SVERIGES GEOLOGISKA UNDERSÖKNING

SER. C. Avhandlingar och uppsatser. N:o 499.

ÅRSBOK 42 (1948) N:o 8.

ON THE OCCURRENCE OF MERCURY IN BOLIDEN AND IN SOME OTHER SULPHIDE DEPOSITS IN NORTHERN SWEDEN

BY

ERLAND GRIP

Pris 1.00 krona

STOCKHOLM 1948
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Preface.

In 1940, after mercury had been discovered in ore from the Boliden deposit, the author was commissioned to make an investigation of the occurrence of this metal in the Boliden mine. The investigation was subsequently extended to comprise some 20 of the larger sulphide ores in northern Sweden. — I wish to express my gratitude to the Director of the Boliden Mining Company, Mr. E. Bengtson, for kind permission to publish the results in this paper.

For the survey of the mode of occurrence of the mercury in Boliden I selected the predominant ore minerals and ore types in the mine and those minerals which might be expected to show an especially high content of mercury. From other deposits I have taken one or several representative samples of the ore or the ore types. In addition some concentrates from the ores have been investigated. The analyses have all been carried out in Stockholm at the research laboratory of the Boliden Mining Company. A new, improved method has been used, also permitting the determination of very small amounts of mercury. At percentages between 0.0002 % and 0.05 % Hg the maximum error of the determinations is calculated to be ± 25 % of the value. At percentages over 0.05 % Hg the error is not expected to reach ± 15 % of the given value. The mercury analyses have been carried out by Miss Thelma Berggren, Miss Anna-Greta Hybbinette, Mrs. Anna-Lisa Vennberg and Mr. C. Herlin. The other analyses have in some cases been made by other analysts.

The Boliden Deposit.

In his study of the Boliden deposit Ödman (9) did not find any mercury mineral. He gives, however, an analysis of tetrahedrite with 0.06 % Hg (No. 5 in Table 1). In several of his analyses of ore minerals there also occur »traces» of Hg.

During my investigation of the mercury contents noteworthy percentages were found in several minerals and ore types, and thanks to more accurate analytical methods those percentages, earlier stated as »traces», could be given numerical values. The results of the chemical investigation of material from the Boliden deposit are shown in Table 1.

The largest percentage of mercury has been found in native gold from stope No. 12 on the 210 m level. It had a content of 3.5 % Hg calculated on gold. Two analyses of native gold from stope No. 26 on the 210 m level showed 0.8 % and 0.7 % Hg, and the average of the three analyses is 1.7 % Hg, calculated on gold (Table 1, Nos. 10—12).

The highest percentage of mercury in the other minerals is 0.06 %, which occurs in two analyses of selenokobellite and in one of tetrahedrite. Another analysis of selenokobellite gives, however, 0.001 % Hg and one of tetrahedrite 0.01 % Hg, indicating that the mercury percentage evidently varies quite considerably also in one and the same mineral.

A large percentage of mercury has also been found in sphalerite, one analysis (No. 28) giving the value 0.05 %. Also in this mineral the Hg-percentage must vary greatly, as another analysis (No. 29) gave only 0.0025 % Hg and analyses Nos. 30—33 show values between these two. The end product of zinc concentrate from Boliden ore, obtained in flotation experiments, contains 0.11 % Hg.

Among the other minerals and ore types analysed it is only a pyrite ore rich

Table 1.

Percentage of mercury in minerals and ores of the Boliden mine.

No.	Level	Mineral or ore	Stage of mineralization	Hg %	Zn %	Zn : Hg
1	20 m	Selenokobellite	2	0.06		
2	210	»	2	0.06		
3	210	»	2	0.001		
4		Tetrahedrite	1?	0.01		
5	50	»	1?	0.06		
6	210	Bi-tellurides	2	0.0005		
7	90	Falkmanite + galena	1?	0.002		
8	210	Sulphominerals in the S wall of apatite-banded FeS_2	1?	0.003		
9	210	Rutile-cobaltite with gold	1	0.0007		
10	210	Gold from a quartz vein. % in Au	2	3.5		
11	210	Gold in quartz. % in Au (21.15 % Ag, 67.11 % Au, 1.2 % Hg)	2	0.8		
12	250	Gold in schist. % in Au (23.93 % Ag, 68.95 % Au, 1.0 % Hg)	2	0.7		
13	50	As ore with $CuFeS_2$	1	0.001	0.15	150
14	170	» » » »	1	0.0002		
15	189	» » » »	1	0.0005	< 0.01	
16	232	» » » »	1	0.0004	< 0.01	
17	250	» » » »	1	0.0004		
18	20	FeS ore	3	0.0022	2.0	910
19	90	» »	3?	0.0012	2.2	1 833
20	187	» »	2—3?	0.0003	0.02	67
21	210	» » apatite-banded	1	0.0013		
22	50	FeS_2 ore	2—3	0.008	2.35	294
23	90	» » with sulphominerals	2—3	0.01	0.42	42
24	97	» »	3	0.004	1.08	270
25	102	» »	3	0.0015	0.26	173
26	105	» »	3	0.0008	1.09	1 362
27	210	» »	3	0.0004		
28	40	ZnS ore	3	0.05	31.5	630
29	130	ZnS	1?	0.0025	26.4	10 560
30	20	ZnS from FeS_2 ore	3	0.011	40.7	3 700
31	71	» » » »	3	0.008	29.2	3 650
32	84	» » » »	3	0.04	52.2	1 305
33	85	» » » »	3	0.006	16.0	2 667
34	84	PbS » » »	1 or 3	0.007	9.1	1 300
35	170	Quartz-tourmaline vein	2	0.0003		
36	177	»	2	0.0005		
37	210	»	2	0.0035		
38	250	»	2	0.0004		
39	210	Disseminated ore	1	0.0009		
40		Zn-conc. (end product)		0.11	52.8	480
41		» (intermed. product)		0.0900	33.3	370
42		» » »		0.0030	1.4	467
43		» (waste product)		0.0020	0.7	350

in sulpho-minerals that reaches 0.01 % Hg. The remaining ones all have considerably lower Hg percentages.

The Boliden ore was formed in three stages (9). In the first stage chiefly arsenopyrite was formed, in the second one ore minerals connected with quartz-tourmaline veins, and in the third stage pyrite ore. Table 1 shows that the percentage of mercury in the ore of the first stage is low. The pure arsenopyrite ore has only 0.0002—0.0005 % Hg. Minerals belonging to the second stage,

on the other hand, contain remarkable amounts of mercury. It is also to be expected that mercury will appear in a mineral association of this type. In the last or pyrite stage of ore formation the Hg percentage is higher than in the arsenopyrite ore but lower than in the quartz-tourmaline ore. In this third stage of mineralization sphalerite has the highest Hg percentages. Quantitatively, most of the mercury of the Boliden deposit is contained in the pyrite ore.

Mercury may enter into the crystal lattice in some of the minerals in Boliden. The quantitatively most important of these is sphalerite, and further we note gold and a few sulpho-minerals. The ratio Hg : Zn in the various samples is not at all constant, and we have reason to suppose that to a large extent the mercury also occurs as cinnabar or possibly in metallic form. It is noteworthy that during the flotation process mercury so constantly accompanies sphalerite (Table 1, Nos. 40—43). If Hg does not enter into the sphalerite lattice, it must occur in small cracks and fissures in this mineral and in spite of milling accompany it during the flotation process. The flotation properties of the mercury minerals are not expected to be the same as those of sphalerite.

Stock and Cucuel have made a study of the distribution of mercury, using new and improved methods of analysis (7). They showed that mercury occurs in determinable amounts everywhere in Nature, in igneous and in sedimentary rocks, in sediments and soils, in fossil coal and in wood, in plants and animals. The order of magnitude of the mercury content is 10^{-6} %. Sedimentary rocks have, however, a considerably higher percentage of mercury than igneous rocks.

Table 2.

The degree of enrichment of the principal elements in the Boliden ore. (The content in the ore compared with the average in the earth's crust. 6.)

Order of magnitude	Element
10^{-1}	Sr, Ba, Mn
1	F, P, Ni, Fe
10	B, Zn, Pb, Co
10^{2}	Cu, Hg, S
10^{3}	Ag, Se, Au, Sb, Te
10^{4}	As, Bi

Table 2 shows the degree of enrichment of mercury in the Boliden deposit compared with the average of the earth's crust and with other elements. The mercury shows a moderately high degree of enrichment, comparable with that of copper and sulphur.

On account of the very dispersed occurrence of the mercury in the ore, it is quite impossible to mine separately a certain ore type with an especially high mercury content. The average percentage in the Boliden ore is calculated to be about 0.001 % Hg.

Other Sulphide Ores in Northern Sweden.

18 other sulphide ores in N. Sweden have been tested on mercury. 14 of these are situated in the Skellefte District, 1 in the Archaean of Norrbotten,

Table 3.

Analyses of ores from sulphide deposits in N. Sweden

No.	Deposit	Level	Ore type	Hg %	Cd %	Zn %	S %	% Sulphides in the ore	% Hg in the sulphide	Zn : Hg
1	Lainijaure	32 m	Ni-FeS- ore	< 0.0003	< 0.05	< 0.01	32	88	< 0.0003	
2	»	» »	Ni-As- »	< 0.0003	< 0.05	< 0.01	15	61	< 0.0005	
3	Laisvall	100 »	Pb- »	< 0.0003				5	0.0009	
4	Bellviksberg	Dh[1]	Pb- »	0.0002		0.03	2	10	0.0020	
5	Liikavaara	Dh	S-Cu- »	0.0002		< 0.1	2	5	0.0040	
6	Långdal	Dh	Au- »	0.0001		1.25	5	15	0.0007	12 500
7	»	Dh	S-Zn- »	0.0005	0.01	12.81	28	55	0.0009	25 620
8	Svansele	Dh	S- »	0.0003		0.50	38	ca 86	0.0003	1 666
9	Kristineberg A	170 »	S-Cu- »	0.0003	< 0.05	0.49	47	91	0.0003	1 633
10	» »	» »	S-Cu- »	0.0004		< 0.03	29	56	0.0007	
11	» »	130 »	S-Cu- »	0.0006		< 0.03	38	75	0.0008	
12	» B	170 »	S- »	0.0004	< 0.05	< 0.02	36	67	0.0006	
13	» »	» »	S-Cu- »	0.0006		< 0.03	23	49	0.0012	
14	Åkulla W	130 »	S- »	0.0006		< 0.01	46	87	0.0007	
15	Mensträsk	Dh	S-Cu-Zn- »	0.0010	0.001	5.29	38	80	0.0013	5 290
16	Elvaberget	Dh	S-Cu-Zn- »	0.0011		1.84	34	67	0.0014	1 673
17	Renström	50 »	S-Zn-Cu- »	0.0014	0.03	12.50	27	77	0.0018	8 929
18	Kedträsk	Dh	S-Zn- »	0.0015	0.001	2.60	42	82	0.0018	1 733
19	Åsen WM	Dh	S-Cu-Zn- »	0.0017		2.28	26	ca 53	ca 0.0032	1 340
20	Kristineberg A	170 »	S-Zn- »	0.001				80	ca 0.0013	
21	» »	» »	S-Zn-Cu- »	0.0017	< 0.02	9.39	41	87	0.0020	5 524
22	» »	—	S-Zn- »	0.0020				ca 80	ca 0.0025	
23	» »	170 »	S-Zn-Cu- »	0.0021	< 0.05	12.20	35	75	0.0031	5 811
24	Åkulla E	130 »	S-Cu- »	0.0025		0.15	40	78	0.0032	60
25	Rakkejaur	240 »	S- »	0.004		1.07	39	75	0.0053	268
26	»	240 »	Cu- »	0.004		0.26	23	52	0.0077	65
27	Långsele	Dh	S-Zn- »	0.0080	0.001	4.80	38	76	0.0105	600

[1] Diamond drill hole.

1 in the Arvidsjaur District, and 2 on the eastern border of the Caledonides. (As regards the situation of the deposits in the Skellefte and Arvidsjaur Districts and for short descriptions of them, see 3, 5.) Table 3 shows the contents of Hg, Zn, Cd and S in representative samples from these deposits or in ore types occurring in them.

In Table 3 the ores are ranged approximately as the percentages of mercury increase, and it is possible to distinguish several groups. A with < 0.0003 % Hg, B with 0.0003—0.0006 % Hg, C with 0.0010—0.0025 % Hg, and D with 0.0040—0.0080 % Hg.

A. Ores with less than 0.0003 % Hg.

To the ores with the lowest mercury contents in the Skellefte District belongs the Lainijaure nickel-pyrrhotite ore, which is genetically connected with a gabbro body intruded in sedimentary rocks. In the same deposit there occurs a second stage of mineralization with a very complex ore type, forming veins with arsenic-nickel minerals, to which the surrounding sediments seem to have supplied sulphur, arsenic, etc. In both types the percentage of mercury is < 0.0003 %, and in relation to the total sulphide content in the ore the mercury percentage is also extremely low (< 0.0005 %).

To the same group belong the disseminated ores in sandstones and nappe quartzites in the border zone of the Caledonides. Two of these ores have been investigated, Laisvall 35 km WNW of Arjeplog in the Province of Norrbotten, and Bellviksberg, 25 km NNW of Hoting in the Province of Västernorrland. At Laisvall the ore occurs in Eo-Cambrian sandstone and it seems to have been formed at a low temperature during tectonic movements. The Bellviksberg deposit is situated in a nappe of »Ströms quartzite», but on the whole it seems to have been formed in the same manner as the Laisvall ore. At Laisvall poor lead ore with 3.8 % Pb contains 0.0003 % Hg, while lead concentrate with about 80 % Pb from the same mine holds 0.0008 % Hg. The lead ore in Bellviksberg contains 0.0002 % Hg. In relation to the total sulphide content the Laisvall ore is calculated to contain 0.0009 %, and Bellviksberg 0.0020 % Hg. In this respect they are comparable with the ores of the Skellefte District in groups B—C.

The copper ore of Liikavaara, 15 km SE of Gällivare, contains 0.0002 % Hg. It consists of chalcopyrite and pyrite disseminations in gneisseous supracrustal rocks and was formed in connection with migmatization and intrusion of the »Lina granite». Its age is probably Karelian. The mercury percentage in relation to the total sulphide content of the ore is 0.0040 % and comparable with the ores of the Skellefte District rich in mercury.

In the copper ore of the Laver mine mercury has not been determined, and an analysis of a copper concentrate in which mercury ought to occur in a higher percentage than in the ore, gave only 0.0001 % Hg. The mineralization at Laver forms ore veins and breccia ores in rhyolitic rocks belonging to the Arvidsjaur porphyries. It is described by Ödman (10) as a hypothermal deposit.

The ore was formed during the Karelian orogenesis (4). In the mine has been found a complex vein which is a few cm thick and rich in native silver and which, contrary to the copper ore, contains relatively high amounts of mercury (11). An analysis of a picked sample of the silver shows the following values (Analyst Miss Thelma Berggren):

Ag	94.27 %
Cu	0.01
Hg	0.05
S	0.10

The silver thus has a remarkable content of mercury, but it does not reach the same magnitude as in the gold in Boliden.

The Adak deposit in the NW part of the Skellefte District is of the same type as Laver and is composed of a copper breccia ore. Copper concentrate (ca 25 % Cu) from Adak contains 0.0012 % Hg. The mercury has probably not been enriched in the same degree as the copper, as some pyrrhotite goes in the waste and the mercury no doubt follows both sulphides. The ore must, however, contain a considerably lower mercury percentage than the copper concentrate and it probably belongs to the group with the lowest Hg percentages or possibly to the following group.

B. Ores with a content of 0.0003—0.0006 % Hg.

To this group belong several of the pyrite-chalcopyrite ores of the Skellefte District, such as Svansele, the pyrite ores of W Åkulla, and the ores of the pyrite-chalcopyrite mineralization stage in Kristineberg. The copper concentrate from Kristineberg contains only 0.0004 % Hg, *i. e.* not more than the ore itself, which indicates that mercury does not accompany the chalcopyrite. In relation to the total sulphide percentage the mercury content is 0.0003—0.0012 %. — The wall rocks of these ores are altered to sericite-chlorite schists.

Contrary to the other zinc ores of the Skellefte District, the pyrite-sphalerite ore of Långdal has a very low mercury content, 0.0005 %. This ore also differs from the other ones by the strong alteration of its wall rocks. The presence of amphibole, biotite, and clinozoisite here indicates a higher temperature of formation than in the other deposits, where the dominating alteration minerals are sericite and chlorite. The temperature of formation of the ore seems to have been too high for mercury enrichment. In Långdal there also occurs weakly mineralized wall rock with gold values. Here the mercury content is only 0.0001 %, but in relation to the total sulphide content it is 0.0007 % Hg.

C. Ores with a content of 0.0010—0.0025 % Hg.

The ores most typical for the Skellefte District belong to this group. They have a high sulphide percentage and consist of pyrite as predominant ore mineral and sphalerite, chalcopyrite, and varying but generally small amounts of other ore minerals. The alteration minerals in the wall rocks are chiefly

sericite and chlorite. The Mensträsk ore has 0.0010 % Hg and that of Elvaberget 0.0011 %. The Renström deposit is composed of a fine-grained complex ore with very weakly altered wall rocks. Besides pyrite, which is the main ore mineral, there is plenty of sphalerite, some chalcopyrite, pyrrhotite, galena, etc., and values of gold and silver. The mercury content is 0.0014 %. By flotation of the Renström ore there have been produced Cu-, Zn-, and Pb-concentrates, which have been analysed (Table 4). The result was that the Cu-concentrate had the highest mercury percentage, 0.0038 %, while the Zn-concentrate had 0.0026 %, and the Pb-concentrate 0.0015 % Hg. As free gold and silver enter into the Cu-concentrate, its high mercury percentage is certainly due to the amalgamation of mercury with these metals. An increase of the mercury content in the zinc concentrate to almost the double value compared with the ore, indicates that mercury also accompanies sphalerite.

The ores of Kedträsk and Åsen consist of coarse-grained pyrite with sphalerite and chalcopyrite. They are accompanied by a strong sericitisation. The mercury percentages are 0.0015 % and 0.0017 %, respectively.

Table 4.

Sulphide concentrates from deposits in N. Sweden.

No.	Deposit	Product	Hg %	Zn %	Cd %	S %	Zn : Hg
1	Laisvall	Pb concentrate	0.0008				
2	Laver	Cu »	< 0.0001				
3	Adak	Cu »	0.0012				
4	Kristineberg	Cu »	0.0004				
5	»	Zn »	0.0014				
6	»	» »	0.0016				
7	Renström	Pb »	0.0015	12.9		20.1	8 600
8	»	Zn »	0.0026	51.8	0.16	33.8	19 923
9	»	Cu »	0.0038	5.83	0.01	34.6	1 535
10	Rävliden	Cu »	0.0025				
11	»	Zn »	0.007				
12	»	» »	0.008				
13	»	» »	0.015	47.88	0.12	32.83	3 192
14	»	» »	0.015				
15	Boliden	Zn » (end prod.)	0.11	52.8	0.07		480
16	»	» » (intermed. »)	0.09	33.3			370
17	»	» » (» »)	0.003	1.4			467
18	»	» » (waste »)	0.002	0.7			350
19	Långsele	» »	0.18	44.3			246

At Kristineberg the formation of zinc ore constitutes a second stage of mineralization. Pyrite, however, is the predominant mineral. The sphalerite is exceptionally light-coloured and poor in iron. The percentage of mercury, 0.0010—0.0025 %, is considerably higher than in the pyrite-chalcopyrite ore of the first mineralization stage, where it is 0.0003—0.0006 %. It is remarkable that the Kristineberg zinc concentrate contains only 0.0014—0.0016 % Hg (Table 4), *i. e.* less than the average of the four samples of zinc ore analysed. In this case it is thus evident that in the flotation mercury does not accompany the sphalerite as faithfully as in Boliden.

In the Åkulla E ore body a copper-bearing pyrite ore with low percentage of zinc contains 0.0025 % Hg, which is a remarkably high value in such an

ore type, especially as the W ore, situated 500 m W of the eastern one, has only 0.0006 % Hg. An explanation is, however, that the mineralization is zoned in relation to a massif of Revsund granite lying some distance further to the W.

D. Ores with a content of 0.0040—0.0080 % Hg.

The Rakkejaur deposit consists of fine-grained pyrite with sphalerite and some arsenopyrite, etc. The pyrite ore encloses two copper-ore bodies, the chalcopyrite brecciating and partly replacing the pyrite-zinc ore. The wall rock is altered to sericite schist. In both ore types the mercury percentage is 0.004 %. The copper ore, which is poor in zinc, contains 0.4 % Sb, and the mercury may be associated with tetrahedrite occurring in the ore.

The Långsele deposit, 4 km W of Boliden, is a pyrite-zinc ore with some copper and surrounded by slightly altered wall rocks. Its mercury content is 0.0080 % and the highest one found outside the Boliden deposit. A zinc concentrate of ore from Långsele contains 0.18 % Hg (Table 4 No. 19). In relation to zinc the mercury percentage is higher in the sample of concentrate than in the ore sample. That may, however, be due to the fact that the analysis of the concentrate only represents a part of the ore, while analysis No. 7 in Table 3 was made on a general sample, and inhomogeneities may naturally occur in the ore body.

This zinc concentrate from Långsele is the one richest in mercury among the ores of the Skellefte District, and in order to find out if it contains metallic mercury an experiment was made to amalgamate a possible mercury content with a gold sheet. The investigation was carried out by Miss Anna-Greta Hybbinette in the following manner: A sample was rubbed vigorously against a gold sheet. $<$ 0.005 % Hg was found in the sheet. The sample was then heated in a drying-stove at 105° C for 30 hours and was analysed as usual. The rest proved to contain 0.22 % Hg (one test). As mentioned above, earlier analyses of the sample had given 0.18 % Hg (average of 3 determinations with 0.15, 0.19, and 0.20 %, resp.) and it is evident that nothing had volatilized during the heating. — Thus, metallic mercury has not been proved in the zinc concentrate, and it is probable that it is combined with sulphide.

When studying the distribution of elements in sphalerites from Swedish deposits by spectrochemical analysis, O. Gabrielson found mercury in sphalerites from four deposits in the Skellefte District (1). Noteworthy amounts were found in ores from Rävliden and Rävlidmyran, while small amounts were observed in ores from Boliden and Östra Högkulla. No quantitative analyses of mercury were carried out, however.

Four analyses of zinc concentrate from Rävliden ore are presented in Table 4. The percentages of mercury are remarkably high and 10 times as high as in the Kristineberg concentrate. The copper concentrate, too, has a considerably higher content of mercury than in Kristineberg. The ore from Rävliden has not been analysed on mercury, but the analyses of the concentrates indicate that it has a mercury content placing it in the highest group of the ores

described above. Judging from the spectrochemical analyses by Gabrielson, the ore from Rävlidmyran also belongs there.

The only mine in Sweden where mercury has been found earlier is the silver deposit of Sala (8). The mercury there occurs in metallic form, as silver-amalgam, and as cinnabar. Zinc ore from the Penning Mine at Sala has been found to contain at the least 0.01 % Hg.

In all the ores investigated (possibly with the exception of Nos. 1, 2 and 3 in Table 3, where no exact determinations were made), the mercury content is of the order of magnitude 10^{-4}—10^{-3} %, *i. e.* considerably higher than the normal amount in the earth's crust, which is of the order of magnitude 10^{-6} %. In relation to the total sulphide content the lowest mercury percentage occurs in nickel ore from Lainijaure and in disseminated chalcopyrite ore from Laver. Low percentages are also formed in most of the pyrite-chalcopyrite ores of the Skellefte District. The highest mercury values, 0.001—0.01 % Hg, are found in the zinc ores of this district. The disseminated ores of copper at Liikavaara and of lead at Bellviksberg also show comparatively high values.

Zinc is the element most constantly associated with mercury, but no exact proportion between the amounts of Hg and Zn exists in the Skellefte District (not even in one and the same ore). In consequence, mercury cannot exclusively enter into the crystal lattice of sphalerite but is likely to appear also in other minerals. As the presence of metallic mercury has not been proved even in concentrates with the highest zinc values, it is probable that it occurs as cinnabar.

Where metallic gold or silver occur, mercury is enriched in remarkable amounts compared with surrounding sulphide ore, and forms amalgam with the precious metals.

Table 5.

Proportions between Zn, Cd and Hg in some of the ores of the Skellefte District.

No.	Table	Deposit	Zn : Cd	Cd : Hg
7	3	Långdal	1 281	20
15	3	Mensträsk	5 290	1
17	3	Renström	417	21
8	4	» Zn-conc.	324	62
9	4	» Cu-conc.	583	3
18	3	Kedträsk	2 600	0.7
27	3	Långsele	4 800	0.1
13	4	Rävliden Zn-conc.	399	8
15	4	Boliden » »	480	0.6

Cadmium is a metal belonging to the same group as mercury and zinc and is therefore of interest from a geochemical point of view. Its relation to the other two metals in some of the ores of the Skellefte District is shown in Table 5. The magnitude of the proportion Zn : Hg varies within wide limits and Cd : Hg within still wider. No real regularity is demonstrated by the scanty material.

Boliden, January, 1948.

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