NGU Report 2002.091

Geological mapping of a planned extraction area for hard-rock aggregates, Seljestokken, Flora, Sogn og Fjordane

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REPORT

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Title:
Geological mapping of a planned extraction area for hard-rock aggregates, Seljestokken, Flora, Sogn og Fjordane

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County:
Sogn og Fjordane

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Flora

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Summary:
Geological mapping of a planned extraction area for hard-rock aggregates has been carried out at Seljestokken, Flora municipality, for Hertig Natursteine AG. A number of hand-specimens of the bedrock were collected and thin-sections were subsequently examined under the microscope.
The bedrock of the area consists of fine-grained, Devonian sandstone with a few, thin beds of siltstone. The thin-sections show that the grain size usually ranges between 0.4 and 0.05 for most of the rocks. The sandstone beds strike between 10° and 25° west of north (i.e., c. NNW-SSE) and dip at 20° towards ENE. The most conspicuous joint sets are transecting the rocks along approximately N-S and ENE-WSW trends.
Field investigations, microscopic examination and mechanical testing indicate that the sandstone is well suited for aggregate production. The homogeneous appearance of the rocks leads us to conclude that it should not be necessary to conduct a drilling programme in the planned extraction area. NGU, however, recommends that the area should be further sampled for mechanical testing according to the plan described in our 2nd preliminary report that is enclosed together with this report.

Keywords: Resource mapping	Hard-rock aggregate	Mineralogy
Los Angeles value	PSV	

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GEOLOGICAL MAP OF THE SELJESTOKKEN AREA (Drawing no. 2002.091-01)

1. INTRODUCTION

In the early fall of 2001, NGU was consulted by Flora municipality with a view to conducting an investigation at Seljestokken to see if conditions there were favourable for aggregate production. Based on that consultation, NGU visited the area in late September of that year to collect samples for thin-section analyses and mechanical testing. This first visit to Seljestokken indicated that the rocks of the area seemed to be well suited for aggregate production. A preliminary report was made and sent to Flora municipality on 22.01. 2002. Following a meeting with Daniel Hertig at NGU, 11.02.02 a proposal by NGU to make a geological map of the area was accepted. The mapping was carried out in the middle of June, 2002, by Svein Gjelle. A second preliminary report was made to point out locations suitable for sampling of the rocks of the planned quarry by surface blasting. This preliminary report is enclosed.

Trondheim, 20th of November 2002
Project Group for Building Raw Materials

Peer-Richard Neeb	Svein Gjelle	Eyolf Erichsen
Project Manager	Senior Geologist	Senior Geologist

2. GEOLOGY OF THE SELJESTOKKEN AREA

2.1 Field investigations

The bedrock of the Seljestokken area is made up of thick, fine-grained, sandstone beds of Devonian age. In some thinner layers the grain size is very fine, and the rock grades into siltstone. In overall appearance, thick, massive benches of sandstone are alternating with thinner, somewhat schistose layers. This variation between massive sandstone beds and schistose siltstone layers is not mappable.

Figure 1. Massive sandstone beds with a reddish grey weathering surface at the escarpment beneath Meskorhatten.

The colour of the sandstone is greenish-grey but on weathered surface it is a more reddish-grey. The weathering surface is usually less than 5 mm thick, but in some places a thickness of up to 10 mm has been recorded. The bedrock generally has a thin cover of superficial deposits of variable thickness and there are a lot of outcrops throughout the area.

Sedimentary structures are scarce. In outcrop, the bedding is usually poorly defined making it difficult to odtain precise readings of strike and dip. In some places, a fine lamination caused by small-scale mineralogical changes is visible on the rock surfaces.

The bedrock shows a remarkably homogeneous appearance in all parts of the Seljestokken area.

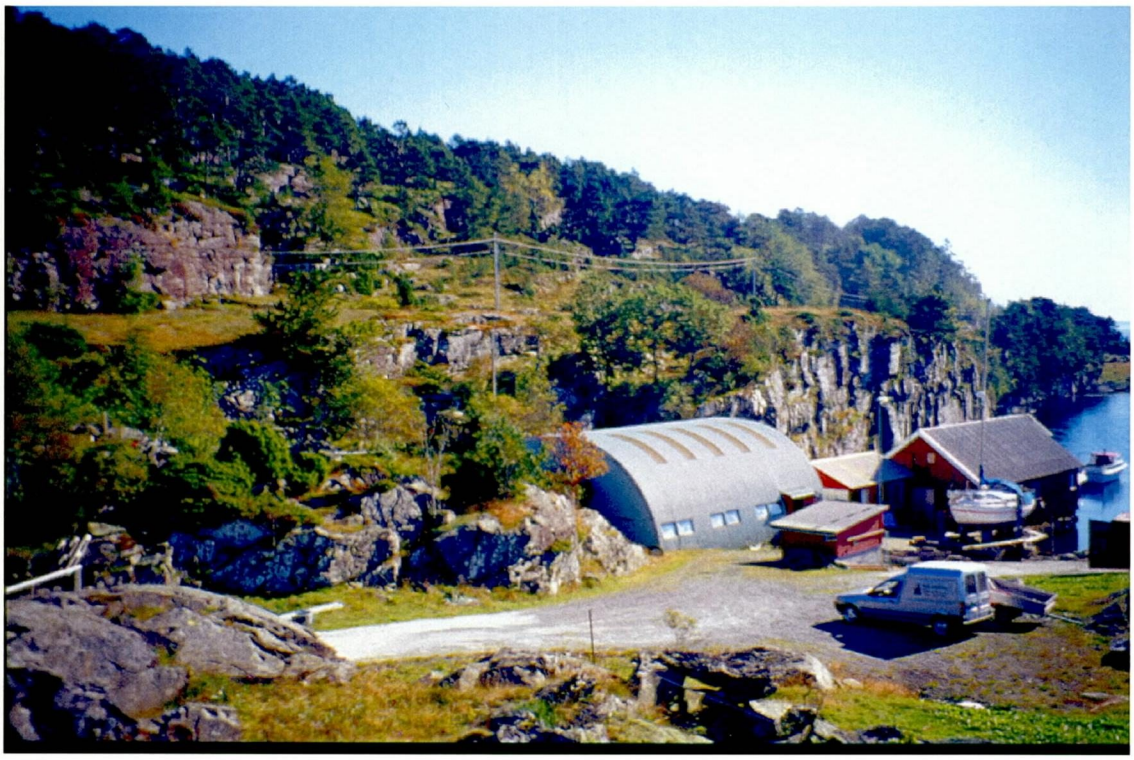
The sandstone beds have a fairly constant orientation, striking at approximately NNW-SSE, about 10° - 25° west of north. The dip is even more constant at about 20° ± 5° ENE. A cross-section through the planned quarry approximately perpendicular to the strike of the rocks illustrates these relationships. The section is shown on the map. Red lines on the map and on the section are showing where a few selected bedding planes are cutting the terrain surface. In the eastern part of the area the dip of the sandstone beds is more or less parallel to the terrain surface. This is shown by the cross-section on the map and also in fig. 2. This means that each sandstone bench here covers a huge surface area.

Figure 2. In the central and eastern part of the area of the planned quarry the dip of the sandstone beds is approximately parallel to the hillside.

Roughly vertical joints are quite common and transect the rocks along several trends. Those visible on aerial photos are drawn on the map as green lines. Some of the most conspicuous ones are roughly N-S orientated; and they have led to the creation of escarpments, a characteristic feature of the landscape in this sandstone terrain. Approximately at right angles to these N-S joints there is another set of roughly vertical joints. In some places joints filled with quartz are found (see fig 3).

Figure 3. Vertical quartz-filled joints in a sandstone bed; photo looking down on a near-horizontal surface. The sandstone beds here dip at c. 20° to the right (east).

The landscape has a step-like appearance caused by the N-S trending escarpments of varying height dipping steeply westwards, in places almost vertical, and slopes dipping gently eastwards. In general the eastward-dipping slopes are reflecting the dip of the sandstone beds.



Figur 4. Escarpments of different size are a characteristic landscape feature of the area. View from Seljestokken towards SE.

2.2 Microscopic examination of thin-sections

Seventeen hand specimens were collected from the Seljestokken area, and thin-sections have been produced and subsequently examined. The result of this examination shows that the rocks have a fairly consistent mineralogical composition. The main rock-forming minerals are quartz, plagioclase, potassium feldspar (both microcline and orthoclase, in places with perthite), muscovite, calcite, chlorite, epidote and clinozoisite. Other minerals observed in thin-sections include biotite, amphibole, sphene, rutile, apatite, tourmaline and zircon, in addition to some opaque minerals.

A visual estimation of the mineralogical composition of the sandstone shows:

- 30-50 % quartz
- 20-40 % feldspar
- 3-15% muscovite
- 3-20 % calcite
- 3-5 % epidote
- <10 % chlorite
- <5 % opaque minerals

Quartz and feldspar usually constitute about 80 % of the sandstone. Plagioclase, microcline and orthoclase, locally with perthite, are the principal feldspar minerals. The small grain size of the rock makes it difficult to distinguish the feldspar minerals from each other and from quartz.

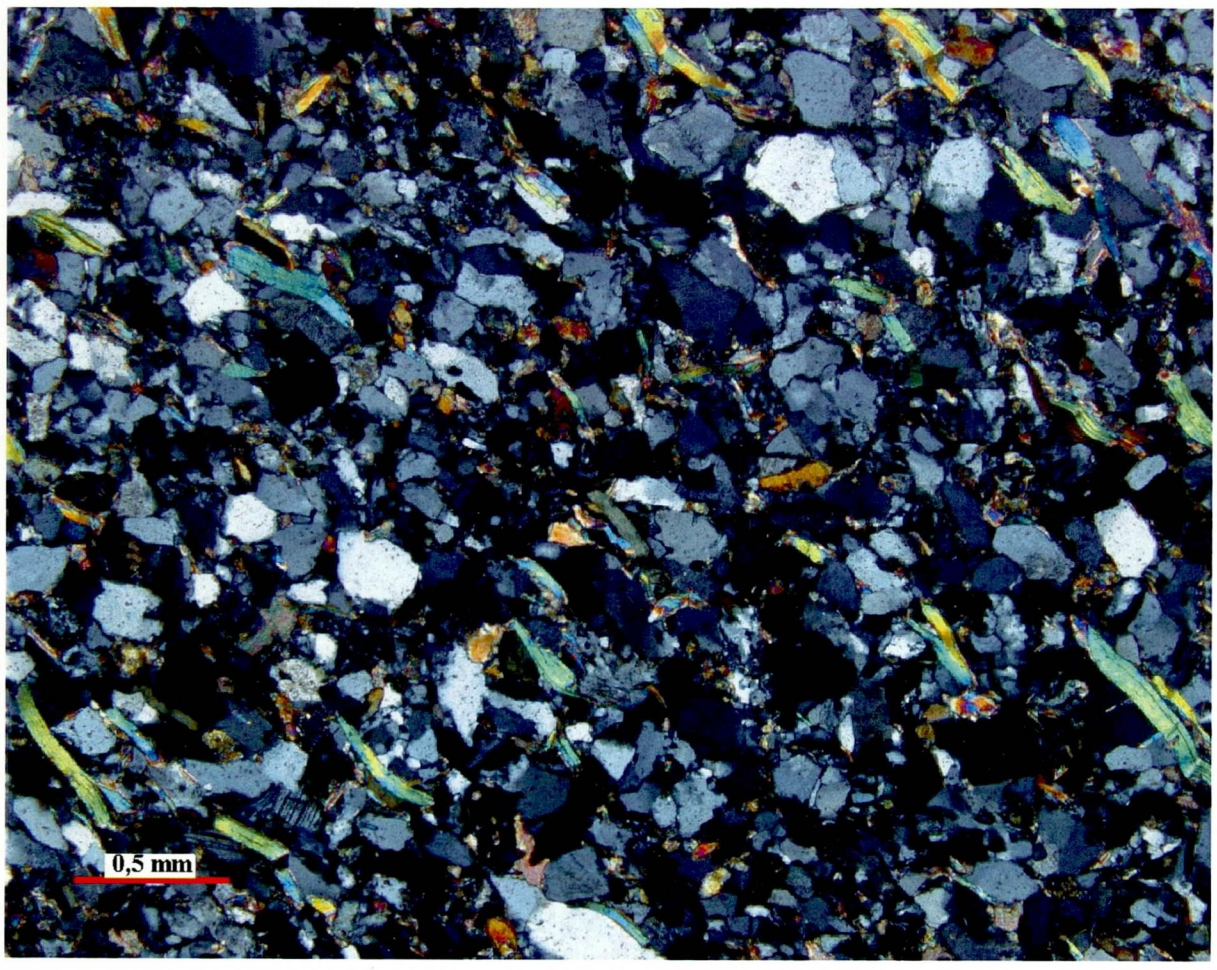


Figure 5. Photomicrograph of thin-section of a typical sandstone, showing faint traces of bedding defined by parallel-oriented mica (yellow, green and blue colours). The bedding is running diagonally across the picture from top left to bottom right. (Crossed nicols.)

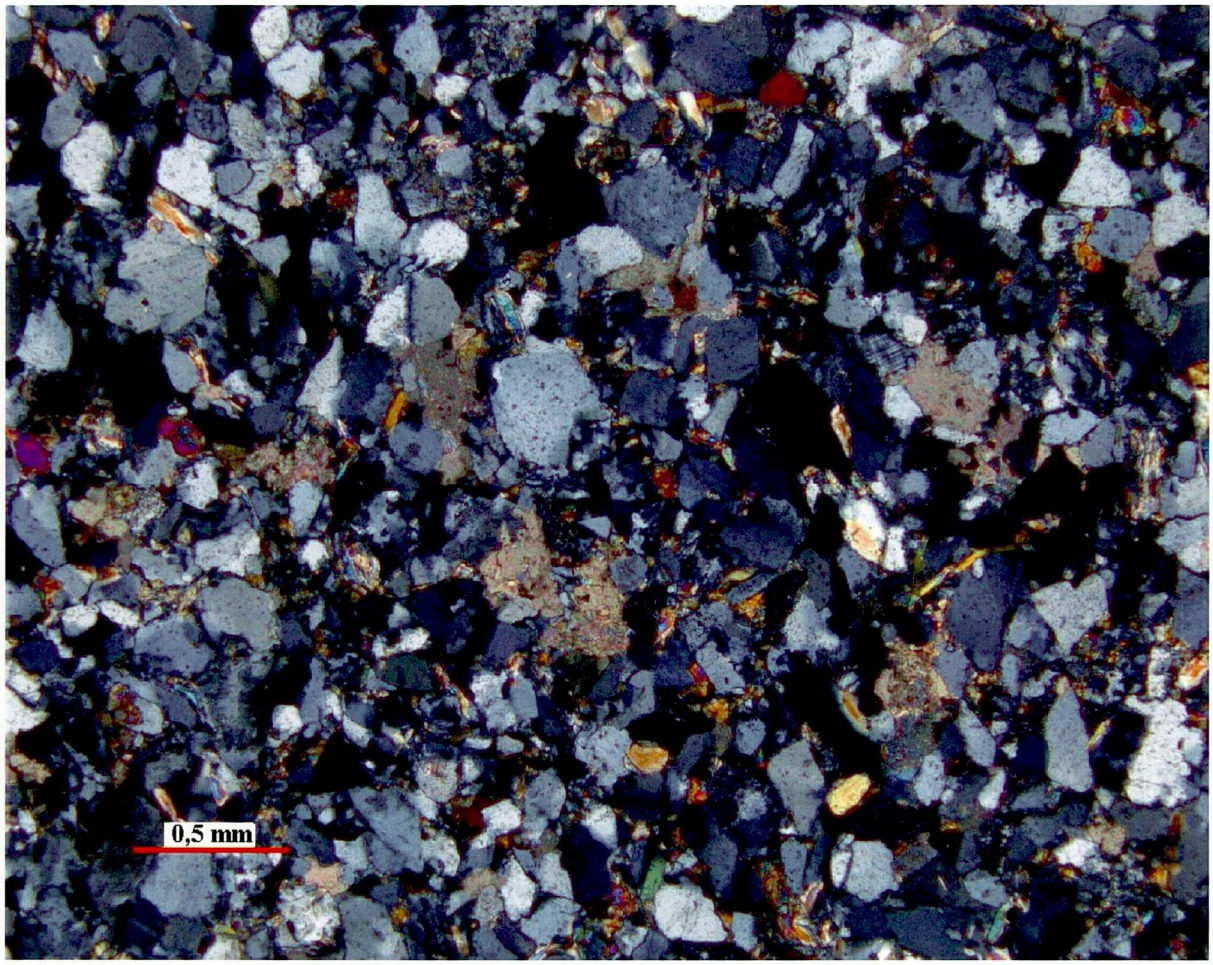


Figure 6. Photomicrograph of thin-section of a sandstone where the bedding is nearly invisible. Quartz and feldspar appear in white, grey and black colours, calcite has a slightly reddish colour and mica is yellow, green and blue. (Crossed nicols.)

Because of this, any estimation of the modal percentage of each mineral is somewhat imprecise. Both quartz and feldspar grains are generally quite angular and are rather evenly distributed throughout the sandstone.

Muscovite and chlorite are always present. The amounts of both minerals usually vary between about 3 and 10 %. Their presence is partly responsible for the vague bedding that is observed both in thin-sections and in the field. In addition to this, the layering is also defined by a mm-scale alternation between thin laminae with a very fine-grained texture, and thicker layers that have a slightly coarser grained texture.

Calcite shows a considerable variation in modal percentage. It is present in all examined thin-sections, ranging from about 1 % to about 15 % with an approximate average of about 5%. The mineral seems to occur both as detrital grains and as matrix material.

Epidote and/or clinozoisite are also present in all examined thin-sections. The content is low, usually in the range 2–5 %.

Opaque minerals are common, but only in small amounts, up to c. 5 % in some thin-sections.

The sandstone is very fine-grained, usually with a grain size less than 0.4 mm. There is a slight tendency towards coarser sandstone beds in the uppermost part of the section (in the upper part of the planned quarry). Here, grain sizes up to 1 mm have been recorded.

The thin layers of siltstone that occur sporadically throughout the area have an average grain size of less than 0.06 mm.

3. MECHANICAL PROPERTIES

The Devonian sandstone within the Seljestokken area has earlier been examined for its mechanical properties. Three samples have been taken. One sample was taken in 1998 by NGU, near Breidvik (figure 7). In 2001, NGU took a new sample consisting of material from three different road-cuts (2-4 in figure 7), while the landowner in the area, Torleif Seljestokken, took one sample, here named Bjørkeliskardet.

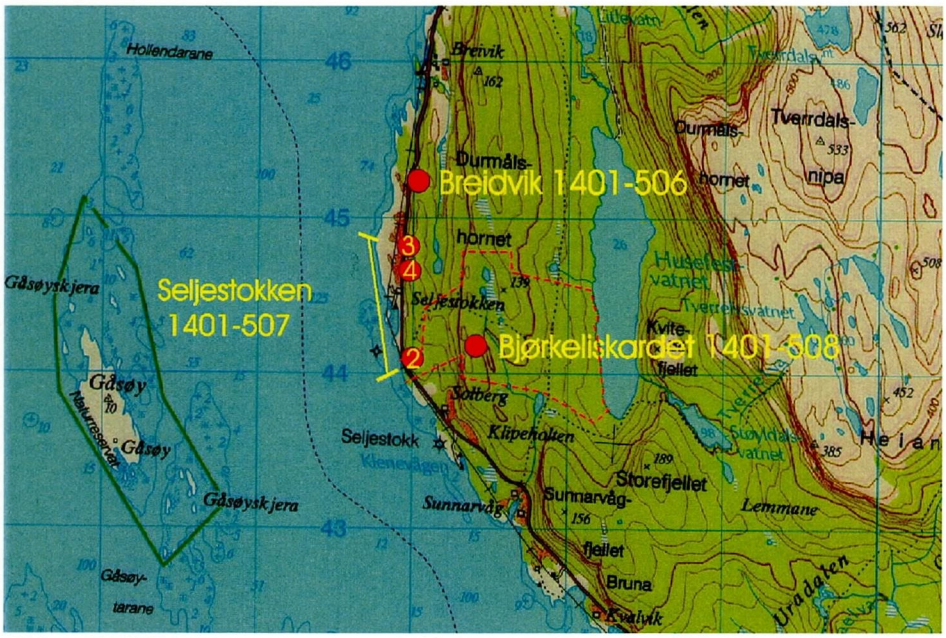


Figure 7. The Seljestokken area and location of the samples taken for mechanical property tests.

The results of the mechanical tests and properties are given in Table 1.

Table 1. Mechanical properties.

Sample	Lab. number	Los Angeles value	PSV
Breidvik	980021	11,8	56
Seljestokken (2-4)	2001157	13,7	55
Bjørkeliskardet	2001164	12,7	57

The results are good enough with regard to the requirements for material intended for building purposes. In general, the Los Angeles value should be less than 20 for exporting to the European market. The requirements of the PSV vary between the different European countries, but values > 55 are considered to be interesting for the European market.

Experience from other areas with Devonian sandstone has shown very little variation in the mechanical properties of this rock-type. The homogeneous appearance of the rock also seems to reflect its overall mechanical strength. Despite this, NGU recommends that the sandstone of the planned extraction area should be further examined by mechanical testing.

4. COMMENTS ON THE 2ND PRELIMINARY REPORT

Sampling site 1a could be made more easy accessible by sampling along a N-S trend instead of E-W, starting at the top of 1a. Only a few metres of the sandstone beds at the bottom of the sampling site will be lost by making this change.
Sampling site 11b also could be readjusted in a similar manner by sampling from the bottom of 1b and upwards towards the southeast to the 124.5 m summit. In doing so, one would gain an additional 5 m at the top of the section.

5. CONCLUSIONS

The area of the planned quarry at Seljestokken is made up of fine-grained, Devonian sandstone consisting of about 70-80 % of quartz and feldspar. Muscovite, chlorite, calcite, epidote and some opaque minerals are the main minerals making up the rest of the sandstone. The minerals are rather evenly distributed throughout the rock. The colour is greenish-grey, with a slightly reddish weathering surface. No significant variation in geological or structural-geological conditions or mechanical properties has been recorded within the mapped area. Both field investigations and microscopic examination of the rocks indicate that this sandstone is remarkably homogeneous in appearance and should be well suited for aggregate production. NGU recommends that the mechanical properties of the rocks should be tested further, and sampling in this connection could be carried out according to the plan presented in our 2nd preliminary report dated 11 July 2002. (Enclosed.)

ENCLOSURES

Geological field investigations of the Seljestokken area, Flora, - 2nd preliminary report

The sandstone layers in the area of the planned quarry have a fairly constant strike direction. They strike approximately NNW-SSE (c. 10° – 25° west of north). The dip is even more constant at about 20° ENE (varying between 15° and 25°). An approximately east-west oriented section through the area show these relations (Fig 1).
Based on the orientation of the sandstone layers and the general outcrop conditions of the area a sampling plan is outlined below (Fig. 2).
Three main areas of sampling is suggested:
Area 1 is the north-south oriented escarpment from Meskorhatten to Bjørkeliskaret. The sampling sites of this area take care of the sandstone layers of the western and central parts of the planned quarry.
Area 2 is the northwest – southeast oriented escarpment from Rabben to Kloppa. These layers continue into the eastern parts of the quarry.
Area 3 is a less pronounced northwest – southeast oriented small escarpment or hillside northwest of Demmetjørna. This area covers the rocks of the central parts of the quarry.
These three areas are marked with red on the map of fig. 2. Three or four sampling sites are suggested within each of these areas. The suggested sites are marked on the map as elongated fields (blue) within each of the three main areas. The sampling sites are also showed in the section of fig. 1 as elongated objects perpendicular to the bedding to illustrate which sandstone layer each sampling site is taking care of.
Additional sampling could be done in area 4 and 5 to bridge the gap between area 1 and 3 and between 3 and 2 as shown by their position on the map and in the section.
The mapping of the area again confirmed that the sandstone is remarkably homogeneous in appearance all over the area.

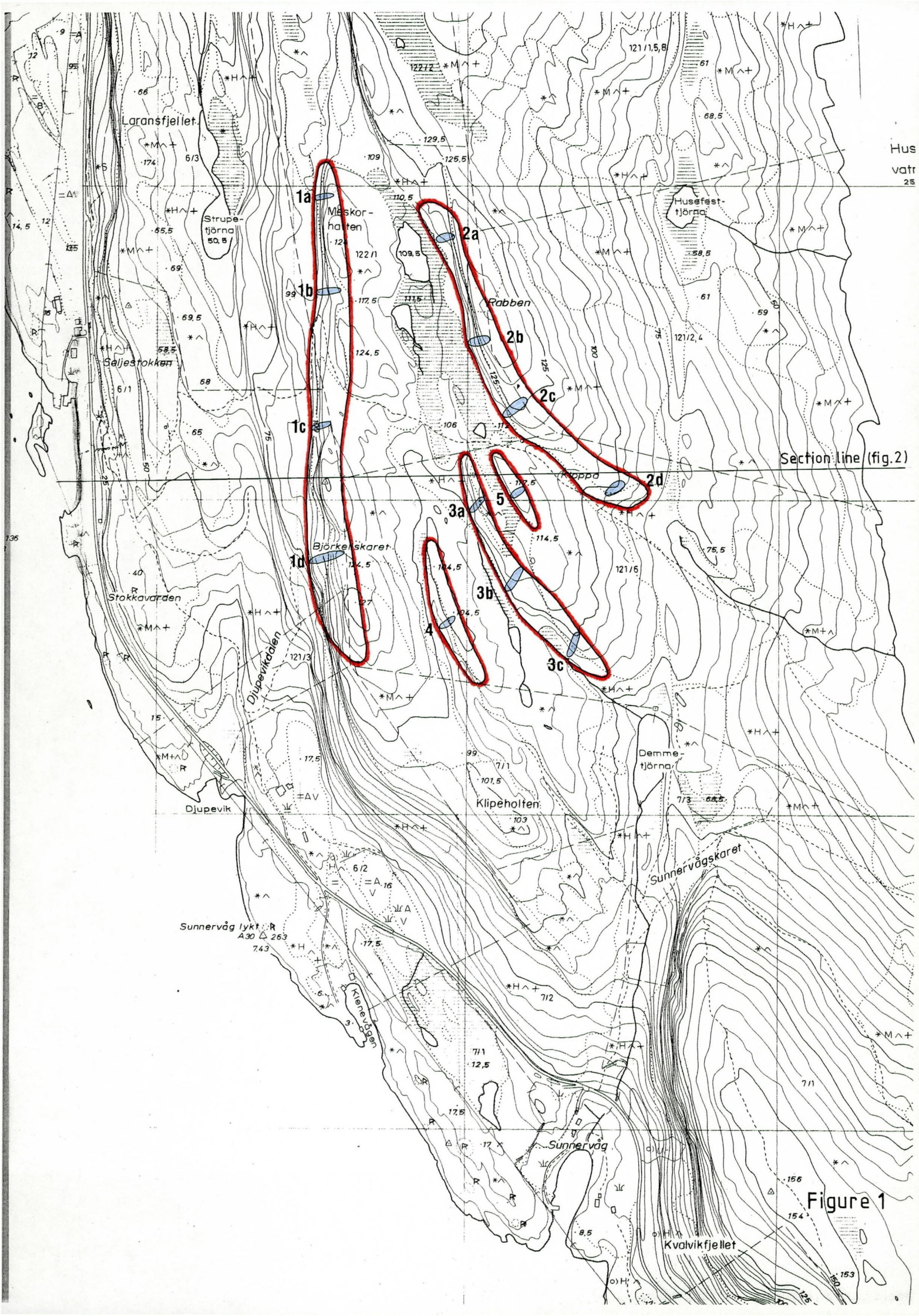

Laransfjellet
Strupe-
tjörna
50,8
Meskor-
hatten
Husefast-
tjörna
Rabben
Kroppa
Section line (fig.2)
1a
1b
1c
1d
2a
2b
2c
2d
3a
3b
3c
4
5
Björkelskaret
Stokkavarden
Djupevikdalen
Djupevik
Seljestokken
Klipeholten
Demme-
tjörna
Sunnervågskaret
Sunnervåg lykt
Klerevågen
Sunnervåg
Kvalvikfjellet

Figure 1

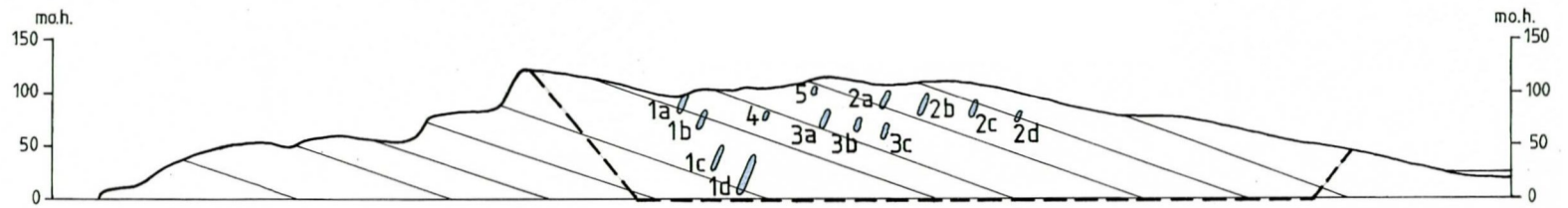


Figure 2

N

Litlevika

Laransfjellet

Måskor-
hatten

Stupe-
tjørna
50,5

Seljestokken

Rabben

Husefest-
tjørna

Husefest-
vatnet
25,5

A'

A

Stokkavarden

Djupevikdalen

Djupevik

Björkeliskaret

Klippa

Klipeholten

Demme-
tjørna

Sunnervågskaret

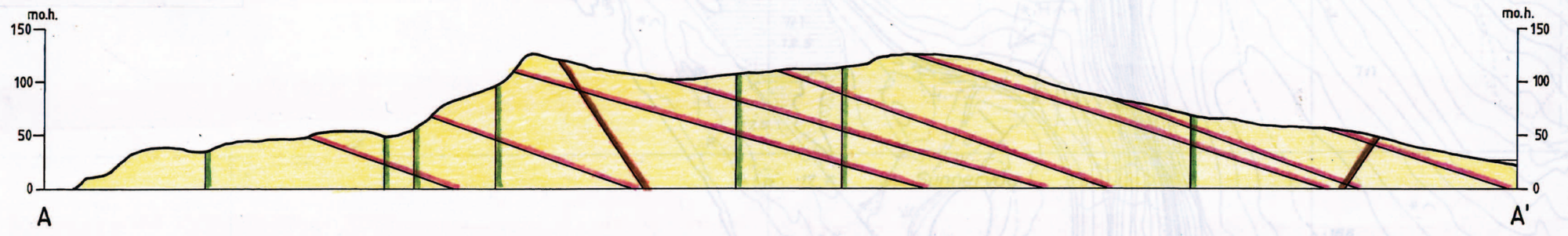
Sunnervåg lykt

A29 △ 136
4,38

A30 △ 263
7,43

Legend

- Fine-grained, Devonian sandstone with thin layers of siltstone
- Trace of bedding (where selected bedding planes cut the terrain surface)
- Joints visible on air photos
- Line delineating the area involved in the aggregate production
- Boundary of planned extraction area
- 1 Photo locality
- /10 Bedding with dip indicated
- A — A' Section line



0 100 200 300 400 500 m

NGU, GEOLOGICAL MAPPING OF A PLANNED EXTRACTION AREA FOR HARD-ROCK AGGREGATES

SELJESTOKKEN

FLORA, SOGN OG FJORDANE

MÅLESTOKK 1:5000

OBS	S.G.	
TEGN	S.G.	Okt.-02
TRAC	ALH	Okt.-02
KFR		

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