12.2 m, thin section no. 15232

Description

Olivine basalt with nearly no phenocrysts of plagioclase but plagioclase laths of variable size.

Alteration is little, only some alteration of olivine.

Photos no. 2.9 and 2.10

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	41
Pyroxene	52
Olivine	2
Opagues	4
Chalcedony	<1
Total	99

FS-32: 13.8 m, thin section no. 15249

Description

Olivine basalt of average grain size with clusters of pyroxene and olivine phenocrysts with some big plagioclase laths. Individual phenocrysts of olivine and pyroxene are also found.

Alteration is very little, only beginning in cracks of the olivine.

Photos no. 4.7 and 4.8.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	49
" as phenocrysts	1
Pyroxene	44
Olivine	3
Opagues	3
Clay	<1
Total	100

FS-32: 40.5 m, thin section no. 15221

Description

Plagioclase porphyritic basalt with some micro-phenocrysts of olivine and pyroxene. The groundmass is rather fine grained, and ophitic texture frequent.

Alteration: Almost no alteration, only olivine slightly altered.

Photos no. 2.5 and 2.6.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	42
" as phenocrysts	12
Pyroxene	41
Olivine	2
Opagues	3
Total	100

FS-33: 21.3 m, thin section no. 15250

Description

Olivine basalt of average grain size with clusters of pyroxene, olivine and plagioclase phenocrysts. Individual phenocrysts are also found.

Alteration is little and only in olivine, mostly in cracks but in rare cases have parts of olivine crystals been replaced by clay.

Photos no. 4.9 and 4.10.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	45
" as phenocrysts	2
Pyroxene	44
Olivine	6
Opagues	3
Clay	<1
Total	100

FS-33: 23.9 m, thin section no. 15222

Description

Olivine basalts average to coarse grained with clusters of plagioclase, pyroxene and olivine phenocrysts, and also individual phenocrysts.

Alteration: The alteration is very small, only beginning in the cracks of olivine.

Photos no. 2.7 and 2.8.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	41
" as phenocrysts	4
Pyroxene	48
Olivine	5
Opagues	2
Total	100

FS-33: 63.1 m, thin section no. 15227

Description

Plagioclase porphyritic basalt of average grain size with some olivine micro-phenocrysts.

Alteration: Nearly no alteration, only brown smectite sporadically found.

Photos no. 1.8 and 1.9

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	44
" as phenocrysts	2
Pyroxene	50
Olivine	<1
Opaques	3
Clay	<1
Total	99

FS-33: 154 m, thin section no. 15233

Description

Vesicular fine grained basalt with tholeiitic texture (both fine grained and high in magnetite). Plagioclase content is low but pyroxene high, which points to basic composition, although no olivine is found. Alteration: The vesicles are filled with zeolites (analcime and stilbite) and chalcedony. Small amount of chalcedony has turned to quartz. Photos no. 2.13 and 2.14.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	26
Pyroxene	61
Opaques	8
Zeolites	4
Pores	1
Total	100

FS-33: 190.3 m, thin section no. 15226

Description

Plagioclase porphyritic basalt. Considerable amount of micro-phenocrysts of pyroxene with hourglass extinction (titanaugite). The groundmass is fine grained, a typical tholeiitic texture. Alteration: Almost no alteration. Brown smectite only sporadically found in

groundmass pyroxene.
Photos no. 1.12 and 1.13.

Point counting of 200 points

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Mineral name	%
Plagioclase in groundmass	45
" as phenocrysts	2
Pyroxene	46
Opaques	6
Clay	<1
Total	99

FS-34: 102.4 m, thin section no. 15234

Description

Basalt of average grained size, probably olivine basalt, although no olivine is found. Part of the clay, however, is altered olivine. Alteration: All olivine is altered to dark-green clay with high refractive index (illite). The cracks of olivine has the typical reddish alteration of iddingsite. The ground mass pyroxene is beginning to turn to green smectite with lower refractive index than the replacement of olivine. Small amount of zeolites (chabazite) is found in vesicles. Photos no. 3.1 and 3.2

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	48
" as phenocrysts	<1
Pyroxene	37
Opaques	2
Zeolites	<1
Clay	12
Pores	<1
Total	99

FS-34: 188.3 m, thin section no. 15235

Description

Olivine basalt of average grained size, olivine mostly as phenocrysts and small amount of pyroxene phenocrysts occur also.

Alteration: The alteration of olivine and groundmass pyroxene is little. Alteration is beginning in the cracks and at the edge of the mineral grains. There is a considerable amount of vesicles in the sample which are filled with zeolites, mostly mesolite.

Photos no. 5.1 and 5.2.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	37
Pyroxene	48
Olivine	7
Opaques	2
Zeolites	6
Pores	<1
Total	100

FS-35: 17 m, thin section no. 15236

Description

Coarse grained basalt with phenocrysts of pyroxene with hourglass structure, titanite.

Alteration: There is considerable alteration of groundmass pyroxene and part of the groundmass pyroxene has been replaced by calcite and some hematite and smectite. This is counted as clay in the point counting but there is also brown to green clay present. The brown clay could also have replaced olivine in a few cases. There are zeolites in a few vesicles (chabazite).

Photos no. 3.3 to 3.4.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	53
Pyroxene	38
Opaques	5
Clay	4
Pores	<1
Total	100

FS-35: 39.3 m, thin section no. 15237

Description

Lava of average grained size, with flow oriented plagioclase laths. The magnetite is bi-modal large and small. The high content of plagioclase points to a basaltic-andesite composition.

Alteration: There is considerable alteration of pyroxene to brown and green smectite. The smectite also surrounds vesicles. Most of the vesicles are empty but some are filled with zeolites (chabazite).

Photos no. 3.7 and 3.8.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	65
Pyroxene	21
Opaques	5
Clay	9
Total	100

FS-35: 75.9 m, thin section no. 15238

Description

Rather fine grained plagioclase porphyritic basalt with some clusters of plagioclase and pyroxene. The clusters could also have consisted of olivine which now is altered to green clay. There are also individual pyroxene phenocrysts present which have all an hourglass extinction (titanaugite). Small amount of sideromelane glass is also found, now

partly altered to green clay. There is also black unaltered tachylitic glass present and this is counted with the opaques in the point counting.

Alteration: Besides alteration of glass which has been mentioned, there is considerable alteration around vesicles and pyroxene is replaced by similar smectite as is replacing the glass.

Photos no. 3.9 and 3.10.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	42
" as phenocrysts	3
Pyroxene	31
Opaques	10
Clay	9
Pores	5
Total	100

FS-35: 98.6 m, thin section no. 15239

Description

Porphyritic basalt of average grainsize with some micro-phenocryst of olivine and pyroxene. There is a considerable amount of glass in the groundmass.

Alteration: All the sideromelane glass has turned to palagonite glass and a part of the palagonite has turned to brown smectite. The brown smectite has also partly replaced olivine and groundmass pyroxene, but the main part of the olivine is fresh. Calcite is found in vesicles. The palagonite glass and the smectite is point counted as clay.

Photos no. 5.3 and 5.4.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	42
" as phenocrysts	4
Pyroxene	39
olivine	2
Opaques	<1
calcite	1
Clay	11
Total	99

FS-35: 145 m, thin section no. 15240

Description

Plagioclase porphyritic basalt of average grainsize with some phenocrysts of pyroxene. Bi-modal magnetite occurs.

Alteration is very little, only at the edge of the pyroxene.

Photos no. 3.11 and 3.12.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	41
" as phenocrysts	3
Pyroxene	50
Opaques	5
Clay	<1
Total	99

FS-36: 13.4 m, thin section no. 15241

Description

Fine grained lava with flow oriented plagioclase laths, and with a few phenocrysts of plagioclase. This could be an andesite as logged in the field, although the magnetite occasionally looks like those in tholeiite basalt.

Alteration: Small amount of the groundmass pyroxene is replaced by brown smectite and calcite.

Photos no. 4.13 and 4.14.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	46
Pyroxene	48
Opaques	5
Calcite	<1
Clay	<1
Total	99

FS-36: 50.2 m, thin section no. 15242

Description

Coarse grained lava with some phenocrysts of plagioclase, and could therefore be classified as plagioclase porphyritic basalt, as logged in the field.

Alteration is little. The pyroxene is beginning to be replaced by brown smectite and calcite.

Photos no. 4.15 and 4.16.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	44
" as phenocrysts	2
Pyroxene	45
Opaques	6
Calcite	<1
Clay	1
Pores	1
Total	99

FS-36: 75.5 m, thin section no. 15243

Description

Fine grained vesicular tholeiite basalt with scattered phenocrysts of plagioclase. There is a considerable amount of tachylitic glass.

Alteration: Vesicles are partly filled with calcite. There is also calcite replacement of glassy groundmass and the pyroxene has small amount of brown smectite in places.

Photos no. 4.17 and 4.18.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	38
Pyroxene	42
Opaques	16
Calcite	1
Clay	<1
Pores	2
Total	99

FS-38: 28.3 m, thin section no. 15244

Description

Rather coarse grained lava with some plagioclase phenocrysts. This could be classified as plagioclase porphyritic basalt, as logged in the field.

Alteration is very little, only beginning in the cracks of olivine.

Photos no. 4.19 and 4.20.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	43
" as phenocrysts	2
Pyroxene	49
Olivine	1
Opaques	3
Opal	<1
Pores	1
Total	99

FS-38: 87.5 m, thin section no. 15245

Description

Rather coarse grained plagioclase porphyritic basalt. Magnetite is often elongated like in olivine basalt, although very little olivine is found. There could be some relicts of olivine but this is not very clear. This sample is rich in tachylitic glass.

Alteration: The vesicles are filled with brown to green clay (smectite) and this clay

seems to have replaced part of the pyroxene and olivine?
Photos no. 4.1 and 4.2.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	36
" as phenocrysts	5
Pyroxene	39
Olivine	1
Opaques	7
Clay	12
Total	100

FS-38: 136.5 m, thin section no. 15246

Description

Lava of average grained size with a few phenocrysts of plagioclase, olivine and magnetite. The magnetite grains, besides the magnetite phenocrysts, are similar to that of tholeiite basalt, as logged in field. Alteration: There is some replacement of pyroxene by brown clay (smectite).
Photos no. 4.3 and 4.4.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	43
Pyroxene	47
Opaques	3
Clay	7
Total	100

FS-38: 154.9 m, thin section no. 15247

Description

Olivine basalt of average grain size. The olivine occurs as phenocrysts with some pyroxene phenocrysts, but true plagioclase phenocrysts do not exist, only big plagioclase laths.

Alteration is very little but iddingsite occurs in cracks of olivine.
Photos no. 4.5 and 4.6.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	42
Pyroxene	53
Olivine	1
Opaques	4
Clay	<1
Total	100

FS-38: 169.7 m, thin section no. 15248

Description

Plagioclase porphyritic basalt of average grained size, with some clusters of pyroxene and plagioclase phenocrysts. Propably rich in olivine, both as phenocryst clusters and as individual phenocrysts. Alteration: There are big lumps of dark-green clay (smectite) which are likely to be relicts of olivine phenocrysts. Parts of the groundmass pyroxene has been replaced by dark green to brown clay (smectite).
Photos no. 4.11 and 4.12.

Point counting of 200 points

Mineral name	%
Plagioclase in groundmass	37
" as phenocrysts	13
Pyroxene	35
Opaques	4
Clay	10
Pores	1
Total	100

FV-1 197.7 m, thin section no. 15225

Description

Plagioclase porphyritic basalt with some

pyroxene and olivine phenocrysts. The groundmass is rather fine grained.

Alteration: Dark brown smectite is common at the edge and in the cracks of olivine. The plagioclase phenocrysts are sometimes found with dots of a light green mineral, probably replacement of glassy inclusions. Opal is found in the groundmass, probably a replacement of glass, and the opal has begun to turn to chalcedony or even quartz. Photo no. 1.10 and 1.11.

Point counting of 400 points

Mineral name	%
Plagioclase in groundmass	42
" as phenocrysts	13
Pyroxene	37
Olivine	1
Opagues	2
Opal	3
Quartz	<1
Clay	<1
Total	98