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The Mofjellet Mine: Results of diamond drilling 2005



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Authors:	Managanta Mila	Client	: Min AS						
Terje Bjerkgard, Mogens Marker,	Margrete Vik		omin AS						
Gagarria		Commune:							
Nordland		Rana							
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Summary:

The report presents the results of diamond drilling carried out by MoMin AS in the Mofjellet Mine in 2005, and also some reinterpretation of older data. Twelve holes were drilled in 2005, distributed in three profiles, with the main target to further define an economic gold-rich mineralization related to the main sulfide ore bodies.

The most interesting results from the work in 2005 were found in the western half of the deposit, where drilling in profile 43480Y revealed a possible gold-rich sulfide zone following the AKP structure, about 70-80 m long and 1-3 m wide containing on average 4.4% Cu+Pb+Zn, 20 ppm Ag and 0.9 ppm Au. More work is recommended in this area by drilling short holes from an old railway tunnel.

Interpretation of old data from the westernmost 800 m of the deposit show average grades of 3% Cu+Pb+Zn, 21 ppm Ag and 0.9 ppm Au over an average thickness of nearly 3 m. More work, including further interpretation of old data, structural geology and drilling is highly recommended in this part of the deposit to define an economic resource.

Keywords: Gold	Silver	Sulfide
Ore deposit	Base metals	Structure
Scientific report	Mofjell	Caledonides

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YZ section showing the gold data in the entire mine available by the end of 2005. The position of profiles drilled in 2005 is shown.

XZ profiles displaying the results from drilling in 2005 and including profile 41500Y in the west. Data displayed includes combined Cu + Zn + Pb, Ag and Au on a geological background.

# 1. INTRODUCTION

NGU was asked by MoMin AS to assist interpreting the results from diamond drilling carried out in the old Mofjellet Mine in 2005. In addition NGU was also asked to help relogging and interpreting analytical results of two older drillholes from 1975 and 1976 that are stored in the NGU core repository at Løkken. The two latter holes were omitted during the project carried out by NGU in 2001 (Bjerkgård et al., 2001).

In 2005, 13 diamond holes were drilled distributed in 4 different profiles, of which one hole (DDH 10-05) was drilled to investigate the possible occurrence of sulfide ore bodies at depth in a major fold closure south of the existing mine. The results from this hole plus additional three deep holes will be treated in a separate report later on when the deep-hole drilling and planned geophysics is finished.

The other holes from 2005 were drilled in profile 43800Y (DDH 1 and 2-05), in profile 44390Y (DDH 3, 4, 5 and 6-05) and in profile 43480Y (DDH 7, 8, 9, 11, 12 and 13-05). All these holes were drilled to investigate and delimit the possibilities of an economic gold enriched mineralization related to the known ore bodies.

The results from the drilling in 2005 are presented in this report connected with existing results from the years the mine were in operation.

# 2. GEOLOGY

# 2.1 Geological framework and accessibility

The Mofjellet deposit is located 1 km to the south of the city Mo i Rana in the county of Nordland at latitude  $66^{\circ}$  17<sup>°</sup> N (Fig. 1).



Figure 1: Geological map of the Mofjellet mining area. The railway tunnel is marked with a white stippled line. The yellow line shows the extent of the mined ore body. Orange, yellow and green colours are various gneisses, and brown is amphibolites.

It is hosted by assumed Late Precambrian gneissic rocks of the Mofjellet Group in the Rödingsfjellet Nappe Complex of the Uppermost Allochthon in the Scandinavian Caledonides.

The Mofjellet deposit is accessible through the former tunnel and drifts from the mining period, which is mainly intact, but partly flooded. Some of the drifts are used today for storage purposes. An abandoned, but still intact, two kilometres long railway tunnel cuts the ore zone along strike and forms an excellent starting point for further investigations (Fig. 1).

# 2.2 Lithologies

The hosting lithologies of the Mofjellet deposit is dominated by quite massive grey gneisses with persistent layers of amphibolite and aluminous biotite and muscovite gneisses. For detailed descriptions of the lithologies are referred to Marker (1983).

The rocks of the mining area are the same as those in the rest of Mofjellet with one exception: Hornblende gneisses, grading into biotite gneisses, are specific for the ore-bearing horizon though they usually do not actually host the ore. The hornblende and hornblende-biotite gneisses, containing subordinate garnet, staurolite and kyanite, have been suggested to represent tuffitic or mixed sedimentary and tuffitic material. There is also a possibility that they represent lithological levels affected by fluid activity. Muscovite or muscovite-biotite gneisses adjacent to the hornblende-bearing gneisses often host the more massive ores. In addition, the ore-bearing horizon contains several layers of amphibolite.

# 2.3 Structural geology

The Mofjellet deposit has a lateral extent of nearly 4 kilometers in the east-west direction, outcropping in the far west where the ore was discovered as early as in 1688 (see Fig. 1).





The deposit consists of three ruler-shaped ore lenses situated more or less on top of each other (Fig. 2). The ore lenses have a maximum width of about 100 meters. The two upper lenses (lenses I and II) are connected through tight folding in a Z-shaped fold structure. The lower north-facing part of the structure is known as the AKP structure, while the upper, south-facing part is known as the "Omlegg-sone". The upper part disappears eastwards together with orel lens I while the AKP-structure can be followed along the entire length of the ore body. Lens

III forms a separate ore lens on the lower limb of this major north-facing fold structure. Based on the lithological succession the ore lenses occur in, it is likely that the separation of Lens III from lenses I and II in the ore zone is a primary feature, though it has been proposed that it was disrupted from the other lenses by faulting. A slightly deeper ore lens structure at the southern continuation of Lens III, known as the Nasa structure, was mined in the central 500 meters of the ore body in the last years before the mine was closed. The lateral extent and shape of the ore-rich Nasa structure is unknown, but is seems to be basically a tight fold structure on the southernmost known part of Lens III. On the basis of surface mapping, a major south-facing major fold closure exists at depth, and since the ore body has not been delimited in the south, it could be that important concentrations of ore are present in this major closure. This is the target for the deep-hole drilling program mentioned above.

Profiles prepared for the report in 2001 (Bjerkgård et al., 2001) show that the ore forming fold structure is most open in the west (e.g. at 41500Y), with a clear separation of Lens I, AKP-Lens II and Lens III with ore in all levels. In the central part of the deposits (e.g. at 44130Y, Lens II and Lens III are still separated, but are very close-lying. Their increasing closeness eastwards may be a primary feature of the ore distribution, but several quite extensive movement zones, expressed as biotite-rich rocks (biotities) with secondary ore mineralisations occur at the top of Lens III. These movement zones are best interpreted as adjustments during folding, but more extensive early shear movements cannot be excluded. In this profile the ore seems to disappear in the upper part of the structure. The Nasa structure is prominent in the southernmost part of Lens III in this part of deposit. In the eastern part of the deposit, Lens II and III have coalesced and cannot really be distinguished from each other. Ore is concentrated in Lens II/III and the AKP structure, while the upper part of the structure is poor in ore.

There is thus a clear trend as to structure and ore distribution from west to east: The lower part of the ore-bearing structure gets tighter towards the east and Lens II and Lens III approach each other and coalesce at about 44500Y with development of movement zones in the area between them. At the same time the sulfide content decreases towards the east in the upper part of the structure.

### 2.4 Ore descriptions

The ore deposit consists of alternating semi-massive ore layers, layers of sulfide disseminations and layers of wall rock at a meter-scale or less. The ore layers rarely contain as much as 50 % sulfides. The most important ore minerals are pyrite and sphalerite, while galena, chalcopyrite and pyrrhotite occur in subordinate amounts. Various sulphosalts, arsenopyrite, native antimony and gold-silver alloys are found in variable, but generally accessory amounts. Important gangue minerals include quartz, biotite, muscovite, calcsilicates (epidote, amphibole, diopside, garnet), calcite, plagioclase, and magnetite.

In many cases, coarse sulfides form disseminations and semi-massive veins, overprinting the more fine-grained sulfide layers or injected into layers of wall rock. These coarse sulfides have much higher contents of galena, chalcopyrite and sulphosalts, and commonly lower contents of sphalerite and pyrite, than the ordinary ore layers and were apparently formed by remobilization of sulfides from the original layers.

Based on the character of the ore deposit, including structure, mineralogy and associated lithologies, the Mofjellet deposit most probably represents a syngenetic, exhalative hydrothermal mineralization, formed at or near the seafloor in the late Precambrian.

### 3. RESULTS FROM 2005

Four profiles have been prepared to present the results of the diamond drilling from 2005, and the reinterpretation of drillholes from 1975-76. The position of the profiles in relation to the data discussed in the report from 2001(Bjerkgård et al, 2001) are shown in the YZ section in the appendix.

The profiles discussed in this report are presented in the appendix in three versions, namely with contents of total basemetals, silver and gold. Here under the data are presented in order from east to west.

### 3.1 Profile 45270Y

Drillholes 7502 and 7601 are stored in the core repository at Løkken. They were relogged and analysed in the same way as the holes drilled in 2005. The holes are projected into the profile 45270Y together with other holes from the easternmost 400 m of the mine (Profiles in appendix). Data from gold-bearing intervals in the holes are listed in Table 4.

DDH	Length	X	Y	Z	Cu	Pb	Zn	Ag	Au	Cu+Pb+Zn
7601	0.92	-506.14	44873.00	-81.76	0.28	0.55	1.54	15.13	0.69	2.37
7601	0.70	-505.97	44873.00	-91.52	0.03	0.18	0.34	9.40	1.98	0.54
7502	4.07	-427.20	44881.00	-104.99	0.39	0.46	2.78	11.95	0.86	3.63
747	1.00	-485.20	44984.00	-91.35	0.13	0.38	2.15	23.60	1.15	2.66
747	1.00	-509.82	44984.00	-87.01	0.22	1.55	3.93	33.30	0.32	5.70
748	1.05	-501.92	44984.00	-83.54	0.11	1.25	3.98	59.00	0.35	5.34
748	0.95	-504.55	44984.00	-82.91	0.28	1.32	4.46	46.00	0.41	6.06
748	2.30	-512.77	44984.00	-80.93	0.66	1.07	5.28	29.17	0.23	7.01
8004	5.80	-512.38	45270.00	-87.26	0.15	0.54	1.61	19.87	0.44	2.30

Table 4: Intervals analysed for gold in profiles 44398Y to 45270Y.

DDH 7601 in profile 44873Y contains two intervals with higher than average contents of Au (0.69 and 1.98 ppm), but both in less than 1 m of core. Contents of base metals are rather low. DDH 7502 which was drilled 8 m further east contains 0.86 ppm Au and 3.6 % base metals in c. 4 m core. The two holes fill some gaps in the data set representing the eastern part of the ore body, and support that it is some enrichment of gold also in the eastern part of the ore body.

The data in Table 4 gives a weighted average of 0.3 % Cu, 0.7 % Pb, 2.8 % Zn, 23 ppm Ag, 0.6 ppm Au with an average thickness of 2 m. The sparse data gives some indications that the grades of gold are lower than further west. However, there are still very long intervals without any data on gold and silver (see also Fig. 3).

### 3.2 Profile 44390Y

The diamond drill holes 3, 4, 5 and 6-05 were all placed in profile 44390Y to investigate the potential for especially gold outside the ore zone related to the AKP structure in this profile (see profiles in appendix). The drilling also aimed at getting some more information about the geometry of the AKP structure itself in this area of the deposit. High gold values had earlier been found in DDH 7601, only 10 m to the east in the structure (1 ppm Au, 51 ppm Ag in 1.15 m and 0.8 ppm Au, 17 ppm Ag in 1.55 m, see table 2).

The results from the 2005 drilling indicate that the extent of the gold mineralization is limited in this profile. Only DDH 5-05 intersected sulfide mineralization with moderate amounts of

precious metals (28 ppm Ag and 0.21 ppm Au in 1.02 m). The other holes did not intersect any sulfide mineralizations (DDH 4-05 was not analyzed). DDH 3-05 was drilled due north into gray gneiss without any sulfides, but also intersected the lens III level without intersecting any sulfides. DDH 6-05 should has been drilled more steeply upwards to intersect mineralization.

In conclusion, most of the holes were drilled in directions where mineralizations were not anticipated, but still gave some valuable information regarding the structures in the area.

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DDH	Interval	Length	Cu	Pb	Zn	Ag	Au						
5-05	0.92-1.94	1.02	0.14	1.38	5.19	28.2	0.21						
7604	246.00-247.15	1.15	0.14	0.57	1.59	51.3	1.06						
7604	254.25-254.75	0.50	0.30	2.13	10.00	17.5	0.29						
7604	254.75-256.30	1.55	0.47	0.23	1.17	17.4	0.76						

Table	- 2.	Gold	-hearing	interval	s in	DDH	5-05	and DD	Ч'	7604.
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### 3.3 Profile 43800Y

The diamond drill holes DDH 1 and 2-05 were placed with a shallow inclination towards the south to investigate the continuation of ore lens III into the Nasa structure. As the profiles (appendix) and Table 1 show, only two very thin zones of mineralization were intersected in DDH 2-05, while DDH 1-05 only intersected one thin zone of very weak impregnation. The mineralizations intersected in DDH 2-05 are likely the continuation of lens III towards the south, even though it was not encountered in DDH 1-05. Investigation of nearby profiles strongly suggest that the two holes were set to low and with to steep angle to intersect the Nasa structure. Additional holes will be drilled in 2006 to test if this is the case.

The weak mineralization intersected in DDH 1-05 was not intersected in DDH 2-05, suggesting that this is an insignificant and very restricted mineralization.

DDH	Interval	Length	Cu	Pb	Zn	Ag	Au
1-05	35.88-36.55	0.67	0.07	0.08	0.56	2.2	0.03
2-05	26.55-26.75	0.20	0.08	0.98	1.97	38.6	0.20
2-05	27.90-28.45	0.55	0.17	0.87	3.08	36.8	0.44

 Table 1: Mineralized intervals in DDH 1-05 og 2-05:

### 3.4 Profile 43480Y

DDH 7, 8, 9, 11, 12 and 13-05 were all placed in profile 43480Y to investigate the potential for especially gold related to the sulfide ore in the AKP structure in this profile (profiles in appendix). As can be seen from the overview in the YZ profile (in the appendix), there are very few analyses of gold in this part of the deposit; the closest profile to the east is at 43600Y, where only one hole has been analyzed for gold (DDH 369 w/0.5 ppm Au in 1.5 m), and to the west in profile 43140Y where two holes show low gold content (up to 0.35 ppm Au in 1.9 m). However, in both these profiles the analyzed holes are not intersecting the AKP structure.

All holes analyzed in profile 43480Y have some intervals with enrichments in gold Table 3, Figure 3). The richest section is in DDH 9-05 (drilled along the fold limb) with more than 10 m with 1.4 ppm Au. The values of zinc are generally low in the gold-bearing intervals, while the values of Pb and Cu are rather high compared to zinc. This can be illustrated by the ratio

Cu+Pb/Cu+Pb+Zn in the average mined ore that was 0.22 compared to an average of 0.44 for the gold-bearing intervals in this profile.

DDH	Interval	Length	Cu	Pb	Zn	Ag	Au
7-05	0.70-1.95	1.25	0.31	1.07	0.05	18.20	0.47
8-05	1.12-1.45	0.33	0.20	0.70	0.61	12.30	0.24
9-05	1.27-1.68	0.41	0.22	1.50	0.04	27.00	1.12
9-05	30.58-30.84	0.26	0.43	6.06	1.55	100.00	0.48
9-05	53.85-55.85	2.00	0.41	0.84	2.84	27.10	0.42
9-05	56.64-57.46	0.82	0.30	0.35	1.17	13.20	0.19
9-05	74.33-86.00	11.67	0.20	0.59	1.47	19.89	1.42
11-05	10.81-13.03	2.22	0.67	2.73	11.15	19.49	0.22
12-05	2.00-2.35	0.35	0.23	0.61	0.01	37.70	1.38
13-05	1.33-4.65	3.32	0.81	0.68	5.07	8.43	0.33

Table 3: Gold-bearing intervals in Profile 43480 Y:



*Figure 3: Gold-bearing intervals in drillholes in profile 43480Y (see also profiles in back cover.)* 

With some degree of uncertainty, it seems that we could have a gold-bearing zone in this profile about 70-80 m long, following the AKP structure upwards and north, about 1-3 m wide (average 2.3 m) and with a weighted average of 0.4% Cu, 1.0% Pb, 3.0% Zn, 20 ppm Ag and 0.9 ppm Au. The lithologies bends southward at a fold hinge at coordinate [490X, 0Z], and it is possible that the mineralized zone extends further. Unfortunately the holes DDH 11-05 and 13-05 were drilled 10-15 m too short to investigate this possibility.

#### 3.5 Profile 41500Y

The western part of the ore body is centered around profile 41500Y. This profile was also presented in the NGU report from 2001 (Bjerkgård et al., 2001). It covers drill holes in the interval 40828Y to 41594Y. The reason for including the profile also in this report is that this part of the ore body has a certain ore potential with respect to gold-rich zones outside the main ore body which has not been discussed in detail earlier.

A number of drill holes intersecting this part of the ore body have intervals enriched in gold compared to the average ore. The data are presented in Table 5 and shown on profiles in the appendix. The data in Table 5 is calculated by adding up several analyses in most cases. This is done by weighing each analysis according to the length of the analyzed section. The gold-enriched intervals are also shown in Figure 4.

DDH	Х	Y	Z	Length	Cu	Pb	Zn	Ag	Au
7710	-290.00	41252.00	57.25	2.90	0.17	0.36	0.03	52.77	1.70
7710	-290.00	41252.00	-0.50	1.00	0.22	0.30	0.71	12.90	0.42
1313	-304.24	41375.00	54.38	1.20	0.24	0.42	0.10	17.40	0.40
1313	-299.31	41375.00	82.34	2.80	0.38	0.32	0.07	44.30	3.88
1315	-310.22	41380.00	46.80	7.70	0.12	0.22	0.59	10.55	0.77
1315	-309.35	41380.00	56.76	1.90	0.87	0.52	2.34	22.16	0.48
1315	-307.24	41380.00	80.92	11.80	0.28	0.52	1.89	10.96	0.31
1316	-315.00	41380.00	35.85	1.30	0.19	0.49	0.12	38.40	0.80
1226	-324.88	41446.00	49.58	1.20	0.37	1.07	3.67	23.00	0.50
1312	-326.37	41488.00	6.51	1.00	0.17	0.35	0.72	7.90	0.27
1312	-320.42	41488.00	28.73	2.30	0.14	0.34	0.41	23.52	0.70
1312	-314.53	41488.00	50.71	2.60	0.35	0.41	0.43	16.23	0.34
7005	-328.17	41490.00	79.53	1.00	0.59	0.75	3.66	10.10	0.36
7001	-328.00	41490.00	43.50	1.00	0.33	0.40	0.43	19.10	0.36
1262	-312.36	41493.00	3.05	1.00	0.11	0.09	0.99	7.00	0.45
1258	-341.83	41506.00	15.29	1.00	0.62	0.94	2.49	51.00	0.80
1258	-323.81	41506.00	49.20	3.00	0.36	0.83	1.99	34.33	1.32
1258	-314.18	41506.00	67.30	2.00	0.80	0.48	2.84	17.50	0.58
1258	-311.91	41506.00	71.58	2.70	0.24	1.83	1.62	43.30	0.62
1304	-330.40	41583.00	68.85	3.10	0.25	0.58	2.00	19.30	0.65
1304	-330.40	41583.00	75.65	0.70	0.94	0.54	1.94	5.00	0.60
1305	-327.13	41583.00	43.28	10.70	0.18	0.84	4.04	18.67	1.19
1305	-325.01	41583.00	67.49	3.20	0.17	0.64	2.78	13.40	0.50
1314	-297.16	41374.00	-15.55	14.90	0.23	0.78	3.82	14.11	0.27
8404	-368.51	41455.00	-2.63	5.00	0.87	2.27	6.93	19.70	0.74

 Table 5: Gold-bearing intervals in profiles 41252Y to 41583Y.



Figure 4: Gold-enriched intervals projected into profile 41500Y. The data is presented in Table 5.

According to the data, gold is concentrated in two different zones (Figure 4). The lowermost zone is intersected by DDH 8404 and DDH 1314 containing 0.74 and 0.27 ppm Au, in intervals of 5 m and 14.9 m respectively. Maximum values are 0.35 ppm in 1.70 m and 1.60 ppm in 1.70 m for the two holes, respectively. This gold enrichment corresponds to ore lens no. III, as shown in Figure 4.

The most interesting zone is present in the upper part of ore lens II, particularly in the fold structure known as AKP, which is connecting lens I and lens II. In this structure several drillholes have intersected intervals enriched in gold, as shown in Figure 4. The best interval is in DDH1305 yielding 10.7 m with 1.19 ppm Au. A weighted average of the drillholes intersecting the whole mineralized zone from lens I to lens II yields 0.3 % Cu, 0.6 % Pb, 1.8 % Zn, 21 ppm Ag and 0.9 ppm Au over an average thickness of 2.9 m. Excluding the values from intersection of lens II (below Z =+20), yields the same values, but the average thickness increases to 3.3 m.

It should be noted that these calculations are very uncertain and should only be used as a guide to further prospecting. There are too few data distributed over too large interval to do a proper analysis of the ore potential.

### 4. IMPLICATIONS FOR FURTHER WORK

The easternmost part of the deposit, from 44800Y and eastwards and including the two drillholes 7601 and 7502, are not sufficiently explored to be evaluated. From the sparse data that has been processed it seems that the grades of all metals are lower than further west, and no more exploration is recommended at this stage.

In profile 44390Y only one of the holes intersected some sulfide mineralization. The others were drilled in directions where the chances of intersecting sulfides were slim. However, the holes provided valuable information regarding the structures in this part of the deposit.

The holes 1 and 2-05 in profile 43800Y to investigate the Nasa structure were perhaps drilled with too much inclination to hit the structure. To be sure about this, additional drillholes are recommended drilled horizontally or slightly upwards. In addition, drilling done earlier in neighbouring profiles should be studied.



Figure 5: Vertical (Y-Z) and horizontal sections (Y-X) of the interval 43100-43600Y with the gold grades in drillholes displayed on a background of the old mine workings (yellow and red dots are >0.5 and >1 ppm Au, respectively, while green and blue are both <0.5 ppm).

The results from drilling in profile 43480Y are encouraging. Not much data exist from this part of the deposit. As shown in figure 5, the zone of gold-rich mineralization, seem to extend upwards from the existing mine. Judging from the existing sections showing the old mine workings, the interesting area covers the area from about 43200Y to 43900Y, a length of 700 m. This is pointing to a potential for delimiting a mineralization large and rich enough to be

economically interesting. More work is recommended in this area and this is most easily done from the old railway tunnel, where the drillholes will be short (30-100 m).

The extreme west is perhaps the most interesting part of the deposit. This is centered around profile 41500Y. To the west and above the existing workings (i.e. westwards from 41620Y) is a part of the mineralization where several holes intersected mineralizations enriched in gold (see section 3.5 and Figure 6). More work is recommended to fill out the gaps between the existing intervals, which are too dispersed to be used to estimate any resources. The drilling could be done from the flat area outside the entrance to the railway tunnel.



Figure 6: Vertical (Y-Z) and horizontal sections (Y-X) of the interval 41300-41750Y with the gold grades in drillholes displayed on a background of the old mine workings (yellow and red dots are >0.5 and >1 ppm Au, respectively, while green and blue are both <0.5 ppm). The horizontal section show the mine workings on level II.

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## APPENDIX

YZ section showing the gold data in the entire mine available by the end of 2005. The position of profiles drilled in 2005 is shown.

XZ profiles displaying the results from drilling in 2005 and including profile 41500Y in the west. Data displayed includes combined Cu + Zn + Pb, Ag and Au on a geological background.































