NGU Report 2007.023

The Hersjø ore deposit, evaluation of ore potential

Geological Survey of Norway
NO-7441 Trondheim, Norway
Tel.: 47 73 90 40 00
Telefax 47 73 92 16 20

REPORT

Report no.: 2007.023	ISSN 0800-3416	Grading: Open

Title: The Hersjø ore deposit, evaluation of ore potential	
Authors: Terje Bjerkgård	Client: Holtålen kommune
County: Sør-Trøndelag	Commune: Holtålen
Map-sheet name (M=1:250.000): Røros	Map-sheet no. and -name (M=1:50.000): 1620-II Dalsbygda
Deposit name and grid-reference: Hersjø - UTM 32 V 608900, 6951900	Number of pages: 33 Price (NOK): 190,- Map enclosures:

Fieldwork carried out: None	Date of report: March 2007	Project no.: 270200	Person responsible:

Summary:

The Hersjø sulfide deposit is situated in the Holtålen municipality, some 17 km to the northwest of Røros. The deposit is situated within the Forollhogna National park, established in 2001, but mining is permitted if the entrance to the mine is outside the park. Holtålen municipality have retained claims on the deposit since 1982. The increased metal prices have led to increased interest for the potential of the Hersjø deposit. Geophysics and drilling campaigns in the 1970s identified a resource of 2.99 mill. t of Cu-Zn ore with 1.70% Cu and 1.40% Zn distributed on three sulfide lenses. Contents of other elements, including Ag and Au, appear to be very low, but are not properly analyzed. None of the three main sulfide lenses are limited at depth, but more drilling from the surface to increase the tonnage would be relatively expensive because of steep angles of the ore axes. A fourth sulfide lens also has a certain potential. At least 15000 m of drilling would be necessary to double the tonnage (if it exists). A thorough analysis of the known grades and possible tonnages should be carried out to find out if it could be an economic deposit, before more drilling is planned.

Sammendrag:

Hersjø sulfidforekomst ligger i Holtålen kommune om lag 17 km NV for Røros. Forekomsten ligger innenfor grensene til Forollhogna Nasjonalpark (etablert i 2001), men gruvedrift tillates dersom inngang til gruva legges utenfor parken. Økte metallpriser har ført fornyet interesse for forekomsten, som kommunen har hatt rettighetene til siden 1982. Diamantboring og geofysikk i første halvdel av 70-tallet påviste en ressurs på 2.99 mill. t med 1.70% Cu og 1.40% Zn fordelt på tre sulfidlinser. Innhold av andre elementer, som Ag og Au, synes å være meget lavt, men er ikke tilstrekkelig analysert. Ingen av de tre viktigste sulfidlinsene er begrenset mot dypet, men malmaksene står temmelig steilt, noe som medfører at mer diamantboring fra dagen for å øke tonnasjen blir relativt kostbart. En fjerde sulfidlinse har også et visst potensiale. Det må regnes med minst 15000 bormetre for å påvise dobbelt så stor tonnasje som det er kjent i dag (dersom den eksisterer). En grundig analyse av de kjente gehalter og mulige tonnasjer må utføres for å finne ut om forekomsten er økonomisk før mer diamantboring gjøres.

Keywords: Massive sulfide	Copper	Zinc
Pyrite	Ore deposit	Greenstone
Structure geology	Geochemistry	Scientific report

CONTENTS

1. INTRODUCTION

The Hersjø sulfide deposit is situated in the Holtålen municipality, some 17 km to the northwest of Røros (Figure 1). It is a quite large massive sulfide deposit, consisting of several ore lenses over a length of about 1.5 km. The deposit was mined on a very limited scale until about 1830, and also in the late 1800s. New investigations were carried out around 1950, and again in a 15 year period between 1969 to 1985. The deposit is now situated within the Forollhogna National park, established in 2001. On the basis of the prospecting reports, pointing to a possible resource of more than 3 mill. tons of Cu and Zn ore, Holtålen municipality have retained claims on the deposit since 1982. The increased metal prices have also led to increased interest for the potential of the Hersjø deposit.

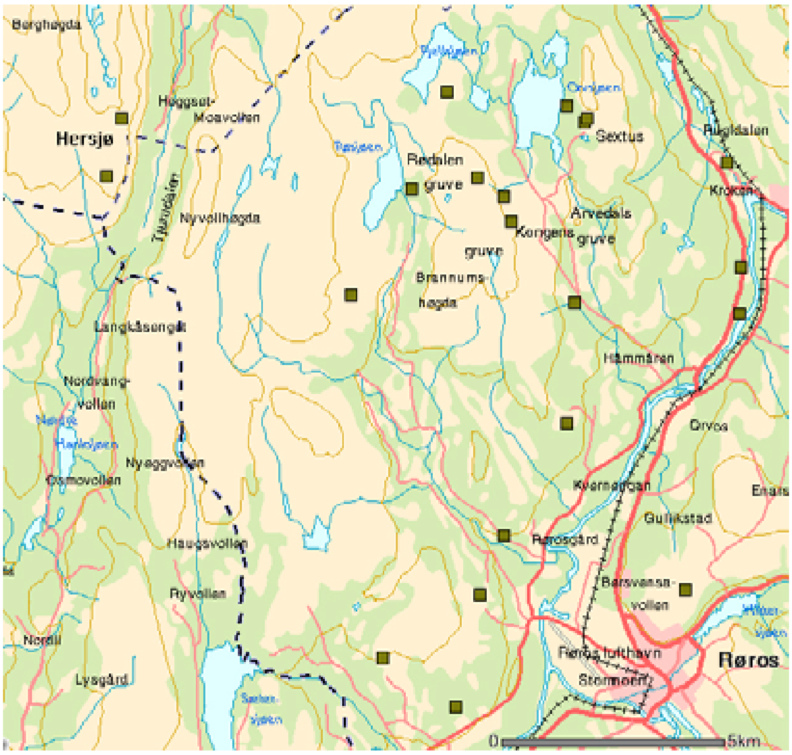


Figure 1: The location of the Hersjø deposit, about 17 km NW of Røros.

According to the regulations of the Forollhogna Nationalpark, it is permitted to do diamond drilling within the park. Mining is also permitted if the entrance to the mine is outside of the park. Ventilation shafts to the mine are permitted within the park.

From the regulations of the park (in Norwegian):
FOR 2001-12-21 nr 1564: Forskrift om verneplan for Forollhogna med tilliggende dalfører, vedlegg 1, vern av Forollhogna nasjonalpark, Holtålen, Midtre Gauldal, Rennebu, Os, Tolga og Tynset kommuner, Sør-Trøndelag og Hedmark.
§ 3. Vernebestemmelser, punkt 1.3 f). Forvaltningsmyndigheten kan gi tillatelse til prøveboring og etablering av nødvendige luftesjakter i forbindelse med underjordisk drift av mineralforekomster med uttakssted utenfor verneområdet.

On this basis Holtålen municipality has asked for an evaluation of the resource potential of the Hersjø deposit based on the existing reports. These reports are mainly stored at the Norwegian Mining Directorate.

2. HISTORY

The Hersjø ore deposit is situated above the tree-line c.1020 m.a.s.l. on the westside of the Kjølidalen/Kjurrudalen valley (Figure 2). The mineralization is outcropping in two main areas, where some small-scale mining have been done.

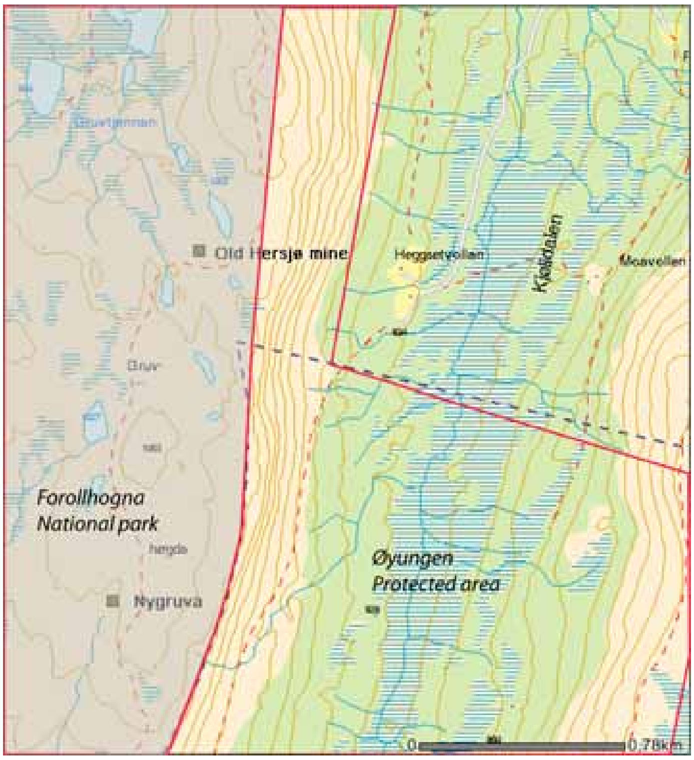


Figure 2: The location of the two main mining areas in the Hersjø deposit. Note the steep west side of the valley, which is ideal for an adit entrance from the valley. The grey shaded area is within the national park, while the thick red line marks the boundaries of the Øyungen Protected area (Landskapsvernområde).

The northern part of the deposit, known as the old Hersjø mine (Figure 3), was claimed by Henning Irgens as early as c. 1670. The mine was handed over to Røros Kobberverk in 1687, which produced c.4000 t of copper ore until 1893. The production was not profitable and the mine was handed over to Irgens again. Since copper production was not economic, Irgens started producing copper vitriole and later ochre. The mine was closed when Irgens died in 1899. Some sporadic mining of pyrite was done in the late 1800s, after investigations by Røros Kobberverk in 1873 and 1881.

The southernmost part of the Hersjø deposit, about 1.5 km to the south of the old Hersjø mine, is known as Nygruva (Figure 2, Figure 4). It was claimed and mined by Røros Kobberverk around 1830, but only c. 70 t of copper ore was extracted from a small excavation into the hillside and two small waterfilled sinks. According to reports the deepest sink is about 13 m deep.

Geophysical investigations by Geofysisk Malmleting in 1948 using TURAM, showed strong and extensive electromagnetic conductors in the Hersjø field. These zones got the designations A, B, C, D, E and F. The A-conductor which was the strongest, was not known before, but turned out to be caused by the largest ore lens when it was drilled later. The B-conductor is due to the mineralization present in the old Hersjø mine, while the C-conductor is represented by two minor showings between the old Hersjø mine and Nygruva. The E-conductor represents the mineralization in Nygruva. The conductors D and F, as the A-conductor, were not known before.

Figure 3: Aerial photo showing the shaft, ditches and waste dumps of the old Hersjø mine. The red color in part of the dump is from the ochre production. North is to the right and the small lake is about 100 m in length.

Diamond drilling commenced in 1970 by Røros Kobberverk AS, and was continued in 1971. Drilling was followed up by AS Sydvaranger in 1974-1975 and by Killingdal Grubeselskap AS in 1976-77. Altogether 12139.9 m were drilled, distributed on 68 holes. Together with ground geophysics and geophysical measurements in the drillholes, about 3 mill. tons of ore was identified containing 1.3 % Cu and 1.5 % Zn.

3. GEOLOGY AND MINE WORKINGS

The Hersjø ore deposit is situated in the Fundsjø Group (aka. Hersjø Formation) in the eastern Trondheim Region Caledonides. The dominating lithology is massive greenstone, composed of mainly dark green hornblende and feldspar with subordinate chlorite, epidote and calcite (Figure 5). Around the ore lenses this rock has been altered to a dark chlorite schist, often with lenses and layers enriched in quartz ± feldspar. Subordinate lithologies in the area includes felsic metavolcanics (quartz keratophyre), metagabbro and pillow metabasalt.

During a campaign in Nord-Østerdalen for the national ore database, NGU carried out field investigations in the Hersjø area in 2000, including sampling from the old dumps and bedrock.

The workings in the old Hersjø mine field consist of two waterfilled shafts and several small diggings in an area about 105 m along strike and about 30 m wide (Figure 3). Mining has been done on several parallel ore lenses with a common strike of 190-210^o and dipping 50-59^o W. The trend of the ore lenses is controlled by folding, shown by a strong lineation with trend 250^o WSW and plunge 46^o. Three lenses of ore are present, varying from 0.7 m to 2 m in width. The dominating ore type is a massive pyrrhotite ore with subordinate, but varying amounts of chalcopyrite and scattered cubes of pyrite. Locally the ore contains considerable amounts of sphalerite. Five samples of ore from the dumps of the Hersjø mine contained between 1.58% and 6.11% Cu and between 0.12% and 1.37% Zn. Contents of Pb, Ag and Au in these samples were extremely low (Pb < 3 ppm, Ag <0.3-6 ppm, Au <0.02 ppm).

The Kjøllufjellet prospect is situated about 300 m to the south of the old mine. The small showing contains massive and semi-massive pyrrhotite ore, with variable amounts of chalcopyrite and sphalerite, partly in stripes. Two samples contained 1.06 and 1.34% Cu and 2.77 and 4.09% Zn, respectively.

Another small showing is situated c. 500 m to the south of the old mine. Here a semimassive to massive 1 m wide mineralized zone is present with mainly finegrained pyrrhotite and chalcopyrite. A sample from the dump contained 2.63% Cu and 0.16% Zn.

The Nygruva mine in the south consists of an excavation in a small hillside, and two minor shafts (Figure 4). The excavation is 3-4 m across strike towards the west, before in turns to the north and follows a 1 meter thick zone of massive, fine-grained diffusely banded pyrite ore with subordinate sphalerite. The ore zone wedges out in both directions along strike, but may continue downwards along the strongly defined lineation/fold axis. In the footwall are numerous bands and lenses of disseminated to semimassive pyrite in quartz. One sample from the dump contained 1.71% Cu and 3.01% Zn. The closest shaft is about 70 m to the north. Here are two thin zones (20 and 80 cm wide) of massive, banded pyrite mineralization. Two samples contained 1.32 and 1.43% Cu and 0.99 and 7.94% Zn, respectively. The second shaft is another 70 m to the north. Here a sample of massive pyrrhotite ore with subordinate chalcopyrite and pyrite contained 1.76% Cu and 0.81% Zn. In all the samples from the Nygruva mine, the contents of Pb, Ag and Au were extremely low (highest values were 24 ppm Pb, 4 ppm Ag and 0.1 ppm Au).

Figure 4: Aerial photograph of the workings at Nygruva, showing the excavation and the major shaft with waste dumps. It is 70 m between the two workings. North is up.

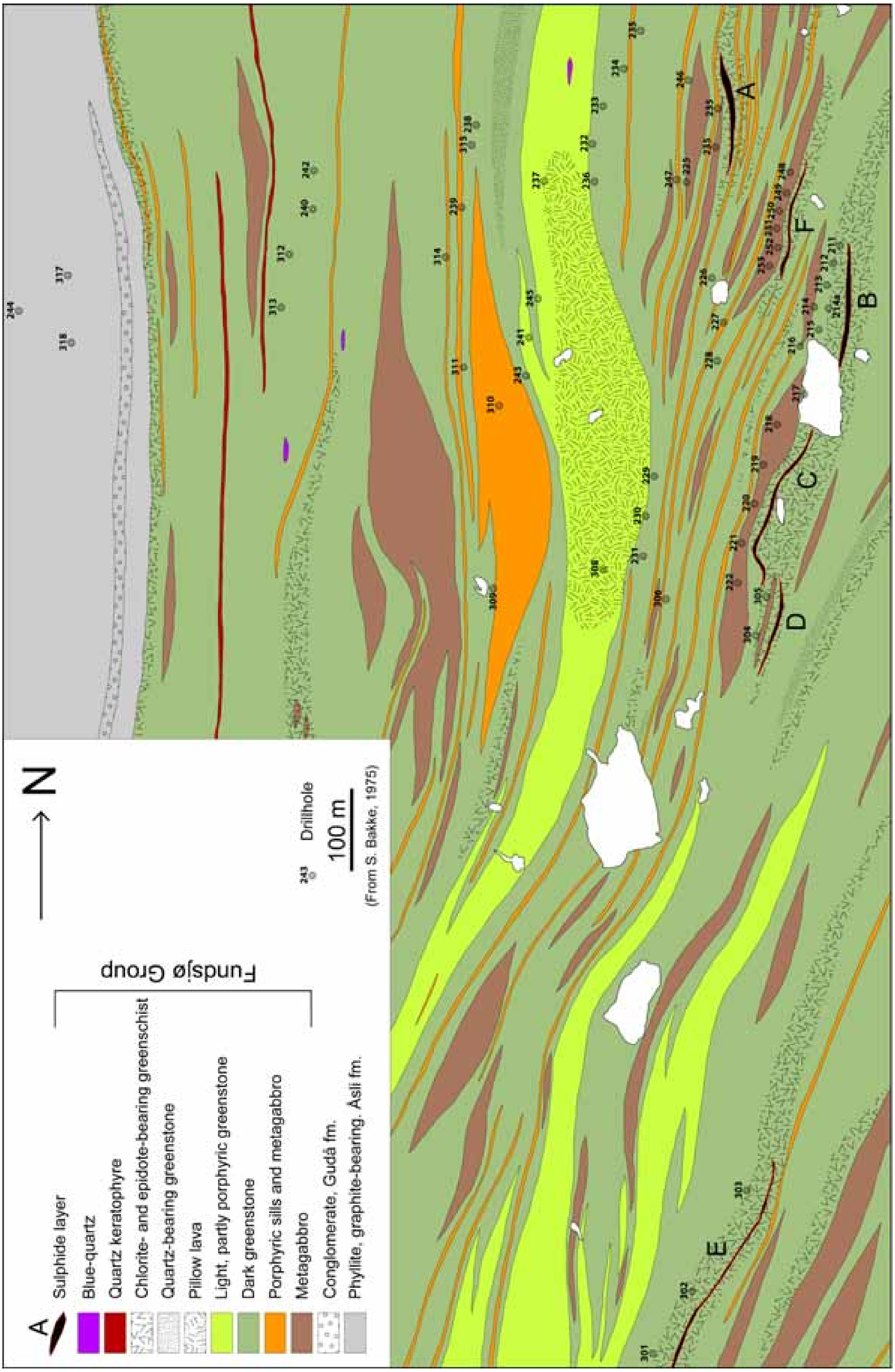


Figure 5: Geological map of the Hersjø ore field. Modified from Bakke (1975).

4. OVERVIEW OF RESULTS FROM PROSPECTING CAMPAIGNS

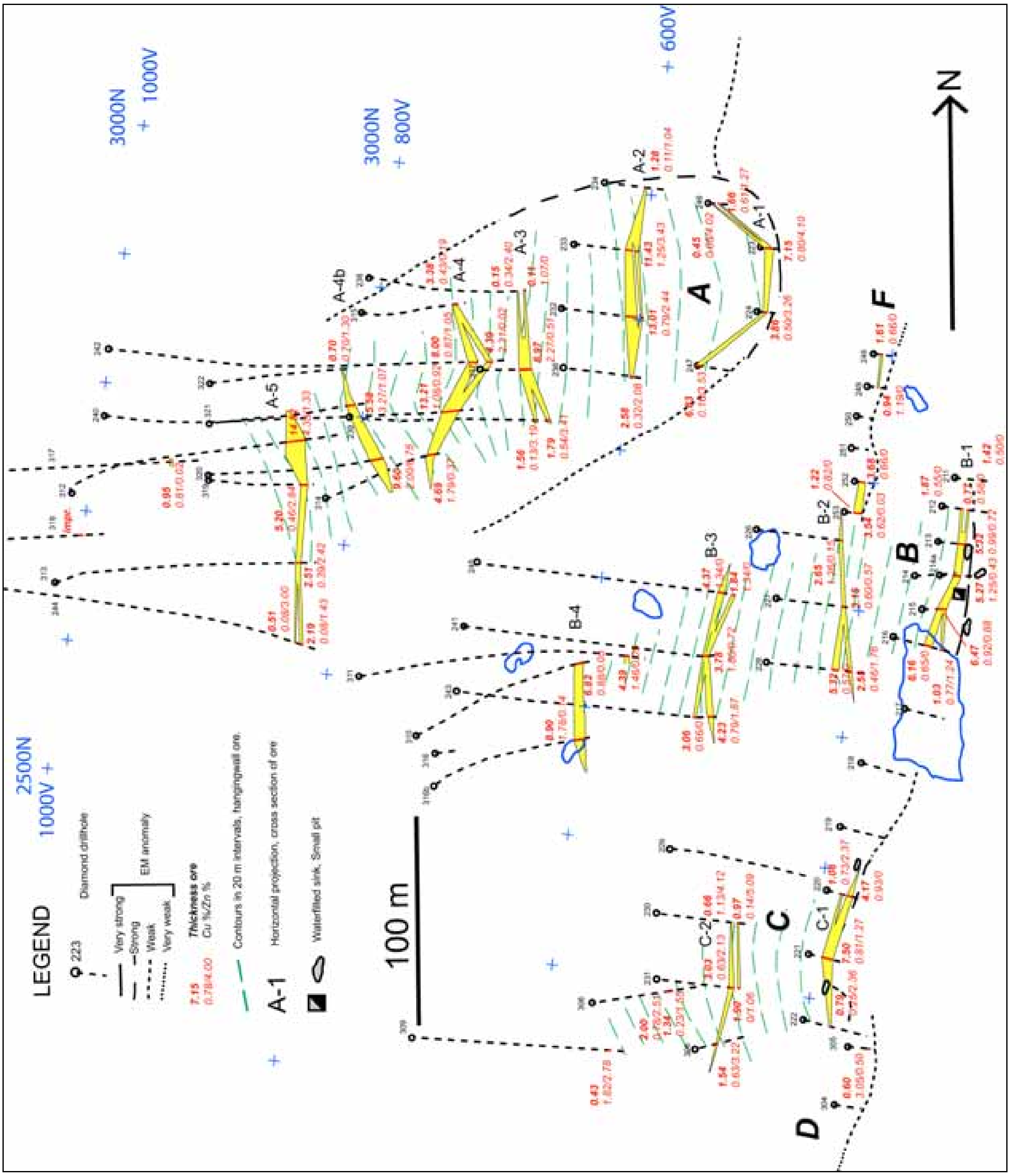


Figure 6: Overview of the northern part of the Hersjø deposit, showing the EM response (TURAM in 1948) from the ore lenses (A, B, C, D, F), the drillholes with assays from the intersections, and the horizontal projections of the intersections of the A, B and C lenses.

4.1 Geophysics

As mentioned above, the outline of six ore lenses were identified by the TURAM measurements in 1948 (Singsaas & Brække n, 1949, see Figure 6). The presence of strong conductors in the area was confirmed by airborne geophysics in 1959 by the Swedish company ABEM (see Rui, 1990). After the drilling campaign in 1970-71 more TURAM measurements were carried out, this time with electrodes placed in the ore lenses (Singsaas

1975, 1976). The results restricted the A-ore lens horizontally in the north and south direction to a depth of about 300 m, as well as the direction of the ore axis (c. 45^o dip to the SW).

Helicopter measurements were carried out in 1974, and the three major ore lenses A, B and C, were easily picked up by the EM (Håbrekke, 1975). The other three ore lenses (D, E, F) could not be distinguished from the background, indicating that these are less conductive and probably of smaller dimensions.

In 1974-75 SP and VLF measurements were carried out in the area, confirming the picture of the A, B and C ores as the most conductive and most extensive ore lenses (Logn, 1974). In addition some thin pyrrhotite mineralizations were found to the west of the main ores. Because shallow graphite horizons overlie the deeper part of the ore lenses in the west (particularly the A lens), VLF could not be used to delimit the ore at depth or along strike.

After the diamond drilling in 1975, CP and SP measurements were carried out in nearly all holes (see Rui, 1990). These measurements showed the continuity of the ore lenses towards depth and also that there are no connections between the individual ore lenses.

4.2 Diamond drilling

The 68 holes drilled in 1970-1977 were distributed on all the six known ore lenses, but naturally with most holes on the three most promising targets, the A, B and C lenses (Gvein, 1976, Rui, 1990).

<u>The A lens</u> was intersected by 24 drillholes distributed in 6 profiles to a vertical depth of 415 m and a length of about 600 m along the axis of the ore lens (Figure 6, Figure 7). In addition, two holes (no.317 and 318) intersected the lens at depths of c.700 and 800 m along the axis, respectively. These holes probably intersected the eastern edge of the lens but proves that the ore lens extends deeper. The ruler shaped ore lens have a length of 100-150 m along strike. The plunge is about 35^o for the first 300 m from the surface and about 45^o further down. The ruler has a thickness of 10-12 m in the central part (along the axis), and tapers and diverges into thinner lenses towards its limits. The best intersection was in hole 312 in profile A-5, which yielded 4.35% Cu and 1.33% Zn over 14.5 m.

The ore types of the A lens can be divided into two main types (Gvein 1976, see Figure A 1 in the appendix):

1) Relatively coarse pyrite ore, quite rich in sphalerite and poor in chalcopyrite. It appears to be present mainly along the south edge and the hangingwall of the ruler.

2) Pyrrhotite ore, relatively rich in chalcopyrite and poor in sphalerite. Magnetite is present in places, either instead of, or together with pyrrhotite. This ore type is generally present in the footwall and the north edge of the ruler. Magnetite seems to be more common in the lowermost and north side of the footwall part of the ore.

The A lens is the largest and richest of the ore lenses. A zinc rich ore is identified in the upper 220 m of the lens, followed by 380 m of copper rich ore. The Zn ore contains 0.54 mill. tons with 0.97 % Cu and 3.59% Zn. The identified resources continues until 600 m depth along the ore axis. Together with an additional 150 m (25% extension of the ore axis) 0.90 mill. tons is present as identified and probable ore between 220 and 750 m with 2.66 % Cu and 1.05% Zn. A further possible resource is present between 750 and 1060 m along the ore axis containing

0.70 mill. tons with 2.66 % Cu and 1.05% Zn. Altogether the A lens contains 2.04 mill. t of identified, probable and possible ore with 2.01 % Cu and 1.56% Zn.

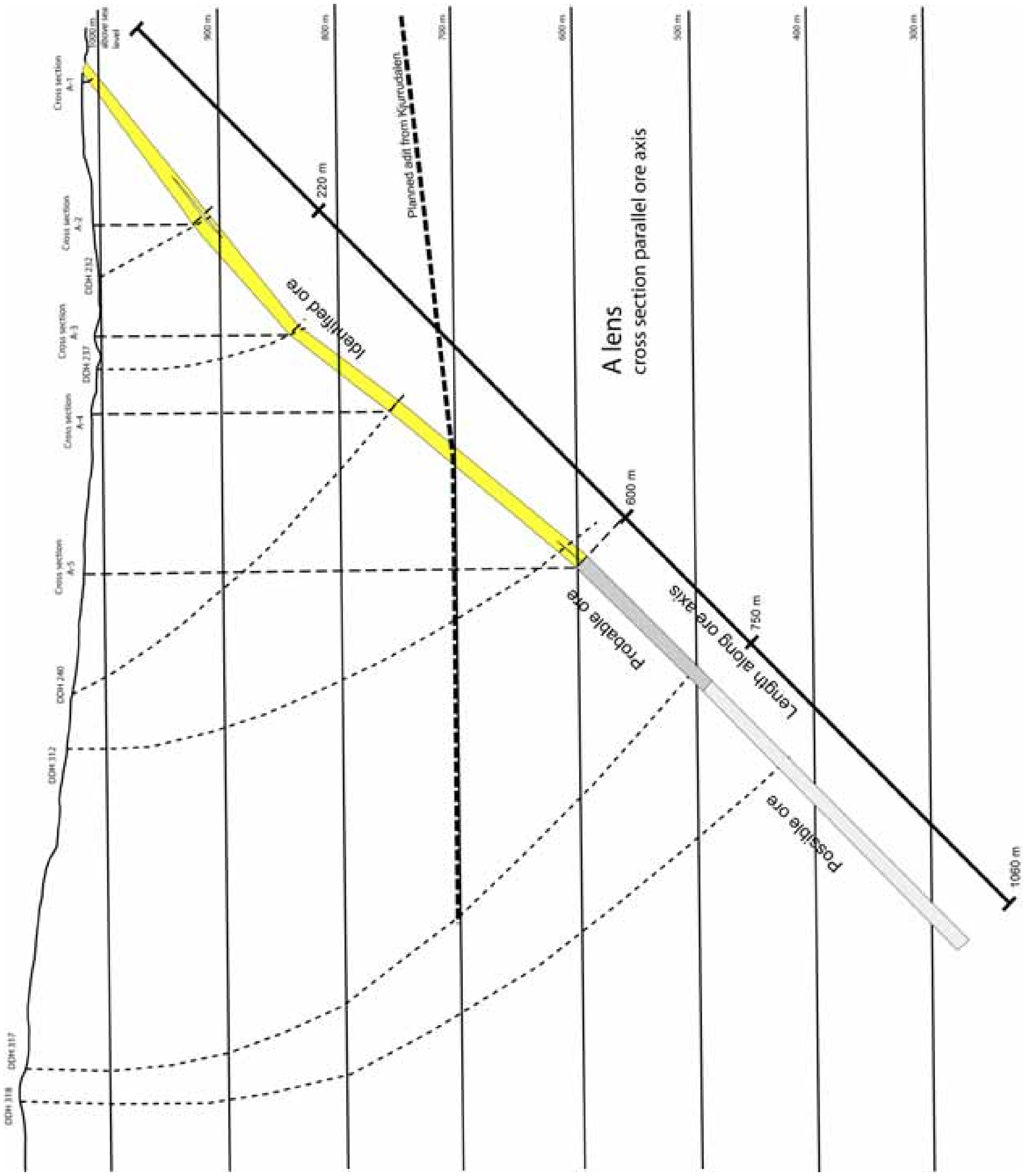


Figure 7: Cross section of the A lens, parallel to the inferred ore axis, showing the identified, probable and possible sections of ore. The planned adit with entrance from Kjurrudalen is also shown (anon., 1985a)

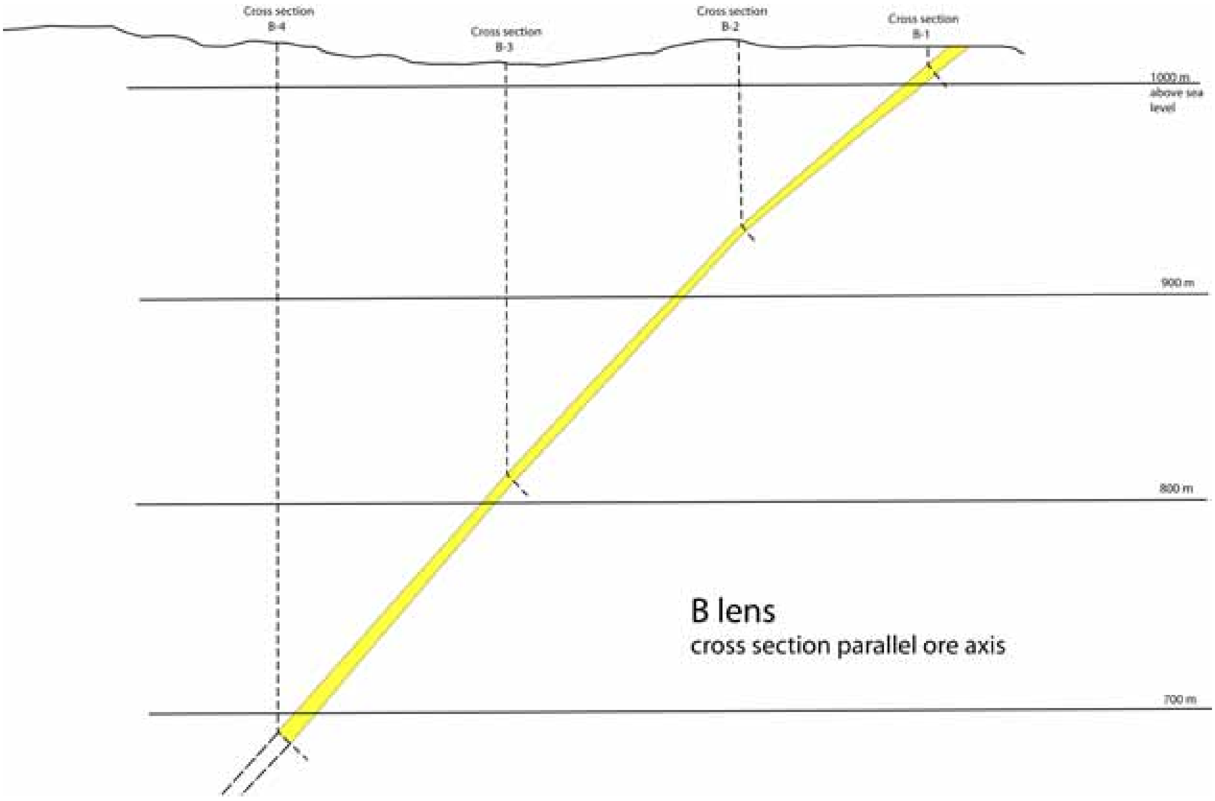


Figure 8: Cross section of the B lens, parallel to the inferred ore axis (Gvein, 1976).

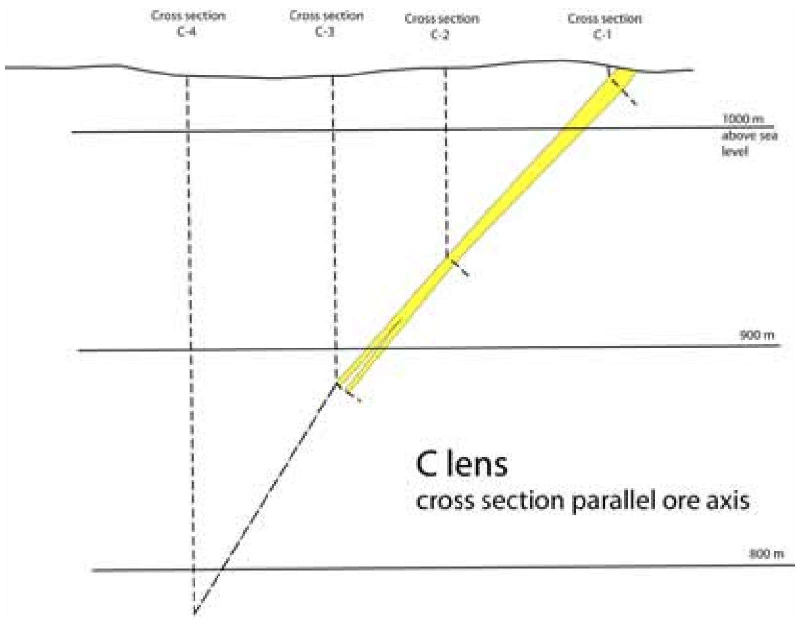


Figure 9: Cross section of the C lens, parallel to the inferred ore axis (Gvein, 1976).

The B lens was intersected by 14 drillholes distributed in 4 profiles to a vertical depth of 320 m and a length of c. 450 m along the ore axis (Figure 8). The ruler is about 100 m in length along strike, and plunges c. 45^{o} towards WSW. The ruler has a thickness of 3-5 m along the central axis and tapers and diverges towards its limits in the horizontal (N-S) directions.

The ore types of the B lens can be divided into three main types (Gvein 1976):

1) Pyrite ore, richer in sphalerite than chalcopyrite. It resembles Type 1 ore in the A lens, but is poorer in sphalerite.

2) Pyrrhotite ore, relatively enriched in chalcopyrite and very poor in sphalerite. Locally it contains thin stripes of magnetite. It resembles Type 2 ore in the A lens.

3) Pyrrhotite ore with varying contents of pyrite, sphalerite, chalcopyrite and magnetite.

Type 2 is present along the north edge of the ruler, and in the hangingwall along the south edge. Type 3 is present in the footwall along the south edge. In the central part of the ruler is all three types present in alternating layers.

The B lens is calculated to contain 0.67 mill. tons probable and possible ore with 1.17% Cu and 0.86% Zn.

<u>The C lens</u> was intersected by 7 holes in four profiles to a vertical depth of 250 m and a length of about 300 m along the ore axis (Figure 9). The hole intersecting the lens at the deepest level (no.309) probably did not intersect the central part of the lens. The ruler-shaped lens is about 100 m along strike and plunges c. 45^o towards WSW. The deepest intersection (hole no. 309) may suggest that the ore axis steepens further down. The ruler has a thickness of 4-7 m in the upper profile, but splits into two or more thinner lenses deeper down (1-3 m).

The ore types of the C lens is similar to the B-lens, but shows an erratic distribution of pyrrhotite and pyrite ore.

The C lens is calculated to contain 0.28 mill. tons of probable ore with 0.74 % Cu and 1.54 % Zn. The C lens is at the same level along strike as the B lens, but holes drilled between the two lenses did not intersect ore.

<u>The D lens</u> is close to the C lens, but is structurally 20-30 meters lower. Two holes were drilled in 1974, of which one (no.305) intersected 0.6 m with 3.05% Cu and 0.50% Zn. Hole no.222 intersected a weak mineralization 20 m below the C lens. The weak mineralization contains 0.31% Cu and 0.22% Zn over 1.08 m and probably belongs to the D lens. Similarly, hole no. 230 intersected 2.68 m with 0.01% Cu and 0.31% Zn 30 m below the C lens.

<u>The E lens</u> was mined in the 1830s (known as Nygruva), but the ore wedged out at a depth of 13 m in the main shaft. Three holes were drilled in 1974, guided by a weak EM anomaly associated with the outcropping mineralization. Hole no. 301 intersected 0.25 m with 3.00% Cu and 0.50% Zn, while holes no.302 and 303 intersected only weak pyrite impregnation.

<u>The F lens</u> is represented by a weak EM anomaly over a length of 140 m. It is situated between the A and B lenses. Six short holes were drilled to intersect the ore at a shallow level. The two central holes (no. 250 and 251) did not intersect any ore, while the pairs of holes on both flanks intersected chalcopyrite-bearing pyrrhotite, varying in thickness from 0.9 to 4.7 m and Cu contents between 0.61 and 1.19%. In hole no. 311, 0.43 m with 1.56% Cu and 3.70% Zn was intersected 60 m above the B lens, probably belonging to the F lens. Hole 310 intersected impregnation of pyrite at the same level (not analyzed). Hole 226 intersected two mineralizations 3 m apart with 0.54 m/0.20% Cu+0.84% Zn and 0.28 m/0.35% Cu+1.40% Zn, respectively, probably belonging to the F lens. Finally, hole 241 intersected 0.86 m of massive sulfide but with very low contents of Cu and Zn.

5. EVALUATION OF THE PROSPECTING CAMPAIGNS

5.1 Geophysics

According to the available reports several rounds of geophysical measurements have been carried out in the Hersjø field (see section 4.1, and references). A number of the geophysical investigations have been carried out from the air, which would not pick up anomalies from possible deep-seated sulfide mineralizations.

Most of the ground geophysical investigations have been concentrated on the known anomalies from the TURAM measurements in 1948 (Singsaas & Brækken, 1949) with the aim of getting a good basis for diamond drilling. Ground geophysics has also been carried out to cover more of the Hersjø field, especially in the northern part (Singsaas, 1972, Logn, 1974), but without finding any more interesting anomalies.

5.2 Results from diamond drilling and ore calculations.

The diamond drilling in the period 1971-1977 resulted in identification of probable and possible resources of 3.00 mill. tons of ore in the three ore lenses A, B and C, and with 2/3 of the resource in the A lens. Examination of the ore calculations from several reports show these to be consistent and very reasonable.

None of the three major ore lenses A, B and C are restricted at depth by drilling, and especially the A lens has a large potential for additional ore at deeper levels. The A lens has very good intersections to a depth of 600 m along the ore axis (cross section A-5, see Figure 6 and Figure 7). Further down are two more intersections (holes no. 317 and 318), the deepest is 240 m below the section A-5. These show weak mineralizations, but this is probably due to intersections of only the footwall of the ore lens. According to geophysical measurements in drillholes (Logn, 1976), the conductive zone continues deeper than the intersection in hole 318. Accordingly it is very reasonable to conclude that we have a ruler-shaped ore lens with axis dimensions of at least 1000 m x 75-100 m x 3-10 m.

As described in section 4.2 and shown in Figure A 1 (appendix) and Figure 10, the ore in the A lens has a pronounced bimodal distribution of Cu and Zn with a footwall enrichment of Cu and hangingwall enrichment of Zn. Cu enrichment is typically associated with pyrrhotite ± magnetite ore and Zn enrichment with pyrite ore. This distribution and zonation of Cu and Zn and their associations with different iron sulfides is typical of Volcanic-Hosted Massive Sulfide deposits (VHMS) and shows that the deposit (at least the A lens) lies right-way-up. As pointed out by Vokes (1983) and shown in Figure A 1, the ore shows a marked zonation in Cu/Zn-ratio along the ore axis, from a Zn rich upper part to a Cu-rich central and deeper part. The content of Zn also increases in the deepest intersections (holes 244, 313 and 319). This zonation supports that the A lens may continue to depths of much more than 1000 m along the ore axis, if the zonation is symmetrical. Vokes (1983) indicates that the ore lens could have a length of at least 1200 m.

The B lens has considerably lower contents of Cu and Zn than the A lens. It is generally richer in Cu than Zn, but the Cu/Zn-ratio varies throughout most of the lens (Figure A 2 in the appendix and Figure 10). Zn is present mainly in the upper and southern part of the lens. The deeper intersections (holes 311, 310 and 316b) contain very little Zn. The thickness and assays do not decrease in the deeper intersections in the B lens, indicating that the ore lens continues deeper. Furthermore, drilling has not constrained the horizontal extent of the lens, especially not to the south.

The C lens is considerably enriched in Zn compared to the B lens (Figure 10 and Figure A 3 in the appendix). Only hole no. 220 contains more Cu than Zn. Drilling on the C lens is limited, except for the upper two cross sections. The deeper ore intersections as in hole no. 308 and hole no. 309, show quite high assays of especially Zn and show that the ore lens is not confined. The lens is also open towards the south.

The F lens is situated at a structural level between the A and B lenses. Unfortunately it is intersected by only 7 holes, which makes it difficult to assess the Cu and Zn distribution. From the few data available (Figure A 4 in the appendix), the upper part is Cu-dominated, while the southern and deepest intersection (hole 311) contains more Zn (Figure A 4, Figure 10). The lens is still open to depth.

The few drillhole intersections of the D and E lenses all contain very restricted and insignificant mineralizations.

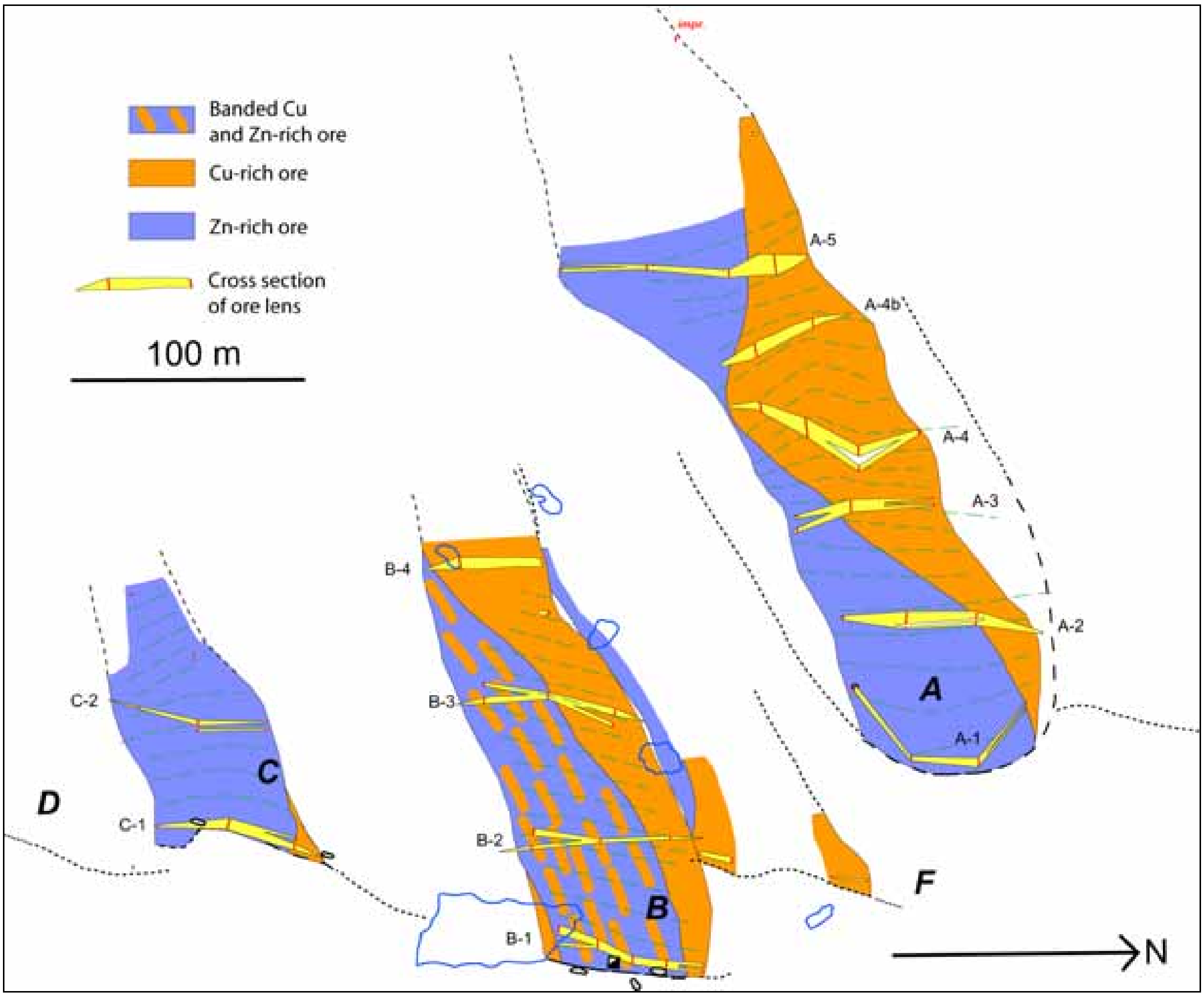


Figure 10: The general distribution of Cu and Zn-dominated ore in the A, B, C and F lenses, based on the data displayed in Figures A1-A4 in the appendix.

The mineralizations intersected by drillholes have generally been analyzed only for Cu, Zn, S and Fe. However, some ore in drillholes from 1970 and 1971 have been mixed and analyzed for other elements, including, Pb, Ag and Au (Table 1).

Table 1: Analyses from mixed drillhole samples (by Rønnskärsverken in 1971):

	A lens Holes 223, 224, 232, 233, 234, 236, 237	**B lens** Holes 211, 216, 226, 227, 228	**C lens** Holes 220, 221, 222, 230, 231
Au (g/t)	0.1	0.1	0.1
Ag (g/t)	4	4	4
Cu (%)	1.10	0.96	0.79
Zn (%)	2.36	0.38	1.55
Pb (%)	< 0.01	<0.01	<0.01
Fe (%)	34.1	34.7	27.4
S (%)	31.3	24.2	22.5
Ni (%)	< 0.01	< 0.01	< 0.01
Co (%)	0.01	0.02	0.02
Bi (%)	0.001	0.001	0.001
Sb (%)	0.001	< 0.001	< 0.001
As (%)	0.01	0.01	0.01
Mo (%)	0.002	0.001	0.001

These data are in accordance with the analyses from samples collected from the dumps by NGU (referred to in Chapter 3) and indicate that the contents of other metals than Cu and Zn in the deposit are very low. However, it should be noted that no data on other elements than Cu, Zn, Fe and S exist from the deeper levels of the deposit, or from any disseminated ores.

6. CONCLUSIONS AND RECOMMENDATIONS

The following questions should be answered positively to justify more work in the Hersjø field:

1) Are the grades or/and tonnages of the known resources sufficient for mining?

Diamond drilling and geophysics on the Hersjø deposit have identified a resource of 2.99 mill.t of Cu-Zn ore with 1.70% Cu and 1.40% Zn. The resource is distributed on three ore lenses, of which the A lens contains 68%, the B lens 22% and the C lens 10% of the resource. The tonnages are obviously too small for mining, especially taking into account the relatively low grades of Cu and Zn with apparently no additions from other elements (e.g. Au or Ag). Whether the average grades of Cu and Zn are high enough for mining should be investigated before more work is carried out.

2) Are there any possibilities for increasing the tonnage or/and the grades to be sufficient for mining?

All of the three major ore lenses are open to depth, and there are good grades and thickness in the deepest intersections of the lenses. In addition, lens F, situated between lens A and B, is not constrained by drilling.

Unfortunately, the graphite-bearing schist of the Åsli Formation overlies the deeper part of the A lens and makes it difficult to interpret the geophysics. The only way to get more information seems to be more drilling. Because of the steep plunge of the ore axis, the next set of holes to intersect the A lens would be very long (e.g. 800-850 m if drilled vertically to intersect the lens at 1000 m along the ore axis). Also new intersections of the other two main lenses would require quite long holes (400-450 m and 300-400 m for the B and C lenses, respectively). A total of at least 5000 m is necessary just to get one new set of cross sections of the three lenses, and to double the tonnage (if it exists) another 10000 m is probably necessary.

A possibility which was discussed in the 1980s, was to make an adit from the Kjurrudalen valley to the ore level at 700 m.a.s.l. and carry out diamond drilling from that level (shown in Figure 7). The length of this tunnel would be about 1700 m (Anon. 1985a). This could later be the main access for mining.

Few analyses of other elements than Cu and Zn have been carried on the ore intersections. Even though the mixed analyses shown in Table 1 show very low values of other elements, it is worth investigating if parts of the ore could have elevated values of e.g. Ag or Au. One weakness is that the data sets in Table 1 are only from the upper part of the ore lenses. Another weakness is that it could be some ore types or disseminations that have elevated values of other metals, which have not been included in the data sets. Most of the old drill holes are stored at the National Core Storage at Løkken (9710 m in 42 holes), and it could be an idea to reanalyze some of the holes and include more elements.

3). Are there any possibilities for undiscovered sulfide lenses in the Hersjø field?
Aerial and ground geophysics have been carried out in several campaigns in the Hersjø field. Especially the methods used on the ground; TURAM, VLF and SP, would have picked up any larger sulfide lenses in addition to the ones already known. Some pyrrhotite mineralization was found, but of no economic interest.

7. REFERENCES

Anon., 1985a: Hersjøfeltet, malmundersøkelser og muligheter for gruvedrift. Report, Killingdal Grubeselskap A/S, 6 pp. and appendices. *BV 3850.*

Anon., 1985b: Hersjøfeltet: - malmundersøkelser, - mulighetene for gruvedrift. Report, Killingdal Grubeselskap A/S, 6 pp. and appendices. *BV 4139.*

Bakke, S., 1975: En malmgeologisk undersøkelse av området ved Hersjø Gruber i Ålen. Thesis, NTH 1975, 72 pp. *BV 6857.*

Grenne, T., 1988: Marginal basin type metavolcanites of the Hersjø Formation, eastern Trondheim District, Central Norwegian Caledonides. NGU bull. 412, p. 29-42.

Gvein, Ø., 1976: Sulfidmalmfeltet Hersjø V. Holtålen, Sør-Trøndelag. Report A/S Sydvaranger, 23 pp. and appendices. *BV 1128.*

Håbrekke, H., 1975: Magnetiske og elektromagnetiske målinger fra helikopter over Harsjø-feltet som omfatter deler av kommunene Holtålen og Røros i Sør-Trøndelag og Tolga, Os i Hedmark. NGU report 1306, 8 pp.

Logn, Ø., 1974: VLF og SP-målinger, Hersjø. Report A/S Sydvaranger.

Pettersen, Ø., 1972: A/S Røros Kobberverk. Hersjøfeltet. Malmberegninger på grunnlag av diamantboringer i 1970 og 1971, pr. 11/2-1972. 3 pp. and appendix. *BV 66.*

Rui, I. 1990: Hersjøfeltet. Report Prospektering A/S (Aspro). *BV 4151.*

Singsaas, P., 1972: El.magn. bakkemålinger Hersjøfeltet. NGU report 1085, 5 pp.

Singsaas, P., 1975: Turammålinger Hersjøfeltet, NGU report 1305, 5 pp.

Singsaas, P., 1976: Turammålinger Hersjøfeltet, NGU report 1392, 6 pp.

Singsaas P. and Brækken H., 1949: Geofysisk undersøkelse 1. Hessdalen Grube 2. Storvoll Grube 3. Rogn- gruben 4. From-gruben 5. Harsjø Grube Vest. Geofysisk Malmleting, Report 63, 41 pp.

Tessem, S., 1985: Hersjøforekomsten: Betenkning I vedrørende undersøkelse og drift. Betenkning II vedrørende gruvedrift på sink- og kobberrik malmreserve. Report Killingdal Grubeselskap A/S, 32 pp. and appendices. *BV 3952.*

Tessem, S. & Lange J.J., 1984: Betenkning vedrørende undersøkelse av drift av Hersjøforekomsten. Malmberegninger for forekomstene: Vingelen, Fløttum, Skrattås, Gressli. Report Killingdal Grubeselskap A/S, 17 pp. and appendices. *BV 4132.*

Vokes, F.M. 1983: Hersjø Vest malmfelt. Report NTH and Killingdal Grubeselskap A/S, 11 pp. and appendices. *BV 1993.*

8. APPENDIX

Table A1-A4: Analytical data of drillhole intersections of the A, B, C, D E and F lenses.

Figures

A 1: The distribution of Cu (red) and Zn (blue) in the intersections of the A lens. The diagrams are placed according to the axis of the ore lens. The bars are placed beside each other with Cu to the left and Zn to the right of the top of each analyzed interval.

A 2: The distribution of Cu (red) and Zn (blue) in the intersections of the B lens. The diagrams are placed according to the axis of the ore lens. The bars are placed beside each other with Cu to the left and Zn to the right of the top of each analyzed interval.

A 3: The distribution of Cu (red) and Zn (blue) in the intersections of the C lens. The diagrams are placed according to the axis of the ore lens. The bars are placed beside each other with Cu to the left and Zn to the right of the top of each analyzed interval.

A 4: The distribution of Cu (red) and Zn (blue) in the intersections of the F lens. The diagrams are placed according to the axis of the ore lens. The bars are placed beside each other with Cu to the left and Zn to the right of the top of each analyzed interval.

Table A1: Analytical data on drill hole intersections of the A lens

DDH	Coordinates	Direction	Dip	Length	Top	Bottom	Meters	Cu	Zn	S	Fe
223	2970N-512V	102	60	30	0	12,26	12,26				
					12,26	14,68	2,42	0,24	3	43,82	38,72
					14,68	15,28	0,6	1,89	1,7	33,41	35,31
					15,28	15,82	0,54				
					15,82	17	1,18	1,35	3,05	36,52	39,05
					17	18,29	1,29	0,78	12,75	33,11	27,17
					18,29	19,52	1,23	1,13	0	14,75	19,73
					19,52	30	10,48				
224	2920N-509V	102	60	30	0	10,2	10,2				
					10,2	10,73	0,53	0,11	2	40,08	37,62
					10,73	15	4,27				
					15	15,48	0,48	0,28	2,55	44,74	39,16
					15,48	15,7	0,22	0,41	1,53	14,33	24,3
					15,7	16	0,3	0,68	2,24	41,28	36,74
					16	17	1	0,82	1,76	42,91	39,6
					17	18	1	0,28	5,45	37,78	35,09
					18	18,92	0,92	0,43	3,72	32,54	33
					18,92	30	11,08				
225	2871N-538V	102	60	30,9	0	30,9	30,9				
246	3000N-557V	102	60	44,4	0	11,9	11,9				
					11,9	11,95	0,05	0,02	0	32,4	43,12
					11,95	12,52	0,57				
					12,52	13	0,48	0,08	4,02	35,6	32,92
					13	16,15	3,15				
					16,15	17,27	1,12	0,73	1,68	36,08	39,2
					17,27	17,92	0,65	0,34	0,39	5,62	19,15
					17,92	18,43	0,51	0,01	0	3,04	18,48
					18,43	23,85	5,42				
					23,85	24,6	0,75	0,05	0	1,24	29,79
					24,6	26,44	1,84	0,02	0	1,07	34,27
					26,44	26,67	0,23	1,13	0	26,4	50,4
					26,67	28,08	1,41	0	0	0,27	11,76
					28,08	29,44	1,36	0,09	0	1,12	53,76
					29,44	31	1,56	0	0	1,53	25,75
					31	32	1				32,28
					32	33	1				18,7
					33	34	1				20,26
					34	34,45	0,45				31,36
					34,45	44,4	9,95				
247	2875N-550V	0	90	54,8	0	39,32	39,32				
					39,32	41	1,68	0,16	6,59	40,2	35,28
					41	42,21	1,21	0,16	4,08	36,93	32,48
					42,21	42,87	0,66				
					42,87	44	1,13	0,11	2,35	42,18	39,31
					44	45	1	0,15	2,52	41,95	38,3
					45	46,15	1,15	0,32	2,57	41,9	36,96
					46,15	54,8	8,65				
234	3000N-640V	102	60	79,85	0	59,53	59,53				
					59,53	60,14	0,61	0,22	1,4	26,11	30,73
					60,14	60,83	0,69	0,02	0,72	7,88	11,88
					60,83	61,69	0,86	0,01	0	2,1	2,14
					61,69	79,85	18,16				

DDH	Coordinates	Direction	Dip	Length	Top	Bottom	Meters	Cu	Zn	S	Fe
233	2960N-655V	102	60	92,6	0	69,68	69,68				
					69,68	70,75	1,07	0,25	5,04	40,9	34,33
					70,75	73,42	2,67	0	0	2,93	7,81
					73,42	74	0,58	0,17	2,24	37,53	32,91
					74	75	1	0,7	2,04	42,24	37,6
					75	76	1	0,36	2,16	40,46	36,51
					76	77	1	0,4	8,1	43,48	34,51
					77	78	1	0,41	10,9	33,53	31,4
					78	79	1	1,15	11,42	32,82	25,42
					79	79,56	0,56	2,16	2,3	28,77	35,72
					79,56	80	0,44	0,14	0,75	9,23	18,72
					80	81	1	0,17	0	4,14	17,1
					81	81,96	0,96	0,03	0	0,44	15,58
					81,96	83	1,04	2	0,1	35,8	54,1
					83	84,24	1,24	5,22	2,25	36,77	50,96
					84,24	85	0,76	0,64	0	38,3	55,94
					85	85,58	0,58	1,55	0	28,83	47,18
					85,58	86,33	0,75	0,31	0	4,03	26,73
					86,33	87	0,67	0,01	0	0,44	20,02
					87	92,6	5,6				
232	2910N-660V	102	60	110	0	89,66	89,66				
					89,66	91	1,34	0,06	4,55	33,77	31,05
					91	92	1	0,24	3	43,55	39,09
					92	93	1	0,62	2,1	32,74	38,34
					93	94	1	0,63	1,85	33,39	41,68
					94	95	1	0,63	3,1	36,19	36,9
					95	96	1	0,58	2,1	41,34	37,9
					96	97	1	0,82	2,95	41,19	39,01
					97	98	1	1,56	2,25	33,36	37,86
					98	99	1	0,5	7,65	20,64	21,06
					99	100	1	3,32	0,2	16,73	23,97
					100	101	1	0,06	0	5,7	5,79
					101	102,7	1,7	0	0	4,24	6,58
					102,7	103,5	0,8	2,32	1,15	19,19	20,1
					103,5	110	6,5				
236	2852N-655V	102	60	105,8	0	92,25	92,25				
					92,25	95	2,75	0,32	2,08	38,86	36,86
					95	96,5	1,5				
					96,5	98	1,5	0,11	0,1	7,68	9,81
					98	99,18	1,18	0,12	0,16	7,75	8,72
					99,18	105,8	6,62				
238	2909N-810V	102	60	224,55	0	205,65	205,65				
					205,65	205,8	0,15	0,34	2,4	30,63	32,14
					205,8	207,32	1,52				
					207,32	208	0,68	0,02	0,42	5,88	13,54
					208	209	1	0,03	0	3,81	14,67
					209	209,24	0,24	0	0	0,87	12,76
					209,24	209,39	0,15	0,03	0	2,66	24,86
					209,39	209,5	0,11	1,07	0	21,23	53,98
					209,5	209,78	0,28	0,05	0,16	1,25	62,8
					209,78	224,55	14,77				

DDH	Coordinates	Direction	Dip	Length	Top	Bottom	Meters	Cu	Zn	S	Fe
237	2850N-715V	0	90	184,7	0	166,9	166,9				
					166,9	168	1,1	1,22	1,56	39,07	39,13
					168	169	1	2,76	1,17	36,08	35,97
					169	170	1	2,59	0,84	33,02	37,16
					170	170,65	0,65	1,44	0,3	26,08	28,12
					170,65	171,68	1,03	1,43	0	33,91	43,27
					171,68	172,46	0,78	1,35	0,22	1,92	3,8
					172,46	173	0,54	1,55	0	31,18	42,5
					173	174	1	3,16	0	29,27	39,45
					174	175	1	2,28	0,31	31,32	44,36
					175	176	1	3,44	0,1	34,16	49,59
					176	177	1	2,65	0,5	35,21	50,53
					177	177,26	0,26	3,45	0,52	21,1	37,27
					177,26	184,7	7,44				
239	2800N-810V	102	60	241,35	0	209,12	209,12				
					209,12	210,7	1,58	0,13	3,19	38,36	34,06
					210,7	220,56	9,86				
					220,56	222,54	1,98	0,54	3,41	33,76	32,02
					222,54	241,35	18,81				
315	2882N-812V	99	85	265	0	250,2	250,2				
					250,2	251,2	1	0,01	0,02	0,85	9,3
					251,2	252	0,8	1,19	0,85	27,2	30,4
					252	253,45	1,45	0,3	0,02	8,2	21
					253,45	254,8	1,35	0,18	0,01	2,98	62,2
					254,8	255,8	1	0,06	0,01	0,71	22
					255,8	265	9,2				
242	2828N-1000V	102	60	398,8	0	373,65	373,65				
					373,65	375	1,35	0,62	3,18	40,42	38,18
					375	376	1	0,93	1,67	41	39,98
					376	377	1	0,82	0,16	43,28	42,56
					377	377,9	0,9				
					377,9	379	1,1	0,84	1,65	41,72	41,2
					379	380	1	1,39	0,26	28,58	49,95
					380	381	1	1,44	0	21,58	51,74
					381	381,65	0,65	0,49	0	35,23	47
					381,65	382,4	0,75	0,03	0	5,1	18,4
					382,4	385,33	2,93	0	0	1,73	12,24
					385,33	386,33	1	0,02	0	3,22	28
					386,33	387,23	0,9	0,16	0	3,21	20,6
					387,23	388	0,77	3,79	0	21,06	34,82
					388	389,03	1,03	5,26	0,1	18,72	32,02
					389,03	390	0,97	0,01	0	2,7	16,8
					390	390,47	0,47	0,82	0	2,66	11,76
					390,47	391,62	1,15	0,54	0	1,05	7,84
					391,62	393	1,38	0	0	0,45	5,04
					393	393,31	0,31	0,91	0,59	2,51	8,06
					393,31	398,8	5,49				

DDH	Coordinates	Direction	Dip	Length	Top	Bottom	Meters	Cu	Zn	S	Fe
240	2775N-997V	102	60	404,3	0	373,79	373,79				
					373,79	375	1,21	0,23	1,5	38,55	34,72
					375	376	1	0,57	0,82	34,61	35,62
					376	377	1	0,34	0,54	35,19	37,52
					377	378	1	0,48	0,26	36,53	39,98
					378	379	1	0,82	0,78	39,52	40,21
					379	380	1	0,6	0	39,26	40,88
					380	381	1	0,37	2,37	37,31	39,31
					381	382	1	0,46	2,32	45,39	40,99
					382	383	1	1,11	0,81	38,06	40,76
					383	384	1	1,52	0,43	33,25	49,5
					384	385	1	3,58	0,76	31,41	49,72
					385	386	1	2,47	0,59	34,04	48,27
					386	387	1	1,57	0,65	32,87	45,92
					387	388	1	0,19	0	4,71	50,28
					388	389	1	0,1	0	1,33	33,82
					389	390	1	0,08	0	3,35	22,17
					390	391	1	0,32	0	12,15	24,86
					391	392	1	0,09	0	10,43	22,94
					392	392,35	0,35	0,17	0	13,94	23,62
					392,35	395	2,65				
					395	396	1	0,04		10,2	12,32
					396	397	1				
					397	398	1	0,19		19,22	22,4
					398	404,3	6,3				
314	2734N-820V	0	90	334,8	0	312,35	312,35				
					312,35	313,35	1	0,01	0,03	0,52	8,7
					313,35	315	1,65	0,71	0,42	31,8	34,2
					315	316	1	1,84	0,34	33,8	40,3
					316	317	1	1,65	0,61	35,5	39,3
					317	318,53	1,53	3	0,18	30,2	45,9
					318,53	319,53	1	0,45	0,05	8,2	31,1
					319,53	334,8	15,27				
322	2810N-920V	86	84	368,7	0	353,3	353,3				
					353,3	354,3	1	0,09	0,15		
					354,3	355	0,7	0,7	1,3		
					355	356	1	0,28	0,05		
					356	368,7	12,7				
321	2780N-915V	86	85	376,7	0	349	349				
					349	349,86	0,86	0,1	0,05	2,2	8,5
					349,86	350,36	0,5	0,73	5,28	37,6	33,6
					350,36	351,06	0,7	0,05	0,12	2,1	5,9
					351,06	352	0,94	0,95	5,38	37,4	33,3
					352	353	1	9,85	1,31	31,1	35,5
					353	354	1	1,32	0,07	32,2	42,9
					354	355	1	1,19	0,01	32,6	42,6
					355	356	1	4,54	0,05	28,3	51,5
					356	357	1	1,63	0,02	8,6	59,3
					357	358	1	0,05	0,01	0,4	60,8
					358	358,85	0,85	0,01	0,01	0,4	55,4
					358,85	361,78	2,93				
					361,78	363	1,22	0,63	0,01	32,3	55,5
					363	363,78	0,78	1,97	0,05	28,9	49,9
					363,78	376,7	12,92				

DDH	Coordinates	Direction	Dip	Length	Top	Bottom	Meters	Cu	Zn	S	Fe
320	2740N-913V	90	84	386,3	0	354	354				
					354	354,97	0,97	0,11	0,27	2,2	8,3
					354,97	356	1,03	0,18	2,38	44,1	38,6
					356	357	1	0,21	3,33	44,6	39,4
					357	358	1	1,24	0,64	41,6	38,2
					358	359	1	0,95	0,07	33	39,9
					359	360	1	4,1	0,26	27,2	30,8
					360	361	1	2,16	0,11	28,8	36,2
					361	362	1	3,45	0,19	34,8	45,1
					362	363	1	3,49	0,23	35,4	46,1
					363	364	1	2,08	0,23	37,4	44,5
					364	365	1	2,63	0,26	36,5	45,6
					365	365,55	0,55	1,09	0,09	34,8	48,8
					365,55	366	0,45	0,45	0,12	10,3	51,9
					366	367	1	1,04	0,08	8	27,9
					367	368	1	0,37	0,14	9,1	25,1
					368	369	1	0,42	0,05	5,6	22,6
					369	386,3	17,3				
312	2713N-1014V	76	85	511	0	454,48	454,48				
					454,48	455,48	1	0,03	0,03	2	7,9
					455,48	457	1,52	0,5	2,07	30,4	30,4
					457	458	1	1,29	0,84	24	35
					458	459	1	1,75	1,01	29,8	40
					459	460	1	3,08	0,24	25,9	39,3
					460	461,27	1,27	3,52	0,21	28,7	38,2
					461,27	463	1,73	0,08	0,02	0,95	8,1
					463	464	1	1,22	1,67	31,8	38,1
					464	465	1	8,5	4,31	32,4	34,2
					465	466	1	10,57	6,4	29,7	34,3
					466	467	1	8,54	0,19	15,9	52,2
					467	468	1	11,41	0,08	26,8	49
					468	469	1	4,15	0,05	15,6	55,7
					469	470	1	4,58	0,03	26,1	53
					470	471	1	0,18	0,07	2,2	25,1
					471	472	1	0,03	0,03	0,81	23,2
					472	511	39				
319	2737N-912V	78	85	437,7	0	412	412				
					412	412,97	0,97	0,04	0,04	1,2	7,3
					412,97	414	1,03	0,15	3,32	42,9	38,5
					414	415	1	0,29	4,33	40,2	37,2
					415	416	1	0,16	3,68	35,8	33,4
					416	417	1	0,25	3,83	41,3	38,5
					417	418	1	0,42	3,16	39,3	37,4
					418	418,5	0,5	2,5	0,95	36,3	45,2
					418,5	418,91	0,41	0,21	0,03	6,8	58,7
					418,91	419,91	1	0,1	0,07	2,3	24,2
					419,91	422,78	2,87				
					422,78	423,86	1,08	1,21	0,02	22	48,3
					423,86	437,7	13,84				

DDH	Coordinates	Direction	Dip	Length	Top	Bottom	Meters	Cu	Zn	S	Fe
313	2643N-1015V	84	85	515	0	484,89	484,89				
					484,89	485,89	1	0,01	0,04	0,49	7,8
					485,89	487	1,11	0,28	1,74	11,9	39,9
					487	488,43	1,43	0,45	2,88	39	38,3
					488,43	489,43	1	0,02	0,13	9,6	1,82
					489,43	515	25,57				
244	2600N-1360V	93	60	744,9	0	717,23	717,23				
					717,23	717,77	0,54	0,08	3	33,75	32,7
					717,77	721,89	4,12				
					721,89	722,72	0,83	0,06	2,46	41,32	37,07
					722,72	723,69	0,97	0,05	0,66	17,98	19,6
					723,69	724,22	0,53	0,16	0,72	15,41	21,28
					724,22	744,9	20,68				
317	2639N-1277V	87	80	760	0	720	720				
					720	721	1	0,08	0,04	0,6	13,2
					721	721,95	0,95	0,81	0,02	22,4	43,7
					721,95	723	1,05	0,06	0,04	1,1	19
					723	760	37				
318	2570N-1266V	75	83	769	0	735	735				
					735	736	1	0,2	0,03	6,3	19,9
					736	737	1	0,22	0,02	2,5	19,1
					737	738	1	0,08	0,02	2,2	18
					738	739	1	0,17	0,01	1,7	19,1
					739	739,5	0,5	0,41	0,03	4,3	21,8
					739,5	769	29,5				

Table A2: Analytical data on drill hole intersections of the B lens

DDH	Coordinates	Direction	Dip	Length	Top	Bottom	Meters	Cu	Zn	S	Fe
211	2813N-339V	102	30	30,15	12,75	14,17	1,42	0,5	0	7,1	16
					14,17	15	0,83	0,05	0	5,14	10,18
212	2790N-347V	102	30	40,4	8,66	9,42	0,76	0	0,14	4,87	8,77
					9,42	10,43	1,01				
					10,43	11,56	1,13	0	0	6,64	10,53
					11,56	14,35	2,79				
					14,35	15,96	1,61	0,05	0	6,78	10,48
					15,96	17,83	1,87	0,55	0	7,9	18,36
					17,83	20,73	2,9				
					20,73	21,52	0,79	0,58	0	8,15	19,6
					21,52	24,79	3,27				
					24,79	25,51	0,72	0,1	0	3,06	14,78
					25,51	25,96	0,45				
					25,96	27,6	1,64	0,25	0	2,88	14,1
					27,6	28,43	0,83				
					28,43	29,53	1,1	0,38	0	2,89	14,2
213	2762N-347V	95	30	34,9	16,6	16,88	0,28	0,5	1,11	15,59	24,09
					16,88	18,75	1,87				
					18,75	20,34	1,59	1,71	0,32	33,06	47,29
					20,34	21	0,66				
					21	22,31	1,31	0,06	1,64	37,81	33,97
					22,31	23,44	1,13				
					23,44	24,26	0,82	2,72	1	23,29	34,74
					24,26	31,71	7,45				
					31,71	32,37	0,66	0,04	3,11	5,45	13,77
214a	2737N-343V	100	30	18,8	10,18	10,36	0,18	0,41	2,94	37,42	35,32
					10,36	13,34	2,98				
					13,34	14,15	0,81	1,04	0,62	27,73	40,36
					14,15	14,62	0,47				
					14,62	16	1,38	1,6	0,04	20,21	35,86
					16	17,5	1,5	1,99	0,82	14,44	27,17
					17,5	18,8	1,3	0,46	0,39	5,95	17,82
214	2736N-360V	95	30	37	28	28,17	0,17	1,04	0,37	38,25	56,65
					28,17	30	1,83				
					30	30,27	0,27	0,57	1,19	32,37	39,63
					30,27	30,85	0,58	0,96	0,94	17,62	18,09
					30,85	34	3,15	2,28	1,98	36,31	48,06
215	2710N-353V	90	30	21,4	10,92	11,37	0,45	0,8	0	32,1	44,32
					11,37	14,7	3,33				
					14,7	16,06	1,36	1,04	0	29,79	41,47
					16,06	16,59	0,53				
					16,59	17	0,41	0,63	0,28	36,68	43,12
					17	17,07	0,07				
					17,07	17,82	0,75	0,32	4	39,24	43,66
					17,82	18,5	0,68	1,27	1,98	37,78	47,3
					18,5	19,67	1,17	1,22	0	15,62	26,62
					19,67	20,11	0,44				
					20,11	21,4	1,29	1,3	0,66	40,08	48,4
					21,4	25,4	4				

DDH	Coordinates	Direction	Dip	Length	Top	Bottom	Meters	Cu	Zn	S	Fe
216	2683N-371V	110	30	55	23,5	24,48	0,98	0,05	0	3,26	11
					24,48	25,16	0,68	0,17	0,1	8,11	18,7
					25,16	26,7	1,54	0,02	0	2,52	9,35
					26,7	28	1,3	0,13	0	7,59	19,8
					28	28,62	0,62	0,07	0	6,36	16,38
					28,62	30	1,38	0,38	0	32,07	50,6
					30	31	1	0,4	0	28,64	44,22
					31	32	1	0,8	0	32,32	48,95
					32	33	1	0,8	0	32,04	39,6
					33	34	1	0,8	0	28,66	45,64
					34	35	1	0,84	0	29,76	45,2
					35	39,22	4,22				
					39,22	39,38	0,16	2,92	0,56	24,57	41,36
					39,38	41,69	2,31				
					41,69	42,73	1,04	0,04	0	3,61	9,35
					42,73	43,76	1,03	0,77	1,24	40,64	42,9
217	2630N-355V	110	30	35,05	11,13	12,91	1,78	0,06	0	6,59	12,98
226	2750N-483V	100	60	133,9	54,4	55,6	1,2	0,03	0,16	6,67	9,32
					55,6	56,14	0,54	0,2	0,84	11,98	16,43
					56,14	59,51	3,37				
					59,51	59,78	0,27	0,35	1,4	14,21	16,87
					115,42	115,79	0,37	0,13	0	3,36	11,32
					115,79	115,96	0,17	0,28	0	15,35	22,64
					115,96	116,8	0,84	0,02	0	3,95	11,99
					116,8	120,19	3,39				
					120,19	120,75	0,56	0,35	0	7,86	18,43
					120,75	121	0,25	1,65	0,65	32,45	53,5
					121	122	1	0,97	0	6,24	18,09
					122	123	1	0,55	0,22	6,85	18,65
					123	123,44	0,44	3,12	0	20,59	31,53
					123,44	124,48	1,04	0,13	0	6,15	11,88
					124,48	125	0,52	0,35	0	11,37	22,6
					125	126	1	0,26	0,1	6,09	15,01
					126	127	1	0,37	0	10,61	22,24
					127	127,79	0,79	0,31	0	11,1	13,08
					127,79	129	1,21	0,02	0	2,54	9,54
					129	130	1	0,72	0	7,15	15,4
					130	130,7	0,7	0,04	0	4,1	7,92
227	2700N-467V	102	60	122,15	94,98	95,15	0,17	0,04	0,64	13	17,1
					95,15	98,18	3,03				
					98,18	98,65	0,47	0,28	0	4,03	7
					98,65	99,48	0,83	1,25	0,79	33,23	42,02
					99,48	101,07	1,59	0	0	3,59	5,4
					101,07	101,91	0,84	0,78	1,13	31,36	31,86

DDH	Coordinates	Direction	Dip	Length	Top	Bottom	Meters	Cu	Zn	S	Fe
228	2650N-467V	102	60	120,6	91,23	92,38	1,15	0,02	0,16	6,45	11,47
					92,38	93,91	1,53	0,03	0,3	7,86	12,77
					93,91	94,69	0,78	0,08	1,12	11,69	18,61
					94,69	95,75	1,06	0	0,84	2,84	7,36
					95,75	96,38	0,63	0,03	0	6,75	14,39
					96,38	97,46	1,08	0,03	0	9,13	19,69
					97,46	98,1	0,64	0,09	0	14,24	24,99
					98,1	98,93	0,83	0,27	0	19,67	28,02
					98,93	100,58	1,65	0,79	0	25,63	36,57
					100,58	101,77	1,19	0,05	0	2,05	4,88
					101,77	102,53	0,76	0,8	0	34,86	54
					102,53	104,19	1,66	0,02	0	2,87	4,1
					104,19	104,59	0,4	1,7	0	32,01	49,78
					104,59	104,93	0,34	0,15	0	9,1	15,33
					104,93	106,5	1,57	0	0	2,46	4,18
					106,5	107,27	0,77	0,45	0	13,51	27,2
					107,27	108,19	0,92	0	0	0,54	2,01
					108,19	109,25	1,06	0,41	1,69	16,23	27,2
					109,25	109,62	0,37	0	0,16	11,56	17,82
					109,62	112,32	2,7				
					112,32	112,84	0,52	0,55	0	9,34	17,06
					112,84	115,03	2,19	0,44	2,08	36,58	37,8
241	2650N-700V	102	58	300,9	135,68	136,12	0,44	0	0,3	14,88	17,6
					136,12	136,49	0,37	0	0	3,66	6,16
					136,49	137,35	0,86	0,02	0,14	35,56	34,16
					137,35	138,07	0,72	0,02	0	9,61	15,22
					279,2	279,31	0,11	0,44	0	6,66	16,8
					279,31	279,46	0,15				
					279,46	280	0,54	2,24	0,03	34,31	53,36
					280	281	1	1,88	0	37,62	59,58
					281	282	1	1,83	0	37,59	58,24
					282	282,4	0,4	1,81	2,42	36,77	48,16
					282,4	282,57	0,17	0,15	0,06	10,11	25
					282,57	283,24	0,67	1,57	2,71	33,12	42,22
					283,24	283,9	0,66	0,31	0,12	6,42	18,14
243	2600N-699V	102	60	305	273,27	273,53	0,26	0,05	0,84	11,59	20,48
					273,53	277,65	4,12				
					277,65	279	1,35	0	0,16	3,72	10,64
					279	279,74	0,74	0,04	0,92	3,94	12,54
					279,74	280,52	0,78	0,16	0	6,89	19,66
					280,52	281	0,48	0,65	0	29,82	48,72
					281	282	1	0,56	0	25,19	38,75
					282	283	1	0,73	0	23,94	43,68
					283	283,58	0,58	0,73	0	28,31	42,66
					283,58	284,17	0,59	0,34	0	16,8	30,46
					284,17	284,75	0,58	0	0	0,84	5,04
					284,75	284,93	0,18	0,63	0	34,87	47,14
					284,93	291,44	6,51				
					291,44	293,4	1,96	0,97	2,12	38,49	38,64
					293,4	293,73	0,33				
					293,73	294,94	1,21	0,53	2,46	39,26	38,04
					294,94	295,67	0,73	0,97	0,5	17,46	27,44

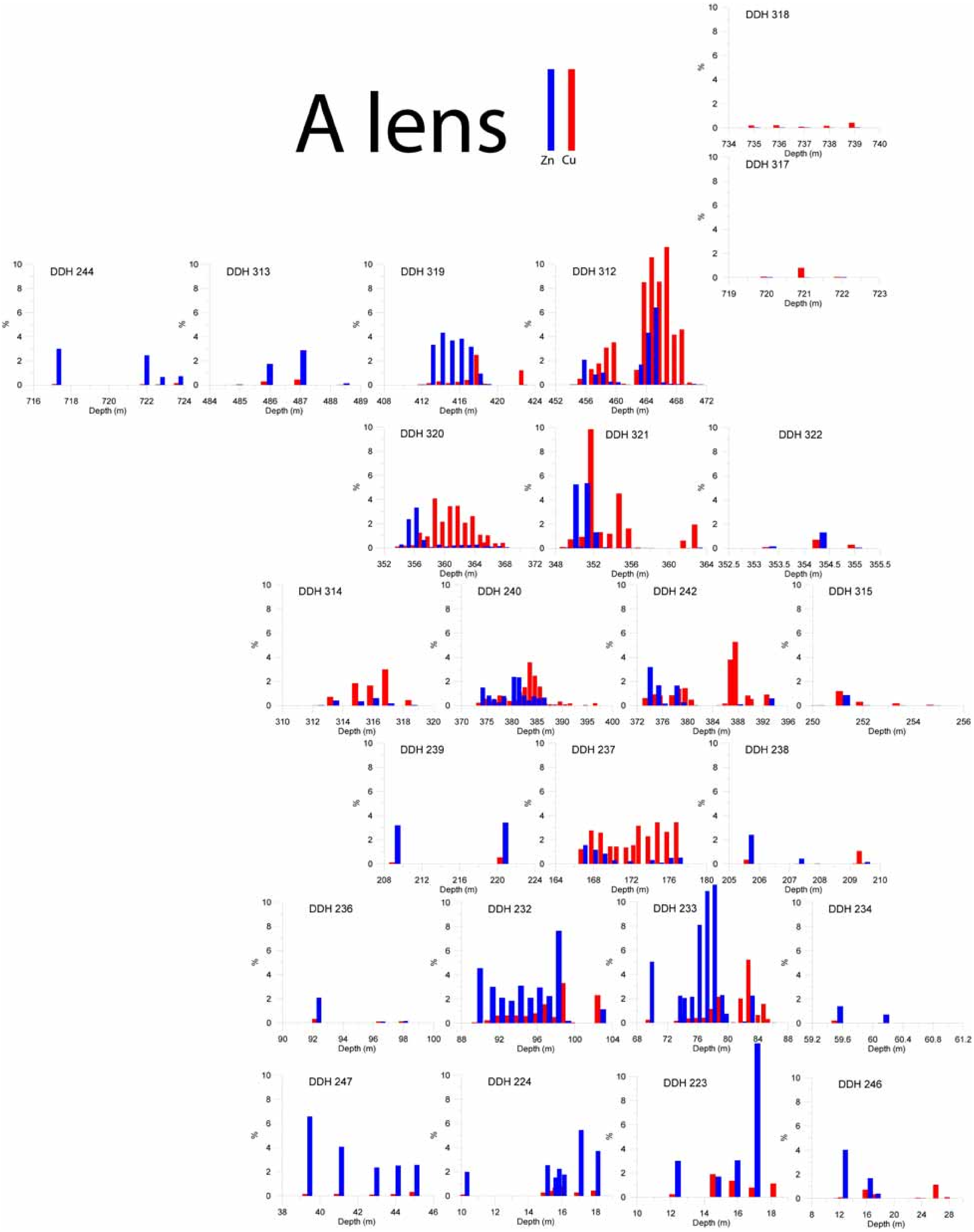
DDH	Coordinates	Direction	Dip	Length	Top	Bottom	Meters	Cu	Zn	S	Fe
245	2700N-697V	102	60	302,4	276,63	278,67	2,04	0,58	0,1	9,1	23,52
					278,67	281,59	2,92				
					281,59	281,85	0,26	1,02	0	5,8	17,36
					281,85	282,63	0,78				
					282,63	283,27	0,64	0,48	0	2,98	16,24
					283,27	284,81	1,54	2,6	0	24,02	41,44
					284,81	286,16	1,35	0,16	0	3,8	13,44
					286,16	287	0,84	0,9	0	7	19,37
					287	288	1	0,21	0	4,6	18,48
					288	292,6	4,6				
					292,6	293,69	1,09	0,37	0	3,45	16,24
					293,69	294,44	0,75	2,59	0	9,13	24,64
					294,44	295,79	1,35	0,08	0	6,5	12,42
311	2602N-775V	0	90	390	300	301	1	0,08	0,2	3,08	11
					301	302,77	1,77	0,1	0,8	7,9	15,5
					302,77	303,16	0,39	1,56	3,7	34,1	34,8
					303,16	304,16	1	0,03	0,03	1,6	9,6
					372,61	373,61	1	0,1	0,03	0,58	14,4
					373,61	375,1	1,49	2,59	0,07	26,2	45,4
					375,1	376	0,9	0,21	0,06	2,55	19,1
					376	377	1	0,34	0,02	1,71	16,4
					377	378	1	1,59	0,04	2,46	14,5
					378	379	1	0,58	0,03	3,17	16,5
310	2562N-725V	0	90	394,8	370	370,94	0,94	0,4	0,05	1,66	15
					370,94	372	1,06	1,05	0,03	13,6	29,8
					372	373	1	0,23	0,03	1,4	12,7
					373	374	1	1,43	0,05	9	25,7
					374	375	1	0,16	0,03	1,06	17
					375	376	1	0,29	0,02	3,32	20,4
					376	377	1	0,32	0,04	0,72	17,6
					377	378	1	2,2	0,13	7,9	25,9
					378	379	1	0,21	0,04	0,89	14,6
316B	2526N-703V	85	70	358,2	328	328,42	0,42	0,09	0,06	1,3	11,3
					328,42	329,83	1,41	1,91	0,06	32,2	49,2
					329,83	331,07	1,24	0,07	0,05	1,3	13,8
					331,07	332,63	1,56	1,7	0,08	28	43
					332,63	333,5	0,87	0,09	0,1	0,8	14,7
					333,5	335,5	2	1,9	0,11	33,4	16,3
					335,5	338,22	2,72	2,54	0,27	36,2	46,5
					338,22	339,22	1	0,39	0,11	5	19,9

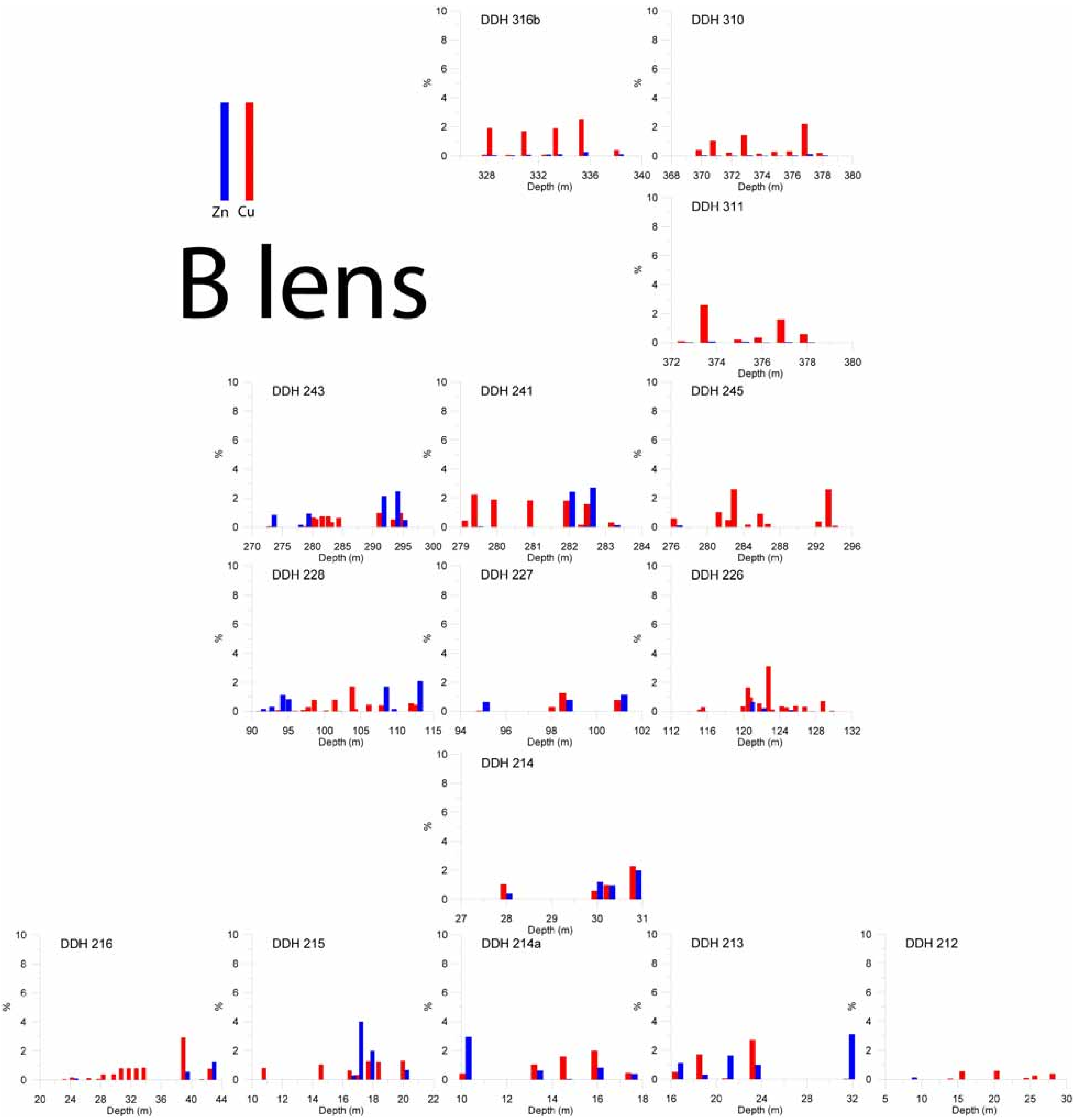
Table A3: Analytical data on drill hole intersections of the C lens

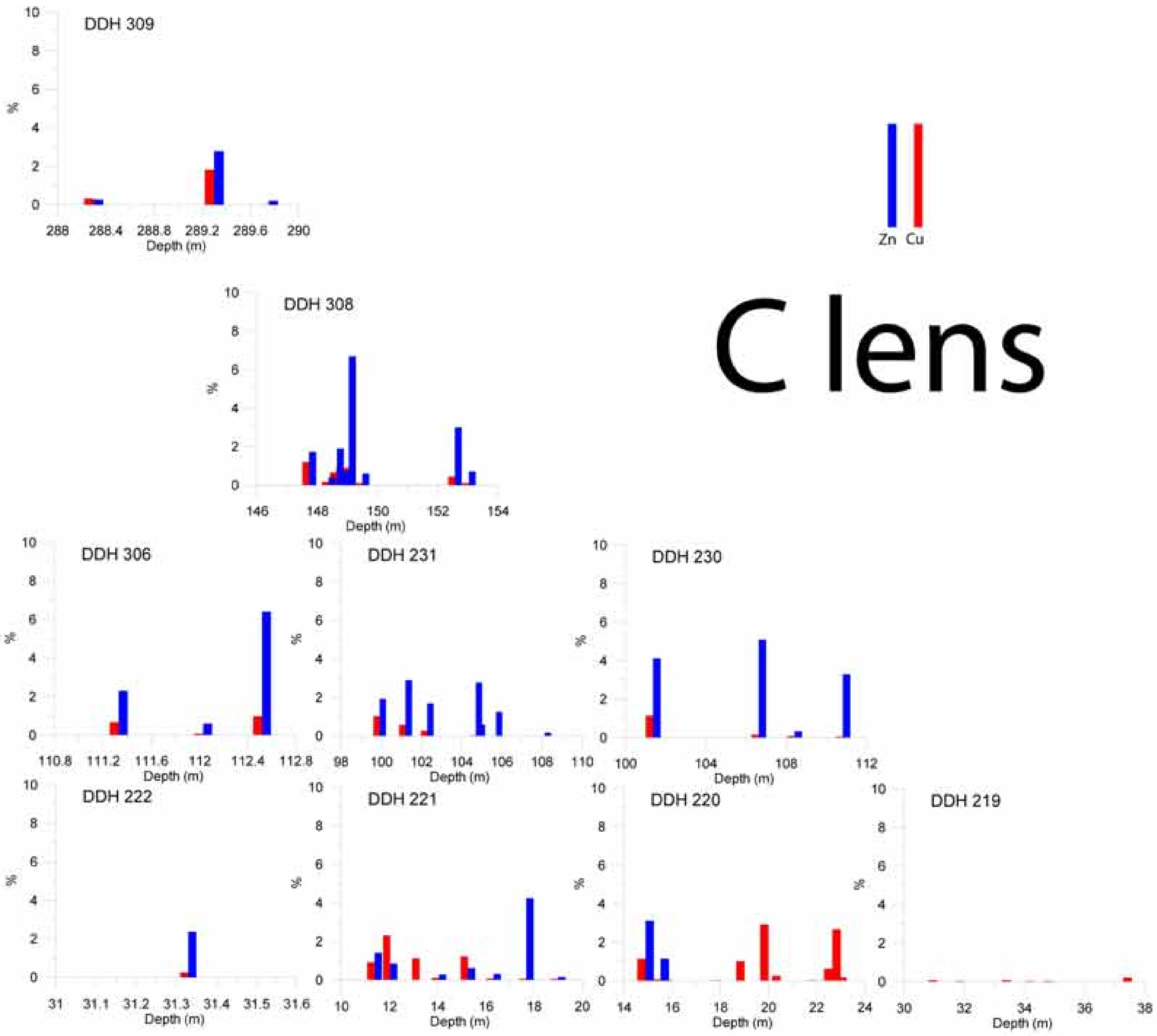
DDH	Coordinates	Direction	Dip	Length	Top	Bottom	Meters	Cu	Zn	S	Fe
219	2534N-392V	110	30	40	31,1	32	0,9	0,06	0	4,81	11,11
					32	33,54	1,54	0,02	0	3,25	11
					33,54	34,34	0,8	0,06	0	6,45	15,95
					34,34	34,92	0,58	0,02	0	4,52	14,08
					34,92	35,53	0,61	0,03	0	2,48	9,35
					35,53	37,56	2,03				
					37,56	37,88	0,32	0,21	0	6,59	12,98
220	2485N-397V	110	30	28,8	14,9	15,52	0,62	1,14	3,11	32,59	41,36
					15,52	16	0,48	0,06	1,15	10,25	13,2
					16	17	1	0,03	0	4,95	2,1
					17	18	1	0	0	5,38	8,35
					18	19	1	0,02	0	2,83	8,46
					19	20	1	1,01	0	19,59	28,82
					20	20,49	0,49	2,92	0	10,57	20,79
					20,49	22	1,51	0,26	0	2,43	8,36
					22	22,65	0,65	0,02	0	2,54	7,25
					22,65	23	0,35	0,63	0	4,92	13,31
					23	23,23	0,23	2,68	0	27,57	37,18
					23,23	23,64	0,41	0,17	0	2,29	11,55
221	2434N-405V	110	30	27,9	11,38	11,91	0,53	0,91	1,4	38,77	35,07
					11,91	12,03	0,12				
					12,03	13,24	1,21	2,31	0,84	32,84	38,61
					13,24	14,05	0,81	1,12	0	6,59	19,46
					14,05	15,25	1,2	0,1	0,28	1,59	10,44
					15,25	16,32	1,07	1,22	0,62	27,29	34,64
					16,32	17,67	1,35	0,07	0,31	6,91	12,65
					17,67	19	1,33	0,05	4,24	38,22	33,88
					19	19,22	0,22	0,05	0,16	4,35	9,8
222	2384N-402V	110	30	52,6	31,33	32,13	0,8	0,25	2,36	26,67	25,52
230	2450N-525V	102	60	180,75	101,38	102,08	0,7	1,13	4,12	28,39	34,1
					102,08	106,64	4,56				
					106,64	107,67	1,03	0,14	5,09	21,36	26,13
					107,67	108,43	0,76	0	0	12,9	14,58
					108,43	109,23	0,8	0,07	0,33	9	11,01
					109,23	110,83	1,6				
					110,83	111,13	0,3	0,05	3,29	14,88	18,03
231	2400N-520V	102	60	114,5	71	71,29	0,29	0,11	1,6	9,21	13,7
					99,92	100,92	1	1,02	1,92	38,44	34,77
					100,92	101,21	0,29				
					101,21	102,29	1,08	0,57	2,89	39,7	35,64
					102,29	103	0,71	0,27	1,7	16,37	19,44
					103	104,71	1,71				
					104,71	104,85	0,14	0,02	2,77	32,95	31,78
					104,85	105,71	0,86	0	0,58	10,35	15,87
					105,71	106,61	0,9	0	1,25	5,18	8,34
					106,61	108,14	1,53				
					108,14	110	1,86	0	0,17	9,22	11,88
306	2350N-483V	76	85	150	111,33	112,03	0,7	0,67	2,3	33,01	30,28
					112,03	112,52	0,49	0,07	0,6	4,86	9,13
					112,52	113,03	0,51	0,97	6,4	32,71	28,52
308	2375N-565V	85	85	210,15	130	131	1	0,03	0,32	1,89	7,27
					147,73	148,38	0,65	1,2	1,72	28,45	42,66
					148,38	148,65	0,27	0,16	0,4	4,17	12,06
					148,65	148,85	0,2	0,65	1,9	32,02	40,7
					148,85	149,05	0,2	0,95	0,7	25,73	30,48
					149,05	149,5	0,45	0,9	6,7	41,01	35,02
					149,5	149,85	0,35	0,1	0,6	18,04	20,03
					149,85	152,57	2,72				
					152,57	153,03	0,46	0,44	3	30,95	34,12
					153,03	154	0,97	0,1	0,7	11,61	20,87
309	2332N-697V	0	90	303,7	288,3	289,3	1	0,32	0,26	5,6	11,9
					289,3	289,75	0,45	1,82	2,78	36,9	40,7
					289,75	290,75	1	0,01	0,2	3,2	8,5

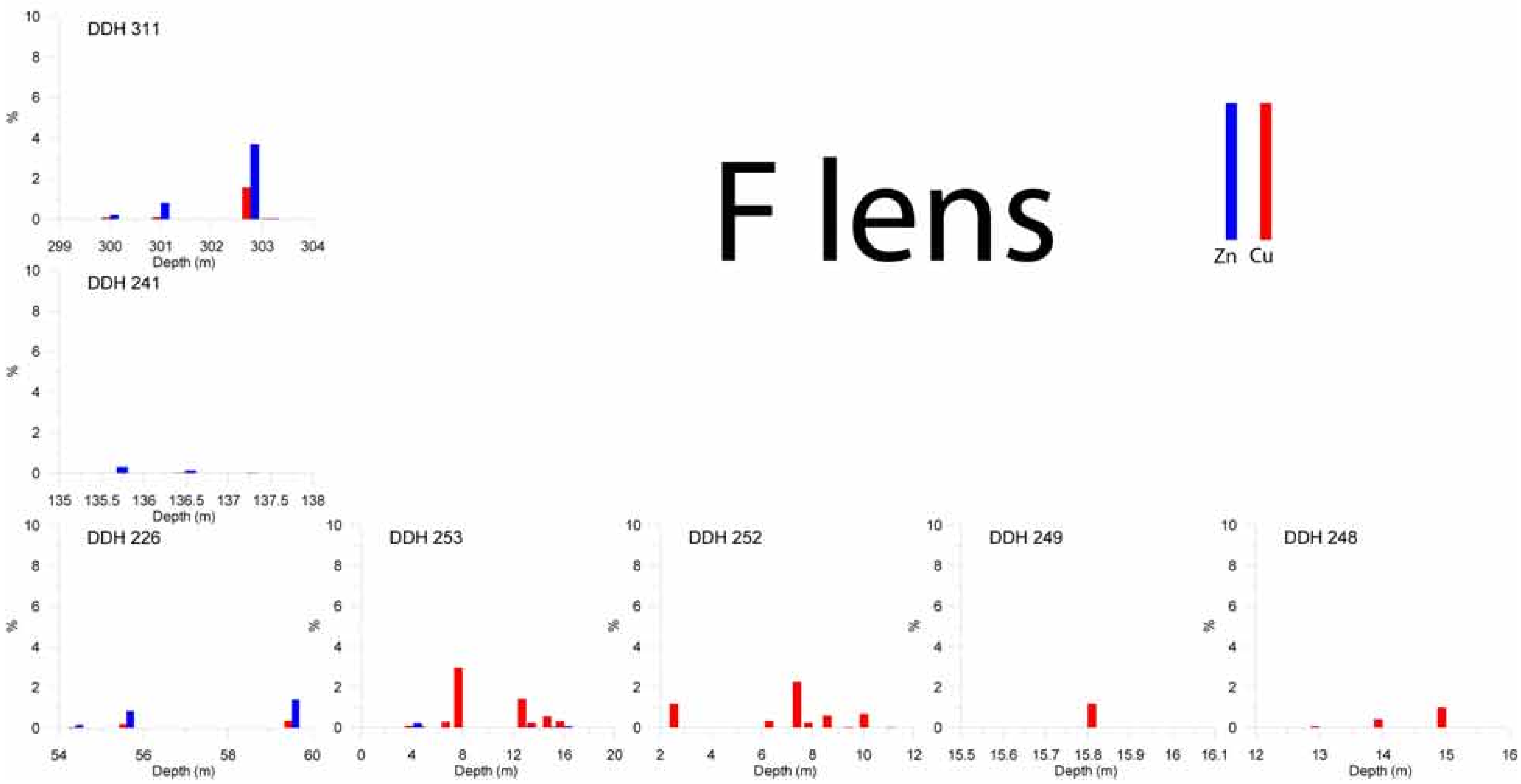
Table A4: Analytical data on drill hole intersections of the D,E,F lenses

DDH	Coordinates	Direction	Dip	Length	Top	Bottom	Meters	Cu	Zn	S	Fe	Ore lens
304	2323N-370V	99	50	31,9	0	32	32					D
305	2368N-366V	99	50	31,1	0	24,75	24,75					D
					24,75	25,35	0,6	3,05	0,5	11,12	20,92	
					25,35	31,1	5,75					
222	2384N-402V	110	30	52,6	51,56	52,64	1,08	0,31	0,22	3,48	14,19	D
230	2450N-525V	102	60	180,75	141,73	144,41	2,68	0,01	0,31	4,24	6,58	D
301	1448N-360V	99	50	25	0	15	15					E
					15	15,8	0,8	0,11	0,27	3,51	7,04	
					15,8	16,4	0,6					
					16,4	16,64	0,24	3	0,5	36,12	34,3	
					16,64	25	8,36					
302	1525N-325V	99	50	26,4	0	24,15	24,15					E
					24,15	25	0,85	0,15	0,61	5,27	10,36	
					25	26,4	1,4					
303	1660N-280V	99	50	22,4	0	22,4	22,4					E
248	2900N-515V	102	60	27,95	13	14	1	0,07	0	5,93	11,87	F
					14	15	1	0,42	0	8,85	19,82	
					15	15,61	0,61	1	0	12,17	26,43	
249	2875N-515V	102	60	30,1	0	15,82	15,82					F
					15,82	16,76	0,94	1,19	0	11,03	25,98	
					16,76	30,1	13,34					
250	2850N-520V	102	60	25,5	0	25,5	25,5					F
251	2825N-520V	102	60	27,9	0	27,9	27,9					F
252	2800N-515V	102	60	32,3	0	2,7	2,7					F
					2,7	2,92	0,22	1,18	0	10,48	18,48	
					2,92	6,45	3,53					
					6,45	7,55	1,1	0,32	0	4,83	10,64	
					7,55	8	0,45	2,27	0	10,29	24,08	
					8	8,75	0,75	0,25	0	3,44	16,8	
					8,75	9,6	0,85	0,6	0	6,59	22,95	
					9,6	10,19	0,59	0,03	0	1,56	16,51	
					10,19	11,23	1,04	0,68	0	5,59	14,65	
					11,23	12	0,77	0,02	0	8,17	10,08	
					12	32,3	20,3					
253	2775N-520V	102	60	26,1	0	4,1	4,1					F
					4,1	5	0,9	0,1	0,24			
					5	6	1	0,08	0			
					6	7	1	0	0			
					7	8	1	0,29	0			
					8	8,22	0,22	2,95	0			
					8,22	13	4,78					
					13	13,77	0,77	1,42	0,04			
					13,77	15	1,23	0,25	0			
					15	16	1	0,55	0,04			
					16	16,54	0,54	0,32	0,08			
					16,54	26,1	9,56					
226	2750N-483V	100	60	133,9	54,4	55,6	1,2	0,03	0,16	6,67	9,32	F
					55,6	56,14	0,54	0,2	0,84	11,98	16,43	
					56,14	59,51	3,37					
					59,51	59,78	0,27	0,35	1,4	14,21	16,87	
241	2650N-700V	102	58	300,9	135,68	136,12	0,44	0	0,3	14,88	17,6	F?
					136,12	136,49	0,37	0	0	3,66	6,16	
					136,49	137,35	0,86	0,02	0,14	35,56	34,16	
					137,35	138,07	0,72	0,02	0	9,61	15,22	
311	2602N-775V	0	90	390	300	301	1	0,08	0,2	3,08	11	F
					301	302,77	1,77	0,1	0,8	7,9	15,5	
					302,77	303,16	0,39	1,56	3,7	34,1	34,8	
					303,16	304,16	1	0,03	0,03	1,6	9,6	


A lens
Zn Cu
DDH 318
DDH 317
DDH 244
DDH 313
DDH 319
DDH 312
DDH 320
DDH 321
DDH 322
DDH 314
DDH 240
DDH 242
DDH 315
DDH 239
DDH 237
DDH 238
DDH 236
DDH 232
DDH 233
DDH 234
DDH 247
DDH 224
DDH 223
DDH 246
%
Depth (m)


Zn Cu
B lens
DDH 316b
DDH 310
DDH 311
DDH 243
DDH 241
DDH 245
DDH 228
DDH 227
DDH 226
DDH 214
DDH 216
DDH 215
DDH 214a
DDH 213
DDH 212
%
Depth (m)


DDH 309
DDH 308
DDH 306
DDH 231
DDH 230
DDH 222
DDH 221
DDH 220
DDH 219
Depth (m)
%
Zn Cu
C lens


DDH 311
DDH 241
DDH 226
DDH 253
DDH 252
DDH 249
DDH 248
Depth (m)
%
F lens
Zn Cu