DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2003/52

PGE and sulphide phases of the precious metal mineralisation of the Skaergaard intrusion

Part 3: sample 90-18, 1010

T. F. D. Nielsen, H. Rasmussen, N. S. Rudashevsky,
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G E U S

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Contents

Contents 2

Abstract 3

Introduction 4

The Platinova Reef of the Skaergaard intrusion 4
The Pd5 level 5
Sample 90-18, 1010 5
The mineralogical report 6
Additional electron microprobe data 6
References 6

Mineralogical investigation 8

Introduction 8
The sample 8
Sample preparation and analytical techniques 8
Results 9
Rock forming minerals and sulphide mineralogy 9
Silicates and oxides 9
Sulphides 9
PGMs and Au-minerals: recovery, grain size and relations to host rock 11
Recovery 11
Grain size of PGMs and Au-minerals 11
Petrographic observations 12
Description and chemistry of PGMs and Au-minerals 12
Unnamed-PdCu 12
Vysotskite 14
Vasilite 15
Keithconnite 16
Au-minerals 18
Other PGMs 18
Bulk composition of sample 90-18 1010 19
Discussion 19
Systematics in the Pd5 level of the mineralisation 19
The PGM and Au-mineral paragenesis 21
Parageneses and order of crystallisation 21
Summary 22
References 22
Abbreviations 24
Rock-forming minerals 24
Sulphides 24
Precious metal minerals 24

Abstract

The Paleaogene Skaergaard intrusion, 68^{o}N, in East Greenland hosts a large tonnage, low-grade, precious metal mineralisation. The Pd5 level of the mineralisation contains more than 20 million ounces of palladium and minor platinum and gold. The Pd:Pt:Au ratio is ca. 88:7:5.The report presents the results of mineralogical investigations of sample 90-18 1010 (core 90-24 from 1057 to 1058 meters) from the most palladium-rich one-meter interval in the main Pd-level in the mineralisation.

The non-magnetic heavy mineral concentrates from sample 90-18 1010 (0.80 kg) were subjected to separation using the HS-01 Hydroseparator technology. From the concentrates enriched in platinum group and Au minerals were prepared polished thin section. The thin sections were investigated under the scanning electron microscope and the electron micro probe. The magnetic concentrates contain no precious metal grains, except for rare grains intergrown with Fe-Ti-oxides. The assay of the sample suggests a combined Pd-Pt-Au concentration of ca. 2.1 g/t.

The sample was found to contain 180 precious metal grains, including 173 grains of platinum group minerals (PGMs) and 7 grains of Au-minerals. The absolutely dominant PGM is “unnamed-PdCu” (63%) followed by vysotskite (24%) and minor vasilite (3%). The grain size of PGMs and Au-minerals varies between 1 and 53 μm with an average of 16 μm.

The HS-concentrates contain spherical sulphide grains identified as sulphide droplets. They are composed of one or more of the Cu-sulphides bornite (dominant), chalcopyrite, chalcosine and digenite. Minor pentlantdite, cobalt-pentlandite and possibly covellite have been observed. Some of the sulphide droplets contain grains or crystals of PGMs. The droplets occur mainly in relation to amoeboidal oxide-rich parts of the matrix and occasionally in the rims of liquidus phases.

Based on the petrographic observations the primary paragenesis consisted of sulphide droplets with grains of unnamed PdCu. Some of these grains appear to be immiscible metal melts inside the immiscible suphide droplets; others are very well develloped crystals. The observations suggest that immiscible Cu-Fe sulphide droplets formed as immiscible melt in iron-rich insterstitial melts, cooled and crystallised mainly bornite contemporaneously with the formation of immiscible Pd-Cu melts. The latter cooled to crystallise “unnamed PdCu” and other phases from the elements not hosted in “unnamed-PdCu”, e. g., Pd-arsenides. Re-equilibration during cooling may have resultet in redistribution of S and the formation of Pd-sulphides like vysotskite.

Introduction

The report describes the mineralogy of sample 90-18 1010 from the lower Pd5 palladium horizon in the ”Platinova Reef” of the Skaergaard intrusion. The report consists of an introduction to the mineralisation and the investigated sample and a mineralogical report. The mineralogical report has been prepared by N.S. Rudashevsky, Ju.L. Kretser and V.N. Rudashevsky on the request of the geological Survey of Denmark and Greenland. Electron microprobe data collected in 1993 by H. Rasmussen (Geological Survey of Denmark and Greenland and Department of Geology at University of Copenhagen) are included as an appendix.

The mineralogical report is based on concentrates of platinum group metal phases produced using the patented Hydroseparator HS-01. Mounts with concentrate have been studied using electron microscopy and electron microprobe. The report gives descriptions of the analytical techniques, the grain characteristics, the parageneses and the compositional variation within the identified groups of minerals, alloys and sulphide droplets.

T.F.D. Nielsen has edited the report.

The Platinova Reef of the Skaergaard intrusion

The Skaergaard intrusion precious metal mineralisation, often referred to as the “Platinova Reef”, is a gabbro-hosted, stratiform Au and PGE mineralisation in the macrorythmic Triple Group of the Skaergaard intrusion (Bird et al., 1991). The Triple Group forms the upper c. 100 meters of the Middle Zone in the Layered Series of the intrusion. The host rocks are well-preserved oxide-rich tholeiitic gabbros.

The mineralisation was located in 1987 by Platinova Resources Ltd. Exploration was conducted by Platinova Resources Ltd. and partners from 1986 to 1990. Exploration drilling was carried out in 1989 (DDH 89-01 to DDH 89-9b) and in 1990 (DDH 90-10 to DDH 90-27). Exploration results are summarised in Watts, Griffis and McOuat (1991).

The general structure of the Platinova reef mineralisation is described in Andersen et al. (1998) and in Nielsen (2001). Peak concentrations of Au and Pd are separated by less that 1 meter at the margin of the intrusion, but by >60 meters in the south, central, part of the intrusion.

The mineralisation consists of a series of levels enriched in Pd. The lower Pd5 level reaches across the intrusion. Pd-levels above have ever-decreasing lateral extend from a central axis in the south central part of the intrusion. Gabbros between the Pd-levels are not mineralised. The structure is best visualised as a series of bowl-shaped Pd-levels of decreasing size. Gold is concentrated at the edges of the bowls. Nielsen (2001) gives further descriptions.

The Pd5 level in the mineralisation is estimated to contain in excess of 300 million tons of gabbro with *c.* 2 g/t PGE over a width of 5 meters. The Pd5 mineralisation alone is suggested to contain > 20 million ounces of precious metals equivalent to >600 tons of palladium, >40 tons of platinum and >30 tons of gold (Nielsen, 2001).

The Pd5 level

The Pd5 level contains the main Pd mineralisation and is located within a macrorythmic layer located below L1 of the Triple Group. The leucogabbro layer in the megacycle below L1 is unofficially named L0.

The Pd variation across Pd5 is quite characteristic and paralleled in all investigated cores and chip lines from the intrusion. Relative changes in Pd/Pt can be correlated across the intrusion (see Nielsen, 2001).

The hanging wall 1 g/t cut-off of the mineralisation is located in the middle of L0 and the foot wall 1 g/t cut-off is located at the density peak below L0. In most cores the distance between foot wall and hanging wall is 5 meters (based on 1-meter average concentrations of Pd). The Pd variation over the 5-meter mineralisation interval is paralleled in all cores from a 19 km^2 area (Nielsen, 2001). The Pd concentration increase slowly from 1 g/t over the first 3 meters, to levels of 3-6 g/t at c. 4 meters above the foot wall before Pd rapidly decreases to less that 1 g/t above the hanging wall 1 g/t cut-off (Nielsen, 2001).

Sample 90-18, 1010

Sample 90-18 1010 was collected from BQ drill core # 90-18. The core was drilled with an azimuth of 320^o and an inclination of –70 from a location at 2 meters a.s.l., on the eastern shore of Skærgårdsbugt. The Hanging wall of the mineralisation (1 g/t cut-off) is located at 1010 meters and the foot wall at 1013 meters.

Sample 90-18, 1010 collects the 1 m interval in the Pd5 level between 1010 and 1011 m. The average Pd concentration between 1010 meters and 1011 meters is 1.7 g/t Pd and an average of combined PGE plus Au of 2.1 g/t.

The recovery between 1010 and 1011 m is c. 80 %. The core has previously been sampled for other purposes. The sample collects 1/3 of the diameter of the preserved core.

Sample	From	To	Length	Au	Pd	Pt
GEUS	m	m	m	average	average	average
				ppb	ppb	ppb
90-18 1008	1008.00	1009.00	1.00	25	412	31
90-18 1009	1009.00	1010.00	1.00	48	692	102
90-19 1010	1010.00	1011.00	1.00	126	1747	196
90-18 1011	1011.00	1012.00	1.00	96	1766	194
90-18 1012	1012.00	1013.00	1.00	46	1240	175
90-18 1013	1013.00	1014.00	1.00	17	703	91
90-18 1014	1014.00	1015.00	1.00	19	1571	95

Data from Watt, Griffis and McOuat, 1991

The mineralogical report

The mineralogical investigation has been carried out by N.S. Rudashevsky, Yu.L. Kretser and V.N. Rudashevsky on request from the Geological Survey of Denmark and Greenland. The mineralogical report has been prepared by N.S. Rudashevsky, Yu.L. Kretser and V.N. Rudashevsky and edited by T.F.D. Nielsen.

Additional electron microprobe data

During a Ph.D. study Henrik Rasmussen (GEUS) collected a suite of microprobe analyses from a thin section at 1010.48 meters (thin section # 90-18 1010.48). The data is shown in Appendix 2a-2c. In these appendixes names of phases are suggested purely on the basis of their compositions.

References

Andersen, J. C. Ø., Rasmussen, H., Nielsen, T. F. D. & Rønsbo, J. G. 1998: The Triple Group and the Platinova gold and palladium reefs in the Skaergaard intrusion: Stratigraphic and petrographic relations. Economic Geology **93**, 488-509.

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Nielsen, T. F. D. 2001: The palladium potential of the Skaergaard intrusion, South-East Greenland. Report GEUS **2001/23**, 38 pp.

Watts, Griffis & McOuat 1991: 1990 Skaergaard project, Platinova/Corona concession, East Greenland, 55 pp. with appendixes in volumes 2A, 2B, 3A and 3B (in archive of Danmarks og Grønlands Geologiske Undersøgelse, GRF no. 20848).

Mineralogical investigation

Rudashevsky, N.S., Kretser, Yu.L. and Rudashevsky, V.N.
Edited by T.F.D. Nielsen.

Introduction

The sample

Drill core sample 90-18 1010 (0.80 kg by weight) of oxide-rich tholeiitic gabbro with Pd mineralisation from the Skaergaard intrusion was provided for the investigation by T.F.D. Nielsen (Geological Survey of Denmark and Greenland). Assays reported by Watts, Griffis and McOuat (1991) indicate concentrations of 196 ppb Pt, 1747 ppb Pd, 126 ppb Au in that particular core interval. In addition, one thin section (90-18 1010.48) was provided for optical investigation.

Sample preparation and analytical techniques

Details of preparation and analytical techniques are described in Nielsen et al. (2003a): PGE and sulphide phases of the precious metal mineralisation of the Skaergaard intrusion, Part 1: sample 90-23A 807.

The whole volume of the sample was crushed up to size –500 μm. After complete grinding, the sample was passed through standard sieves on ”Retsch” classifer: -45 (180 g), 45-75 (122 g), 75-125 (110 g) and +125 μm (370 g).

Powder samples (free of magnetic minerals after wet magnetic separation): -45 μm, 45-75 μm and 75-125 μm – were passed through hydroseparator HS-01. Two polished sections were produced from the heavy concentrates.

Results

Rock forming minerals and sulphide mineralogy

Silicates and oxides

The only well crystallised cumulus crystals observed in sample 90-18 1010 is ferrous pyroxene. It has typical exsolution textures (Plate 1, #1 and 7-9; Table 1, analyses 5-22). Plagioclase (Table 1, analyses 1-2), Fe-Ti-oxides (Table 1, analyses 31-44) and Cu-Fe sulphides (Plate 1, #3 and 8-9) are mainly intercumulus phases and fill the space between cumulus pyroxene.

Fe-Ti oxide grains and aggregates fill the spaces between pyroxenes and plagioclase grains. Fe-Ti-oxide aggregates are anhedral and 1-3 mm in size. As a rule, Fe-Ti-oxides grains and aggregates are rimmed by silicates:

1) *pyroxene* in contact with Fe-Ti oxide may be rimmed by fayalite (Plate 1, #2; Plate 2, #5-8; Table 1, analyses 23-30) and plagioclase, enriched in anorthite (Plate 1, #4-5*:* Plate 2, #7; Table 1, analyses 3-4),
2) *plagioclase* in contact with Fe-Ti oxide may be rimmed by hornblende (Plate 2, #*2*; Table 1, analyses 49-53).

Fe-Ti-oxides are often associated with H_2O-bearing minerals such as:

1) *biotite* (Plate 1, #4-6: Plate 2, #9 and 11; Table 1, analyses 45-46 and 50-51),
2) *hornblende* (Plate 2, #2, 7, 10 and 12-13),
3) *actinolite* and *ferrosaponite* (Plate 1, #4 and 5; Plate 2, #8 and 13; Table 1, analyses 47-49, 58 and 59). Ferrosaponite, a mineral recently approved by IMA, has the formula $Ca_{0.3}(Fe^{2+}{}_{,}Mg,Fe^{3+})_3(Si,Al)_4O_{10}(OH)_{2*}4H_2O$. It is a secondary mineral and replace mainly olivine (Plate 1, #3-4; Plate 2, #*8*).

Note should be taken that ilmenite contains inclusions of baddeleyite (Plate 2, #1).

Sulphides

<u>*Description*</u>

Sample 90-18, 1010 is poor in sulphides (0.1 vol. %). The aggregates of sulphides, usually less than 0.1 mm and up to 0.2 mm in size, occur between grains of primary rock-forming minerals. The sulphide grains are mostly found at the boundaries of Fe-Ti-oxides, pyroxenes (Plate 1, #6 and 9) and plagioclase (Plate 1, #3). Inclusions of sulphides are common in titaniferous magnetite and ilmenite crystals (Plate 1, #9), as well as in aggregates of pyroxenes (Plate 1, #8). Exsolution textures in two-pyroxene grains (grains with clinopyroxene-orthopyroxene exsolutions) are always absent in a halo round inclusions of Fe-Ti-oxides and Cu-Fe-sulphides. The clinopyroxene exsolution is lost. H_2O-bearing silicates are common at the rims Cu-Fe-sulphide aggregates. As a rule, the hydrous silicates *do not* replace the primary silicate and oxide matrix minerals.

As is observed in the polished sections sulphides aggregates usually have irregular shapes (Plate 1, #3, 6 and 9), sometimes rounded or droplet-like (Plate 1, #7-8). In concentrates of sample 90-18 1010 are found many irregular (Plate 3, #11-21), as well as droplet-like micro-globules of sulphide grains and aggregates (Plate 3, #1-10), some of which are spherical (Plate 3, #3). Numerous examples of intergrowths between Cu-Fe-sulphides and rock-forming minerals (Plate 3, #11-17), as well as with late H_2O-bearing minerals are found in the concentrates (Plate 3, #9 and 18-21). Calcite is occasionally found at the margins of sulphide micro-globules.

The concentrates of sample 90-18, 1010 yielded 180 grains of precious metal minerals and sulphide grains with precious metal phases. Of these are 150 particles and grains of PGE-bearing sulphide aggregates. They are dominanted by *bornite* and *chalcosine-group* minerals (Plate 3, #1 and 4-10). The volume proportions of these minerals vary significantly (see Plate 3-7).

Mineral chemistry

The average composition of *bornite* (Table 2; 13 analyses in 13 particles) is stoikiometric with (wt. %): Cu 62.1; Fe 11.7 and S 25.1 (sum 98.9) equivalent to the structural formular $Cu_{4.96}Fe_{1.06}S_{3.98}$. Chalcosine-group minerals (Table 2; 29 analyses in 29 different sulphide globules) are represented by 24 analyses of chalcosine and 5 analyses of digenite (see also Plate 3, #1 and 4-10; Plates 4-5 and 6-7). The average compositions of chalcosine and digenite are:

1) *chalcosine* (wt%): Cu=77.3, Fe=1.1 and S=20.5 (sum=98.9); equivalent to the structural formular $(Cu_{1.95}Fe_{0.03})_{\Sigma 1.98}S_{1.02}$,
2) *digenite* (wt%): Cu=75.8, Fe=1.3 and S=22.0 (sum=99.1) equivalent to the structural formular $(Cu_{8.75}Fe_{0.17})_{\Sigma 8.92}S_{5.08}$.

In addition to bornite and chalcosine group minerals the sulphide globules also contain minor:

1) *chalcopyrite* (Plate 3, #1; Plate 4, #32; Plate 5, #24; Table 2, analysis 4),
2) *covellite* (?) (Plate 5, #17; Table 2, analysis 13),
3) *pentlandite* (Plate 4, #49),
4) *cobalt pentlandite* (Plate 5, #3; Plate 6, #44 and 45; Table 2, analyses 47 and 48).

Note should be taken that cobalt pentlandite (Table 2, analysis 47, grain #75-2, 5) associated to unnamed-PdCu, vysotskite, atokite and chalcosine (Plate 5, #3) contains 7.8 % of Rh (Table 2, analysis 47).

PGMs and Au-minerals: recovery, grain size and relations to host rock

Several PGM grains (2-7 μm in size) were found in thin section (# 18-1010.48) using SEM. They were all in the close relationship with Cu-Fe- sulphides or as inclusions in titaniferous magnetite, ilmenite (Plate 1, #3) and pyroxenes (Plate 1, #8-9). They were all grains of unnamed-PdCu (Plate 1, #3 and 9) except for one grain of (Pt-Fe-Pd)-alloy (Plate 1, #8).

The characteristics of the PGMs and Au-mineral paragenesis are shown in Table 3 and Fig. 1 and 2. SEM images of the different groups of PGMs and Au-minerals are shown in Plates 4-5 and 6-7. The chemical compositions of all PGM and Au-mineral phases are listed in Tables 4-7. Compositional variations in the main Pd-phase unnamed-PdCu are illustrated in Fig. 3.

Recovery

The HS-concentrates of the sample (90-18, 1010) contained 170 PGM grains and 10 grains with Au-minerals (Table 3). In total 17 different precious metal mineral phases were found in sample 90-18, 1010. The volume proportions of PGM and Au-minerals are shown in Table 3 and Fig. 1.

The dominant phases are:

1) *unnamed-PdCu* (63 %) and variants thereof,
2) *vysotskite* (24%),
3) *vasilite* (3.2 %).

Other rare PGMs include:

1) *keithconnite*,
2) *atokite,*
3) *unnamed (Pd-Cu-Sn)-alloy* and variations thereof,
4) *zvyagintsevite*,
5) *isomertieite*,
6) *guanglinite*,
7) (*Pt-Cu-Fe)-alloy* and variants thereof,
8) *unnamed-Pd_3Cu* and variants thereof,
9) *unnamed-$PdCu_3$* and variants thereof.

The observed and analysed Au-minerals include:

1) *unnamed-$PdAuCu_2$*,
2) *tetra-auricupride*,
3) *bogdanovite*,
4) *(Au-Ag)-alloy*.

Grain size of PGMs and Au-minerals

Grain sizes (E.C.D.) for the selection of the sample 90-18, 1010 of precious metal mineral grains vary from around 1 to 53 μm, with an average of 16 μm (Table 3; Fig. 2).

Petrographic observations

PGMs and Au-minerals generally occur in intergrowth with sulphides (n=150), mainly bornite and chalcosine group minerals (see above). These include rare intergrowth with Cu-Ni sulphides and many polymineral intergrowths of different PGMs (Plate 5, #1-36; Plate 6, #39-42 and 44-47; Plate 7, #1, 6, 13-15 and 18) and intergrowths with (Au-Cu-Pd-Ag)-alloys (Plate 4,#53; Plate 5, #19; Plate 6, #43; Plate 7, #1-11*)*.

Intergrowths of PGMs and Au-minerals with rock forming silicates and Fe-Ti oxides (no Cu-Fe sulphides present) were observed in 7 grains (Plate 4, #46-47 and 49-50; Plate 7, #1-2 and 13). Totally liberated grains of precious metal minerals were encountered 23 times (Plate 4, #53, 55-68; Plate 5, #2 and 19 and 21-22; Plate 7, #6-7 and 15).

Intergrowths of PGMs and Au-minerals in the presence of Cu-Fe sulphides are quite common. Intergrowths with the following minerals have been observed:

1) *orthopyroxene* (Plate 4, #1, 2, 47 and 49-50; Plate 6, #1, 2, 39 and 52; Plate 7, #13),
2) *magnetite* (Plate 4, #3, 7; Plate 5, #3 and 11; Plate 6, #3 and 27; Plate 7, #1 and 13),
3) *ilmenite* (Plate 4, #46; Plate 7, #1-2 and 22),
4) *clinopyroxene* (Plate 4, #48),
5) *plagioclase* (Plate 4, #10),
6) *chlorite* (Plate 4, #5; Plate 5, #13; Plate 6, #12, 41 and 49),
7) *hornblende* (Plate 7, #13),
8) *biotite* (Plate 6, #4).
9) *apatite* (Plate 4, #4 and 46),
10) *calcite* (Plate 7, #14).

Description and chemistry of PGMs and Au-minerals

Unnamed-PdCu

<u>Description</u>

The dominant PGM – unnamed-PdCu - is found in the concentrates as 1 to 46 μm sized grains, with an average of 18 μm (Table 3). The majority of unnamed-PdCu grains occur as inclusions in Cu-Fe-sulphide aggregates. Many totally liberated grains of unnamed-PdCu were also found (Plate 4, #46-68).

PGM-bearing sulphide aggregates often retain classic droplet-like forms even after crushing (Plate 4, #1and 5-8; Plate 5, #12, 14-15, 17-18, 24, 27-28, 33, 35 etc). As a rule, PGE-phases are localised at the margins of the host sulphide globules (Plate 4, #1-7, 9-28 and 30-37; Plate 5, #1, 5, 10, 23-24, 35, etc). Some very fine "droplets" (1-3 μm) can be distributed throughout a sulphide grain (Plate 4, #8). In general, PGM grains have shape of:

1) droplets (Plate 4, #*8*-11, 14, 18, 42-45; Plate 5,#9, 21, etc),

2) isometric shape with the round outline (Plate 4, #3, 16, 19, 21, 26, 28, 31, 35, 46, 48 and 51-55; Plate 5, #1, 5, 8, 10-12, 30-32, 35, etc),
3) euhedral crystals (Plate 4, #14-16, 23 and 39-41; Plate 5, #7, 18-19, etc),
4) anhedral grains (Plate 4, #2, 5-6, 17, 20, 29-30, 37-38, 49-50 and 56-68; Plate 5, #2-6, 22, 26, etc).

The volume of PGE-phases in the sulphide globules varies significantly:

1) globules with fine inclusions of PGMs (Plate 4, #1 and 3-16),
2) PGE-phase(s) form half of the grain or more (Plate 4, #36, 3 and 39-43; Plate 5, #17 and 24),
3) globules dominated by the PGE-phase(s) (Plate 5, #11, 18, 20, 27 and 33).

The grain boundaries between PGE- and sulphide-phases in the droplets are normally sharp and protuberant for PGE-phase and concave for Cu-Fe-sulphides (see Plates 4-5). However, in several PGM-sulphide globules (Plate 5, #15 and 18) Cu-Fe-sulphide are observed to fill the space between crystals of PGMs.

At the margins of PdCu-bearing sulphide globules (Plate 4, #1-3, 5, 7 and 10) and in some liberated unnamed-PdCu grains (Plate 4, #46-50) have different rock-forming minerals been identified:

1) *orthopyroxene* (Plate 4, #1, 2, 47 and 49-50; Plate 7, #13),
2) *clinopyroxene* (Plate 4, #48),
3) *plagioclase* (Plate 4, #10),
4) *ilmenite* (Plate 4, #46; Plate 7, #1-2),
5) *magnetite* (Plate 4, #3 and 7; Plate 5, #3; Plate 7, #1 and 13),
6) *chlorite* (Plate 4, #5; Plate 5, #13),
7) *hornblende* (Plate 7, #13).

About 2/3 of a total of 100 grains are associated with Cu-Fe sulphides (Plates 4-5). The remaining PdCu grains occur in a variety of intergrowths with the following PGMs and Au-minerals:

1) *atokite* (Plate 5, #1-6), Pd-Cu-Sn-alloy (Plate 5, #7-17),
2) *keithconnite* (Plate 5, #17-21; Plate 7, #1),
3) *vasilite* (Plate 5, #20 and 22-26; Plate 7, #1 and 6),
4) *vysotskite* (Plate 5, #27-29; Plate 7, #6 and 9),
5) *zvyagintsevite* (Plate 5, #30-34),
6) *(Pt-Fe-Cu-Pd)-alloys* (Plate 5, #35-36),
7) *unnamed-*$PdAuCu_2$ (Plate 7, #1, 2 and 5),
8) *bogdanovite* (Plate 7, #8 and 9),
9) *unnamed-*Pd_3Cu (Plate 7, #10, 13 and 15),
10) *unnamed-*$PdCu_3$ (Plate 7, #18),
11) *tetra-auricupride* (Plate 7, #11).

All the above mentioned precious metal minerals usually occur at the boundaries, or as very small inclusions in unnamed-PdCu. This suggests that PdCu predates all these phases and minerals.

Mineral chemistry

The composition of unnamed-PdCu was determined in 108 different grains (Table 4). Nine elements were found to be incorporated in the phase:

element	Range (wt%)	Average (wt%)
Pd	39.9-63.9	55.05
Pt	<16.7	3.83
Au	<23.9	5.02
Cu	26.5-34.4	30.38
Fe	0.7-7.6	3.22
Zn	< 4.0	1.63
Sn	<4.7	0.63
Te	<2.9	0.42
Pb	< 5.8	0.70

The average composition corresponds to the chemical formula:

$$(Pd_{0.912}Au_{0.045}Pt_{0.035})_{\Sigma 0.992}(Cu_{0.842}Fe_{0.102}Zn_{0.044}Sn_{0.009}Te_{0.006}Pb_{0.006})_{\Sigma 1.009}.$$

In intergrowths with Au-minerals, unnamed-PdCu is always enriched in Au (see e. g., Plate 7, #1-2, 4-6; Table 4, analyses 104, 6, 37, 3, 66). In intergrowths with (Pt-Fe-Cu-Pd)-alloys, unnamed-PdCu is enriched by Pt (Plate 5, #35–36, Table 4, analyses 76 and 101).

Vysotskite

Description

The grain size of vysotskite varies from 3 to 53 μm. The average is 15 μm (Table 3, Fig. 2, Plate 5, #27-29; Plate 6, #1-46; Plate 7, #3, 6, 9 and 14).

Vysotskite occurs almost always as inclusions in Cu-Fe sulphide aggregates. Vysotskite grains are always anhedral. Vysotskite-bearing aggregates of Cu-Fe-sulphides can form:

1) irregular grains (Plate 6, #1, 3-4, 15-20, 22-25, 27-32 and 35-46; Plate 7, #3, 6 etc),
2) grains with rounded outlines (Plate 5, #27-29; Plate 6, #2, 5-10, 12-14, 17, 18-21, 26, 32-3 and 40; Plate 7, #9 and 14).

As a rule, grains of vysotskite are located at the rims of Cu-Fe-sulphide aggregates (see Plate 6, #1, 2 and 4-40). Sometimes, these grains have inclusions of rock-forming minerals such as:

1) *orthopyroxene* (Plate 6, #1, 2 and 39),
2) *magnetite* (Plate 6, #3 and 27),
3) H_2O-bearing silicates including *chlorite* (Plate 6, #12 and 41) and *biotite* (Plate 6, #4).

In general, visotskite-bearing sulphide grains contain no other PGMs (see Plate 6, #1-38). Exceptions are relatively rare intergrowths of visotskite with:

1) *unnamed-PdCu* (Plate 5, #18 and 27-29, Plate 6, #42, 45; Plate 7, #6),
2) *keithconnite* (Plate 5, #18 and 27; Plate 6, #39-42 and 46),
3) *vasilite* (Plate 6, #46; Plate 7, #6),
4) *atokite* (Plate 6, #45),
5) *unnamed-PdAuCu$_2$* (Plate 6, #3 and 6),
6) *bogdanovite* and *tetra-auricupride* (Plate 6, #9),
7) *(Pt-Fe-Pd)-alloy* (Plate 6, #40),
8) *(Au-Ag)-alloy* (Plate 6, #43),
9) *unnamed-(Pd,Au)$_3$Cu* (Plate 7, #14).

Mineral chemistry

The chemical composition of vysotskite (44 microprobe analyses in 43 grains) is shown in Table 5, analyses 1-44. In vysotskite Pd can be replaced by:

Element	Max substitution (wt%)	Reference to Table 5
Ni	8.6	analysis 6
Cu	5.2	analysis 39
Fe	1.4	analysis 9

Vysotskite may be strongly zoned. Different zones of can have contrasting compositions, e. g., Ni content (Plate 6, #21 – Table 4, analyses 1-2). The average chemical composition of visotskite (n = 44; wt. %) is:

	Pd	Ni	Cu	Fe	S	sum
vysotskite	71.8	1.9	1.5	0.5	23.5	99.2

The composition corresponds to the structural formula:

$$(Pd_{0.92}Ni_{0.04}Cu_{0.03}Fe_{0.01})_{\Sigma 1.00}S_{1.00}.$$

Vasilite

Description

In the HS-concentrates the grain size of vasilite varies from c. 2 to 22 μm. The average size is 14 μm (Tabl. 3). Vasilite is found as:

1) droplet-like grains (Plate 5, #20; Plate 6, #47-48),
2) anhedral grains or aggregates (Plate 5, #22-26; Plate 6, #46 and 49-52; Plate 7, #1and 6-7).

In some Cu-Fe sulphide globules vasilite seems to be the only PGM (Plate 6, #48-52), but occurs generally together with other minerals. In the grains of the HS-concentrates vasilite is found to coexist with PGMs and Au-minerals including:

1) *unnamed-PdCu*,
2) *keithconnite,*
3) *vysotskite,*

4) *unnamed-PdAuCu_2,*
5) *bogdanovite.*

and with the Cu-Fe sulphides:

1) *bornite,*
2) *chalcosine,*
3) *digenite,*
4) *chalcopyrite.*

Vasilite-bearing aggregates (with or without Cu-Fe-sulphides) sometimes includes silicates and oxides including:

1) *orthopyroxene* (Plate 6, #52),
2) *ilmenite* and *magnetite* (Plate 7, #1),
3) *chlorite* (Plate 6, #49).

As mentioned above, vasilite and vysotskite are some of the last formed PGMs of the precious metal paragenesis (see Plate 7, #1 and 6-7).

<u>*Mineral chemistry*</u>

The chemical compositions of vasilite (10 microprobe analyses in 10 grains) is given in Table 5 (analyses 45-54). The average chemical composition of vasilite is (wt. %):

	Pd	Cu	Fe	S	sum
vasilite	71.8	14.1	0.4	12.6	98.9

The average composition corresponds to the structural formula:

$$Pd_{11.97}(Cu_{3.93}Fe_{0.13})_{\Sigma 4.06}S_{6.97}.$$

Keithconnite

<u>*Description*</u>

Keithconnite is found in 14 grains (Table 3; Fig. 1). The grain size varies from 2 to 20 μm. The average grain size is 10 μm (Table 3). Keithconnite-bearing grains are either:

1) classic micro-globules (Plate 5, #17-18 and 20-21; Plate 6, #40 and 47),
2) irregular shaped grains (Plate 5, 19; Plate 6, #39, 41-42 and 46; Plate 7, #1 and 15-17).

As a rule, keithconnite occurs in association with other PGMs, Au-minerals and Cu-Fe-sulphides (Plate 5, #17-18 and 20; Plate 6, #39-42 and 4-47; Plate 7, #1 and 16-17). Some rare grains with keithconnite as the only PGM are also found (Plate 5, #19 and 21; Plate 7, #15). Keithconnite is closely associated to:

1) *unnamed-PdCu* (Plate 5, #17-18 and 20-21;Plate 6, #42; Plate 7, #1),
2) *vysotskite* and *vasilite* (Plate 5, #18 and 20; Plate 6, #39-42 and 46-47; Plate 7, #1),
3) *Au-minerals* (Plate 5, #19; Plate 7, #1),
4) *(Pt-Fe-Pd)-alloy* (Plate 6, #40).

Rock-forming minerals are found as inclusions in keithconnite-bearing grains or aggregates. They are generally found at the rims of the grains or aggregates and include:

1) *orthopyroxene* (Plate 6, #39),
2) *ilmenite* and *magnetite* (Plate 7, #1),
3) *chlorite* (Plate 6, #41).

In all studied grains keithconnite has formed later than unnamed-PdCu (see Plate 5, #17-18 and 21), and contemporaneously the above-mentioned Pt- and Au-minerals. Keithconnite, however, predates the crystallisation of the Pd-sulphides vysotskite and vasilite (see Plate 5, #18; Plate 7, #1).

Mineral chemistry

Compositions of keithconnite are shown in Table 6 (analyses 19-32). The following substitutions have been observed:

Site	Substitution	Max. (wt. %)	Analysis in Table 6
Pd	Cu	4.6	27 and 32
Pd	Fe	2.0	26
Te	Sn	5.1	29
Te	Pb	7.7	22
Te	As	1.0	24
Te	Sb	1.2	30

The compositions divide into two groups:

1) keithconnite with limited substitution in the Te site (Table 6, analyses 19, 21, 23-28 and 29-31). The average structural formular (4 cations) would be:
$(Pd_{2.88}Cu_{0.12}Fe_{0.04})_{3.04}(Te_{0.91}Sn_{0.03}Pb_{0.02}As_{0.01})_{0.97}$,
2) keithconnite with significant substitution in the Te site by Sn and Pb (Table 6, analyses 20, 22 and 29). The average structural formular (4 cations) would be:
$(Pd_{3.11}Cu_{0.06}Fe_{0.02})_{3.21}(Te_{0.49}Sn_{0.18}Pb_{0.15})_{0.85}$.

Au-minerals

Au-minerals are not common. In total only 13 grains have been found. The grain size of Au-minerals varies from 1 to 25 μm. The average grain size is c. 10 μm (Table 3). Au-minerals in sample 90-18, 1010 are represented by 4 phases (Table 3; Fig. 1):

1) *unnamed-$PdAuCu_2$* (Plate 7, #1-6; Table 7, analyses 1-6),
2) *bogdanovite* (Plate 7, #7-9; Table 7, analyses 7-9),
3) *tetra-auricupride* (Plate 5, #19; Plate 7, #8-11),
4) *(Au-Ag)-alloy*, small inclusions (Plate 6, #43; Plate 7, #12).

Some of the Au-minerals occur in complicated aggregates composed of Au-minerals and PGMs with/or without Cu-Fe-sulphides. These composit grains are irregular (Plate 7, *#1-7 and 11*) or characteristic micro-globules (Plate 7, *#8-10*). Some of these aggregates have inclusions of rock-forming minerals, such as ilmenite and magnetite (Plate 7, *#1-2*). Au-minerals are closely associated with:

1) *unnamed-PdCu*, Au-rich,
2) *unnamed-Pd_3Cu*,
3) *vasilite,*
4) *vysotskite*,
5) *keithconnite*.

Other PGMs

Other relatively rare PGMs in sample 90-18 1010 include:

1) *braggite* (Plate 6, #53; Table 3; Table 5, analysis 55),
2) *atokite* (Plate 5, #1-6; Plate 6, #44-45; Table 3; Table 6, analyses 1-6),
3) *(Pd-Cu-Sn)-alloy* (Plate 5, #7-14; Plate 7, #20-21; Table 3; Table 6, analyses 7-18),
4) *zvyagintsevite* (Plate 5, #30-34; Table 3),
5) *guanglinite* (Plate 7, #23; Table 3; Table 6, ananalysis 34),
6) *isomertieite* (Plate 7, #22; Table 3; Table 6, analysis 33),
7) *(Pt-Fe-Cu-Pd)-alloys* (Plate 5, #35-36; Plate 6, #40: Table 3; Table 7, analyses 14-16),
8) *unnamed-Pd_3Cu* (Plate 7, #10 and 13-15; Table 3; Table 4, ananalyse 106-108),
9) *unnamed-$PdCu_3$* (Plate 7, #18; Table 3; Table 4, analysis 105).

At first glance, all of these minerals can be divided into two groups:

1) PGMs enriched in Sn, Pt and Pb and related to unnamed-PdCu. They include atokite, Pd-Cu-Sn-alloy, zvyagintsevite, and (Pt-Fe-Cu-Pd)-alloys,
2) PGMs including Pd-Cu-phases (unnamed-Pd_3Cu and unnamed-$PdCu_3$) enriched in Au and (Pt-Fe-Pd)-alloy. They are closely associated to Au-rich unnamed-PdCu, keithconnite and vysotskite (see Plate 6, #39; Plate 7, #10, 13-15 and 18).

The first group of minerals probably formed from amounts of minor elements excluded from early crystallising unnamed-PdCu. Excess Sn formed atokite and (Pd-Cu-Sn)-alloy (see

Plate 5, #1-17), excess Pt formed (Pt-Fe-Cu-Pd)-alloys (see Plate 5, #35-36) and excess Pb formed zvyagintsevite (see Plate 5, #30-35).

The second group of rare PGMs picked up elements exceeding the solubility in unnamed-Pd_3Cu and unnamed-$PdCu_3$. Excess Au resulted in the Au-minerals, Te led to crystallisation of keithconnite and Pt was picked up by (Pt-Au)-alloys.

The associations of braggite (Plate 6, #53), guanglinite (Plate 7, #22) and isomertieite (Plate 7, #23) have not been studied in detail.

Bulk composition of sample 90-18 1010

Below the assay concentrations of Pd, Au and Pt are compared to relative bulk concentrations for these element calculated from the recovered precious metal minerals and phases:

element	Assay (ppb)	Mass balance (ppb)
Pd	1747	1774
Au	126	188
Pt	196	106

The assay sum of Pd, Au and Pt is 2069 The assay proportion of Pd has been reproduced, but significant deviations are observed for Au and Pt. These deviations are not explained, but may be due to “nugget effect” due to the relatively lower number of Au-mineral and Pt-mineral grains. However, the main part of Au and Pt appears to be substituted into unnamed-PdCu.

Discussion

Systematics in the Pd5 level of the mineralisation

Sample 90-18 1010 is collected in the in the Pd peak of the Pd5 level of the precious metal mineralisation. A previously described sample (90-24 1057; Nielsen et al., 2003b) was collected almost at the same level in the Pd5 peak in core 90-24. The distance between the two cores is app. 2 km.

The two samples are here compared in a attempt to define the general characteristics of the Pd-peak in the Pd5 level of the mineralisation in the central parts of the Skaergaard intrusion.

The characteristics of precious metal mineralisation of the samples 90-18 1010 and 90-24 1057 are summerized as follows:

Characteristics of the sample	Smaple 90-24 1057	Sample 90-18 1010
Pd, ppb (assay)	2800	1747
Pt, ppb (assay)	170	196
Au, ppb (assay)	97	126
Pt/Pd	0.06	0.11
Au/Pd	0.03	0.07
PdCu, %	94	63
Pd-sulphides, %	0.1	27
Au-minerals, %	1	4.5
Pt-minerals, %	<0.1	0.1
Pt in PdCu, %	1.1	3.8
Au in PdCu, %	2.2	5.0

The bulk compositions of the two samples are best compared looking at the ratios Pt/Pd and Au/Pd. The table shows that sample 90-24 1057, apart from having a higher total Pd concentration, has relatively lower Au and Pt concentrations and lower Pt/Pd and Au/Pd ratio than sample 90-18 1010. The reason for this is, in part, that sample 90-24 1057 collects the absolute Pd-peak in the Pd5 level, whereas sample 90-18 1010 collects a slightly higher section in the Pd-peak (see page 5). As observed in many Au-bearing PGE mineralisations Pt and Au are vertically displaced from the possition of the lower Pd-peak (e.g., Oberthür et al., 2003). This may explain the relative enrichment in Pt and Au in sample 90-18 1010. The lower bulk concentration of Pd may related to the sampling-bias caused by the use of 1-meter average samples.

Unnamed-PdCu is the dominating Pd-mineral in both samples. However, sample 90-18 1010 contains, as opposed to sample 90-24 1057, significant amounts the Pd-sulphides vysotskite and vasilite (27 %) and Au-minerals (4.5 %). The latter reflects the relative enrichment in Au. The enrichment in Au and Pt in the bulk composition is also reflected in the composition of unnamed-PdCu. Unnamed-PdCu in sample 90-18 1010 is 3 times as rich in Pt and at least twice as rich in Au compared to unnamed-PdCu in sample 90-24 1057.

The proportion of Pt-rich minerals is quite small in both samples (<1% of the Pt) as Pt is mainly substituted into unnamed-PdCu. By contrast, a significant proportion of Au is allocated to Au-minerals. In sample 90-24 1057 20% of the Au and in sample 90-18-1010 40% of the Au forms Au-minerals.

In both samples the predominant Au-minerals have comparatively low concentrations of Au:

1) *unnamed-PdAuCu$_2$* (av. Au = 42.5 %; 15 analyses),
2) *tetra-auricupride* (av. Au = 49 %; 4 analyses).

Ag-rich minerals have not been found. Ag is contained in rare small (<5μm) grains of (Au-Ag) alloy occurring as inclusions in other minerals and phases.

The PGM and Au-mineral paragenesis

The unnamed-PdCu association

The observations show that unnamed-PdCu is the dominant PGM in the studied sample. Unnamed-PdCu shows a wide compositional range (Table 4). Its composition depends on the PGM and Au-mineral paragenesis. As described in Nielsen et al. (2003b) the compositional groups of PdCu are:

a) PdCu that is not related to any other precious metal minerals has, as a rule, the most simple compositions – (Cu,Fe,Zn)Pd,
b) PdCu that coexists with unnamed-$PdAuCu_2$, bogdanovite and keithconnite is enriched in Au-(Te),
c) PdCu that coexists with atokite, unnamed-(Pd,Cu,Sn)-alloy and zvyagintsevite is enriched in Sn-(Pb),
d) PdCu that coexists with (Pt-Fe-Cu-Pd)-alloys is enriched in Pt.

All the observations and the inter-grain relations (Plates 1-7) suggest that all these PGMs and Au-minerals associated with unnamed-PdCu are part of a single paragenesis. This conclusion is shown by the correlation between the chemical composition of the PdCu and its associated precious metal minerals. Further more, the chemical composition of PdCu is in sample 90-18 1010 as well as in sample 90-24 1057, correlated to the bulk concentrations of Pd, Pt and Au of the sample (see table above).

Vysotskite and vasilite

About 1/3 of PGM-bearing grains in sample 90-18 1010 are the Pd-sulphides: vysotskite and vasilite (Table 3). In the majority of the studied grains of Pd-sulphides form monomin-erallic inclusions in Cu-Fe-sulphide globules (e. g., Plate 5), but they do also, to a minor extend, occur in aggregates composed of several PGE(Au)-minerals. In these aggregates Pd-sulphides are always formed later than unnamed-PdCu and other phases related to the unnamed-PdCu paragenesis. Pd-sulphides seems to be the last formed group of precious metal minerals in the sample and they are suggested to form part of a re-equilibration paragenesis.

Parageneses and order of crystallisation

Many observations document that unnamed-PdCu was the first PGM to form. Unnamed-PdCu crystallised from PdCu metal droplets formed by immiscibility in immiscible Cu-Fe sulphide melt-droplets. Dependent on the concentrations of the minor elements in the PdCu-droplets, crystallisation of unnamed-PdCu is followed by crystallisation of:

a) *atokite* and/or *unnamed-(Pd,Cu,Sn)-alloy, zvyagintsevite* in PdCu-droplets carrying Sn and Pb;
b) *Au-minerals* (unnamed-$PdAuCu_2$, bogdanovite, tetra-auricupride, unnamed-$(Pd,Au)_3Cu$, and keithconnite in PdCu-droplets carrying Au and Te;
c) *(Pt-Fe-Cu-Pd)-alloy* in PdCu-droplets carrying Pt.

Pd-sulphides, mainly vysotskite, appear to postdate all of these minerals. The late formation of vysotskite and vasilite could be linked to the liberation of sulphur during re-equilibration of Cu-Fe paragenesis. The S-depleted and re-equilibrated Cu-Fe mineral paragenesis is characterized by chalcosine rather than bornite (e. g., Plate 5, #18). Sulphur expelled during re-equilibration of bornite to chalcosine could combine with pure metal phases (f. ex., unnamed-PdCu) to form Pd-sulphides such as vysotskite and vasilite and other low-temperature phases.

Summary

1. 180 grains of PGMs were were found in the HS-concentrates of sample 90-18 1010.

2. The dominating PGM is unnamed-PdCu (63 wt. % of PGMs). In addition, 16 other precious metal minerals were identified: vysotskite (24 %), vasilite (3.2 %), and minor proportions of keithconnite, braggite, atokite, zvyagintsevite, guanglinite, isomertieite, unnamed-$PdAuCu_2$, tetra-auricupride, bogdanovite, (Au,Ag)-alloy, unnamed-Pd_3Cu, unnamed-$PdCu_3$, unnamed (Pd-Cu-Sn)-alloy and (Pt-Fe-Cu-Pd)-alloy.

3. Two precious metal mineral parageneses are identified:
   a) *Unnamed-PdCu* and related PGE(Au)-minerals,
   b) *Pd-sulphides* including vysotskite and vasilite.

4. The primary paragenesis dominated by unnamed-PdCu crystallised from immiscible droplets with a bulk composition close to PdCu. Minor elements, that were not substituted into unnamed-PdCu resulted in a suite of minerals associated to unnamed-PdCu. The PdCu metal droplets formed inside immiscible Cu-Fe droplets.

5. During re-equilibration in Cu-Fe droplets bornite was substituted by chalcosine. Free sulphur reacted with Pd-rich primary PGMs to form Pd-sulphides such as vysotskite and vasilite.

6. Compared to the assay for sample 90-18 1010 the Pd concentration and the total (Pd+Au+Pt) is reproduced in the mass balance calculation. Significant and unexplained deviations are seen for both Pt and Au.

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Abbreviations

Abbreviations used in figures and tables.

Rock-forming minerals

PL1	= plagioclase
PL2	= anorthite
CPX	= monoclinic pyroxene (clinopyroxene)
OPX	= orthorhombic pyroxene (orthopyroxene)
ILM	= ilmenite
TIMT	= titaniferous magnetite
MT	= magnetite
BDL	= Baddeleyite
FSPN	= Ferrosaponite
ACT	= actinolite
HB	= hornblende
BT	= biotite
EP	= epidote
CHL	= chlorite
OL	= olivine
AP	=Apatite

Sulphides

BORN	= bornite
CP	= chalcopyrite
CHC	= chalcosine
DGN	= digenite
PN	= pentlandite
COV	= coverlite
COPN	= cobalt pentlandite

Precious metal minerals

AT	= atokite
BGD	= bogdanovite
BRG	= braggite
GNG	= guanglinite
ISM	= isomertieite
KTH	= keithconnite
VYS	= vysotskite
VSL	= vasilite
ZV	= zviagintsevite
Au, (Au,Ag)	= native Au
(Au,Pd)Cu	= tetra-auricuprite

Abbreviations; Precious metal minerals continued:

(Au,Pd,Cu,Pt)	= (Au-Pd-Cu-Pt)-alloy
(Pd,Au)Cu	= unnamed-PdCu with Au sustitution
$PdAuCu_2$	= unnamed-$PdAuCu_2$
$(Pd,Au)_3Cu$	= unnamed-Pd_3Cu with Au substitution
PdCu	= unnamed-PdCu
Pd(Cu,Sn)	= unnamed-PdCu with Sn substitution
(Pd,Cu,Sn), (Pd,Sn,Cu), (Pd,Sn,Fe)	= unnamed (Pd-Cu-Sn-Fe)-alloys
Pd_3Cu	= unnamed-Pd_3Cu
(Pd,Pt)Cu	= unnamed-PdCu with Pt substitution
$PdCu_3$	= unnamed-$PdCu_3$
(Pt,Cu,Fe), (Pt,Fe,Pd), (Pt,Fe,Pd), (Pt,Fe,Pd)	= (Pt-Cu-Fe-Pd)-alloys

Table 1: Chemical composition and formulas of silicates and oxides of oxide-rich tholeiitic gabbros (sample 90-18, 1010)

An.	Object	Association of minerals	Mineral		SiO_2	TiO_2	Al_2O_3	V_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Cl	Total
1	P s, p 1	PL1+CPX+OPX+ ILM+TIMT	PL1	Wt.%	56.8	-	27.9	-	-	-	-	-	10.0	5.9	-	-	100.6
				F. c.	2.53	-	1.47	-	-	-	-	-	0.48	0.51	-	-	O=8
2	P s, p 8	PL1+CPX+OPX+ ILM+	PL1	Wt.%	58.1	-	26.4	-	-	-	-	-	8.5	6.6	0.3	-	100.0
				F. c.	2.60	-	1.39	-	-	-	-	-	0.41	0.57	0.02	-	O=8
3	P s, p 1	ILM+TIMT+OL+PL2 +PdCu+CHL	PL2	Wt.%	48.8	-	32.6	-	-	-	-	-	15.6	2.6	-	-	99.6
				F. c.	2.24	-	1.76	-	-	-	-	-	0.76	0.23	-	-	O=8
4	125-1, 5R	ILM+OL+PL2+HB	PL2	Wt.%	43.8	-	35.6	-	-	-	-	-	18.9	1.0	-	-	99.4
				F. c.	2.04	-	1.95	-	-	-	-	-	0.94	0.05	-	-	O=8
5	P s, p 1	PL+CPX+OPX(exs)+ ILM+TIMT	CPX	Wt.%	52.2	-	1.4	-	-	12.4	0.4	13.1	20.2	-	-	-	99.7
				F. c.	1.97	-	0.06	-	-	0.39	0.01	0.74	0.82	-	-	-	O=6
6	P s, p 1	PL+CPX+OPX(exs)+ ILM+TIMT	CPX	Wt.%	50.8	0.7	1.7	-	-	13.3	0.4	12.3	20.6	-	-	-	99.8
				F. c.	1.93	0.02	0.08	-	-	0.42	0.01	0.70	0.84	-	-	-	O=6
7	P s, p 5	CPX+ILM+BORN +PdCu	CPX	Wt.%	50.7	0.8	1.6	-	-	13.1	0.3	12.3	20.1	-	-	-	98.9
				F. c.	1.94	0.02	0.07	-	-	0.42	0.01	0.71	0.83	-	-	-	O=6
8	P s, p 4	CPX+OPX (exs)	CPX	Wt.%	50.7	0.4	0.9	-	-	12.7	0.3	13.3	20.3	-	-	-	98.6
				F. c.	1.95	0.01	0.04	-	-	0.41	0.01	0.76	0.83	-	-	-	O=6
9	125-1, 4R	CPX+OPX+BORN +CP	CPX	Wt.%	50.5	0.6	1.0	-	-	14.4	0.4	12.6	20.4	-	-	-	99.9
				F. c.	1.93	0.02	0.04	-	-	0.46	0.01	0.72	0.84	-	-	-	O=6
10	125-2, 7R	PL+CPX+OPX+ ILM+TIMT	CPX	Wt.%	51.8	0.74	0.79	-	-	13.1	-	12.6	20.7	-	-	-	99.73
				F. c.	1.97	0.02	0.02	-	-	0.42	-	0.71	0.84	-	-	-	O=6
11	125-2, 7R	BORN+CHC+CPX	CPX	Wt.%	49.1	0.8	1.4	-	-	14.5	0.3	12.1	20.7	-	-	-	98.9
				F. c.	1.91	0.02	0.07	-	-	0.47	0.01	0.70	0.86	-	-	-	O=6
12	125-2, 12R	ILM+OL+CPX+OPX (exs)	CPX	Wt.%	50.8	0.4	0.7	-	-	14.0	0.4	11.3	22.1	-	-	-	99.7
				F. c.	1.95	0.01	0.03	-	-	0.45	0.02	0.65	0.91	-	-	-	O=6
13	75-2, 3R	BORN+CHC+CPX	CPX	Wt.%	50.6	0.8	0.9	-	-	13.7	0.3	12.5	21.1	-	-	-	99.9
				F. c.	1.93	0.02	0.04	-	-	0.44	0.01	0.71	0.86	-	-	-	O=6
14	75-2, 5R	BORN+CPX	CPX	Wt.%	50.4	0.6	1.1	-	-	14.0	0.4	12.2	21.2	-	-	-	99.9
				F. c.	1.96	0.02	0.05	-	-	0.45	0.01	0.69	0.87	-	-	-	O=6

Table 1continued: Chemical composition and formulas of silicates and oxides of oxide-rich tholeiitic gabbros (sample 90-18, 1010)

An.	Object	Association of minerals	Mineral		SiO_2	TiO_2	Al_2O_3	V_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Cl	Total
15	P s, p 1	PL1+CPX+OPX+ ILM+TIMT	OPX	**Wt.%**	**51.5**	-	-	-	-	**26.8**	**0.8**	**18.9**	**1.5**	-	-	-	**99.5**
				F. c.	1.98	-	-	-	-	0.86	0.03	1.09	0.06	-	-	-	O=6
16	P s, p 3	TIMT+BORN+OPX+ PL+BT	OPX	**Wt.%**	**52.1**	-	**1.6**	-	-	**24.7**	**0.7**	**18.5**	**1.0**	-	-	-	**98.6**
				F. c.	2.00	-	0.07	-	-	0.79	0.02	1.06	0.04	-	-	-	O=6
16	P s, p 4	ILM+OPX+BORN +CHL	OPX	**Wt.%**	**50.4**	-	**0.6**	-	-	**27.2**	**0.5**	**18.3**	**1.8**	-	-	-	**98.8**
				F. c.	1.96	-	0.03	-	-	0.88	0.02	1.06	0.07	-	-	-	O=6
17	P s, p 7	ILM+HB+OPX+CPX +BORN	OPX	**Wt.%**	**50.0**	**0.4**	**1.2**	-	-	**27.8**	**0.7**	**17.8**	**1.3**	-	-	-	**99.2**
				F. c.	1.94	0.01	0.06	-	-	0.90	0.02	1.03	0.06	-	-	-	O=6
18	P s, p 8	OPX+CPX(exs)	OPX	**Wt.%**	**51.9**	-	**1.7**	-	-	**25.6**	**0.5**	**18.9**	**1.1**	-	-	-	**99.7**
				F. c.	0.99	-	-	-	-	1.13	0.02	0.86	0.04	-	-	-	O=6
19	125-1	BORN+CHC+OPX	OPX	**Wt.%**	**50.2**	**0.8**	-	-	-	**33.1**	**0.6**	**14.1**	**1.0**	-	-	-	**99.8**
				F. c.	1.98	0.03	-	-	-	1.09	0.02	0.83	0.04	-	-	-	O=6
20	125-1, 2R	ILM+OPX+BT	OPX	**Wt.%**	**50.6**	**0.4**	-	-	-	**28.5**	**0.5**	**18.9**	**0.6**	-	-	-	**99.5**
				F. c.	1.96	0.01	-	-	-	0.92	0.02	1.09	0.02	-	-	-	O=6
21	125-1, 4R	OPX+CPX(exs)+ BORN+CP	OPX	**Wt.%**	**49.9**	-	-	-	-	**28.9**	**0.7**	**17.4**	**2.3**	-	-	-	**98.2**
				F. c.	1.96	-	-	-	-	0.95	0.02	1.02	0.09	-	-	-	O=6
22	125-2, 8R	ILM+OPX	OPX	**Wt.%**	**50.7**	**0.7**	-	-	-	**27.2**	**0.5**	**19.3**	**1.0**	-	-	-	**99.4**
				F. c.	1.96	0.02	-	-	-	0.88	0.02	1.11	0.04	-	-	-	O=6
23	P s, p 1	ILM+TIMT+OL+PL2 +PdCu+FSPN	OL	**Wt.%**	**33.7**	-	-	-	-	**44.3**	**0.5**	**20.1**	-	-	-	-	**98.6**
				F. c.	1.00	-	-	-	-	1.10	0.01	0.89	-	-	-	-	O=4
24	P s, p 1	ILM+TIMT+OL+PL2 +PdCu+FSPN	OL	**Wt.%**	**33.8**	-	-	-	-	**44.4**	**0.6**	**20.5**	-	-	-	-	**99.3**
				F. c.	1.00	-	-	-	-	1.09	0.01	0.06	-	-	-	-	O=4
25	P s, p 1	ILM+TIMT+OL+PL2 +PdCu+FSPN	OL	**Wt.%**	**34.2**	-	-	-	-	**47.4**	**0.6**	**18.9**	-	-	-	-	**101.1**
				F. c.	1.00	-	-	-	-	1.16	0.01	0.82	-	-	-	-	O=4
26	P s, p 1	ILM+TIMT+OL+PL2 +PdCu+FSPN	OL	**Wt.%**	**33.5**	-	-	-	-	**47.3**	**0.7**	**18.0**	-	-	-	-	**99.5**
				F. c.	1.00	-	-	-	-	1.18	0.02	0.80	-	-	-	-	O=4
27	125-1, 5	ILM+OL+PL2	OL	**Wt.%**	**34.2**	-	-	-	-	**45.3**	**0.6**	**20.2**	-	-	-	-	**100.3**
				F. c.	1.00	-	-	-	-	1.11	0.01	0.88	-	-	-	-	O=4

Table 1continued: Chemical composition and formulas of silicates and oxides of oxide-rich tholeiitic gabbros (sample 90-18, 1010)

An.	Object	Association of minerals	Mineral		SiO_2	TiO_2	Al_2O_3	V_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Cl	Total
28	125-2, 3R	ILM+MT+OL+FSPN	OL	**Wt.%**	**33.9**	**-**	**-**	**-**	**-**	**46.5**	**0.7**	**19.0**	**-**	**-**	**-**	**-**	**100.1**
				F. c.	1.00	-	-	-	-	1.15	0.02	0.83	-	-	-	-	O=4
29	125-2, 11R	ILM+OL+FSPN	OL	**Wt.%**	**33.6**	**1.4**	**-**	**-**	**-**	**41.0**	**0.5**	**23.3**	**-**	**-**	**-**	**-**	**99.8**
				F. c.	0.97	0.03	-	-	-	0.99	0.01	1.00	-	-	-	-	O=4
30	125-2, 12R	ILM+OL+CPX+OPX	OL	**Wt.%**	**34.2**	**-**	**-**	**-**	**-**	**46.2**	**0.5**	**19.7**	**-**	**-**	**-**	**-**	**100.6**
				F. c.	1.00	-	-	-	-	1.13	0.01	0.86	-	-	-	-	O=4
31	P s, p 1	ILM+TIMT+OL+PL2 +PdCu+FSPN	ILM	**Wt.%**	**-**	**50.8**	**-**	**0.7**	**8.0**	**39.6**	**0.5**	**1.0**	**-**	**-**	**-**	**-**	**100.6**
				F. c.	-	0.96	-	0.01	0.15	0.83	0.01	0.04	-	-	-	-	ΣK=2
32	P s, p 4	ILM+OPX+BORN +FSPN	ILM	**Wt.%**	**-**	**50.7**	**-**	**1.3**	**3.7**	**42.5**	**0.4**	**1.5**	**-**	**-**	**-**	**-**	**100.1**
				F. c.	-	0.95	-	0.03	0.07	0.89	0.01	0.05	-	-	-	-	ΣK=2
33	P s, p 5	ILM+BORM+PdCu +CPX+OPX	ILM	**Wt.%**	**-**	**50.2**	**-**	**1.8**	**1.8**	**41.8**	**3.3**	**-**	**-**	**-**	**-**	**-**	**98.9**
				F. c.	-	0.97	-	0.04	0.03	0.89	0.07	-	-	-	-	-	ΣK=2
34	125-1, 1R	ILM+HB+PL	ILM	**Wt.%**	**-**	**51.7**	**-**	**0.6**	**1.8**	**43.7**	**0.4**	**1.3**	**-**	**-**	**-**	**-**	**99.5**
				F. c.	-	0.98	-	0.01	0.03	0.92	0.01	0.05	-	-	-	-	ΣK=2
35	125-1, 2R	ILM+OPX+BT	ILM	**Wt.%**	**-**	**50.9**	**-**	**0.5**	**4.2**	**41.9**	**0.6**	**1.9**	**-**	**-**	**-**	**-**	**100.0**
				F. c.	-	0.95	-	0.01	0.08	0.87	0.01	0.07	-		-	-	ΣK=2
36	125-1, 3R	ILM+HB	ILM	**Wt.%**	**-**	**51.0**	**-**	**0.4**	**3.8**	**42.7**	**0.5**	**1.4**	**-**	**-**	**-**	**-**	**99.8**
				F. c.	-	0.96	-	0.01	0.07	0.90	0.01	0.05	-	-	-	-	ΣK=2
37	125-1, 5R	ILM+OL+PL2	ILM	**Wt.%**	**-**	**51.8**	**-**	**0.4**	**2.5**	**44.0**	**0.6**	**0.8**	**-**	**-**	**-**	**-**	**100.1**
				F. c.	-	0.98	-	0.01	0.05	0.92	0.01	0.03	-	-	-	-	ΣK=2
38	125-2, w.n.	ILM+OL	ILM	**Wt.%**	**-**	**51.4**	**-**	**0.4**	**3.5**	**41.8**	**0.6**	**2.1**	**-**	**-**	**-**	**-**	**99.8**
				F. c.	-	0.97	-	0.01	0.06	0.87	0.01	0.08	-	-	-	-	ΣK=2
39	125-2, 4R	ILM+BT+BORN	ILM	**Wt.%**	**-**	**50.3**	**-**	**0.4**	**4.5**	**42.0**	**0.8**	**1.4**	**-**	**-**	**-**	**-**	**99.4**
				F. c.	-	0.95	-	0.01	0.09	0.88	0.02	0.05	-	-	-	-	ΣK=2
40	125-2, 12R	ILM+OL+CPX+OPX	ILM	**Wt.%**	**-**	**50.9**	**-**	**0.4**	**3.6**	**42.8**	**0.6**	**1.4**	**-**	**-**	**-**	**-**	**99.7**
				F. c.	-	0.96	-	0.01	0.07	0.90	0.01	0.05	-	-	-	-	ΣK=2
41	P s, p 1	TIMT+ILM+OL+CP X+OPX	TIMT	**Wt.%**	**-**	**8.3**	**3.1**	**2.1**	**47.5**	**39.6**	**-**	**-**	**-**	**-**	**-**	**-**	**100.6**
				F. c.	-	0.23	0.14	0.06	1.33	1.24	-	-	-	-	-	-	ΣK=3

Table 1continued: Chemical composition and formulas of silicates and oxides of oxide-rich tholeiitic gabbros (sample 90-18, 1010)

An.	Object	Association of minerals	Mineral		SiO_2	TiO_2	Al_2O_3	V_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Cl	Total
42	P s, p 1	ILM+TIMT+OL+PL2 +PdCu+CHL	MT	**Wt.%**	**-**	**2.8**	**-**	**1.9**	**62.2**	**31.4**	**-**	**-**	**-**	**-**	**-**	**-**	**98.3**
				F. c.	-	0.08	-	0.06	1.97	1.08	-	-	-	-	-	-	ΣK=3
43	P s, p 8	PL1+CPX+OPX+ ILM+MT	MT	**Wt.%**	**-**	**0.6**	**-**	**0.6**	**67.3**	**31.4**	**-**	**-**	**-**	**-**	**-**	**-**	**99.9**
				F. c.	-	0.02	-	0.02	1.95	1.01	-	-	-	-	-	-	ΣK=3
44	125-2, 4	PdCu+BORN+MT	MT	**Wt.%**	**-**	**0.9**	**-**	**-**	**67.3**	**31.9**	**-**	**-**	**-**	**-**	**-**	**-**	**100.1**
				F. c.	-	0.03	-	-	1.95	1.03	-	-	-	-	-	-	ΣK=3
45	P s, p 1	ILM+TIMT+OL+PL2 +BT+PdCu+FSPN	BT	**Wt.%**	**39.8**	**2.0**	**15.1**	**-**	**-**	**13.5**	**-**	**18.9**	**0.8**	**-**	**8.3**	**-**	**98.4**
				F. c.	2.82	0.11	1.27	-	-	0.80	-	2.00	0.06	-	0.75	-	O=11
46	P s, p 8	ILM+MT+BORN+BT +CPX+OPX	BT	**Wt.%**	**39.4**	**2.3**	**15.4**	**-**	**-**	**11.8**	**-**	**20.3**	**-**	**-**	**10.1**	**-**	**99.3**
				F. c.	2.78	0.12	1.28	-	-	0.70	-	2.14	-	-	0.91	-	O=11
47	P s, p1	ILM+TIMT+OL+PL2 +FSPN	FSPN	**Wt.%**	**33.7**	**-**	**9.4**	**-**	**6.6**	**26.8**	**-**	**3.9**	**2.6**	**-**	**-**	**-**	**83.0**
				F. c.	3.03	-	0.99	-	0.45	2.01	-	0.52	0.25	-	-	-	O=11
48	P s, p2	TIMT+OL+FSPN+ PL2+BT+HB	FSPN	**Wt.%**	**27.8**	**-**	**14.6**	**-**	**14.2**	**20.4**	**-**	**3.5**	**2.6**	**-**	**-**	**-**	**83.1**
				F. c.	2.50	-	1.55	-	0.46	1.53	-	0.47	0.25	-	-	-	O=11
49	P s, p4	ILM+FSPN+OPX	FSPN	**Wt.%**	**37.2**	**0.5**	**8.5**	**-**	**-**	**28.2**	**-**	**6.0**	**3.5**	**-**	**-**	**-**	**83.9**
				F. c.	3.23	0.04	0.87	-	-	2.05	-	0.77	0.33	-	-	-	O=11
50	125-1, 2R	ILM+OPX+BT	BT	**Wt.%**	**37.0**	**3.6**	**14.7**	**-**	**-**	**16.7**	**-**	**17.9**	**0.3**	**1.9**	**5.9**	**-**	**98.0**
				F. c.	2.68	0.20	1.25	-	-	1.01	-	1.93	0.03	0.26	0.55	-	O=11
51	125-1, 5R	ILM+BT	BT	**Wt.%**	**39.2**	**3.0**	**14.8**	**-**	**-**	**12.0**	**-**	**20.7**	**-**	**-**	**9.4**	**-**	**99.1**
				F. c.	2.76	0.16	1.23	-	-	0.71	-	2.18	-	-	0.84	-	O=11
52	P s, p7	ILM+BORN+HB+ OPX+CPX	HB	**Wt.%**	**42.8**	**2.9**	**10.2**	**-**	**-**	**16.1**	**-**	**11.9**	**11.1**	**3.3**	**1.0**	**0.35**	**99.65**
				F. c.	6.35	0.32	1.79	-	-	2.00	-	2.63	1.76	0.95	0.20	0.09	O=23
53	125-1, 1R	ILM+HB+PL	HB	**Wt.%**	**41.3**	**2.8**	**10.5**	**-**	**4.3**	**11.4**	**-**	**12.7**	**12.0**	**2.1**	**1.0**	**-**	**98.1**
				F. c.	6.14	0.31	1.84	-	0.48	1.43	-	2.81	1.91	0.58	0.19	-	O=23
54	125-1, 3R	ILM+HB	HB	**Wt.%**	**42.9**	**0.6**	**11.5**	**-**	**-**	**15.8**	**0.2**	**11.6**	**12.7**	**2.4**	**0.2**	**-**	**97.9**
				F. c.	6.42	0.07	2.03	-	-	1.97	0.03	2.58	2.04	0.67	0.03	-	O=23

Table 1 continued: Chemical composition and formulas of silicates and oxides of oxide-rich tholeiitic gabbros (sample 90-18, 1010)

An.	Object	Association of minerals	Mineral		SiO_2	TiO_2	Al_2O_3	V_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Cl	Total
55	125-2, 10R	ILM+HB	HB	**Wt.%**	**41.4**	**2.0**	**10.1**	**-**	**6.3**	**9.4**	**-**	**13.4**	**12.6**	**1.9**	**1.0**	**-**	**98.1**
				F. c.	6.17	0.22	1.77	-	0.71	1.16	-	2.96	2.01	0.52	0.18	-	O=23
56	75-2, 7R	BORN+CHC+HB+ ACT	HB	**Wt.%**	**43.6**	**3.2**	**8.3**	**-**	**3.7**	**10.8**	**-**	**10.8**	**12.0**	**1.2**	**0.9**	**-**	**98.1**
				F. c.	6.52	0.37	1.47	-	0.42	2.41	-	2.41	1.92	0.33	0.17	-	O=23
57	75-2, 7R	BORN+CHC+HB+ ACT	ACT	**Wt.%**	**52.2**	**-**	**-**	**-**	**-**	**28.0**	**0.3**	**6.7**	**11.3**	**-**	**-**	**-**	**98.5**
				F. c.	8.00	-	-	-	-	3.59	0.04	1.53	1.85	-	-	-	O=23
58	125-2, 3R	ILM+MT+OL+FSPN	FSPN	**Wt.%**	**30.5**	**0.8**	**8.5**	**-**	**18.9**	**17.8**	**-**	**5.9**	**1.8**	**-**	**-**	**-**	**84.2**
				F. c.	2.70	0.05	0.88	-	1.26	1.32	-	0.78	0.18	-	-	-	O=11
59	125-2, 11R	ILM+OL+FSPN	FSPN	**Wt.%**	**29.4**	**0.9**	**6.2**	**-**	**27.3**	**13.0**	**-**	**7.0**	**1.2**	**-**	**-**	**-**	**85.0**
				F. c.	2.59	0.06	0.64	-	1.82	0.96	-	0.93	0.12	-	-	-	O=11

P. s. – polished section, f. c. – formula coefficient; FeO and Fe_2O_3 – are colculated from tipical formula of minerals, ΣK – sum of kations.

Table 2: Chemical composition and formulas of Cu-Fe-Ni-Co-sulphides in PGM-bearing aggregates of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain	Mineral		Cu	Fe	Ni	Co	Rh	S	Total
1	45-1, 12	VYS+BORN+DGN	BORN	**Wt.%**	**60.7**	**11.4**	**-**	-	-	**26.1**	**98.2**
				F. c.	4.84	1.03	-	-	-	4.13	10
2	45-1, 12	VYS+BORN+DGN	DGN	**Wt.%**	**75.7**	**1.3**	**-**	**-**	**-**	**22.1**	**99.1**
				F. c.	8.72	0.17	-	-	-	5.11	14
3	45-1, 21	PdCu+DGN	DGN	**Wt.%**	**74.7**	**1.6**	**-**	**-**	**-**	**23.0**	**99.3**
				F. c.	8.57	0.21	-	-	-	5.22	14
4	45-1, 25	(Pd,Pt)Cu+VSL+BORN+ CP	CP	**Wt.%**	**38.2**	**28.9**	**-**	**-**	**-**	**33.0**	**100.1**
				F. c.	1.12	0.96	-	-	-	1.92	4
5	45-1, 25	(Pd,Pt)Cu+VSL+BORN+ CP	BORN	**Wt.%**	**62.6**	**12.2**	**-**	**-**	**-**	**23.9**	**98.7**
				F. c.	5.05	1.12	-	-	-	3.83	10
6	45-1, 47	VYS+DGN+BORN	DGN	**Wt.%**	**77.2**	**1.1**	**-**	**-**	**-**	**21.6**	**99.9**
				F. c.	8.90	0.15	-	-	-	4.95	14
7	45-1, 47	VYS+DGN+BORN	BORN	**Wt.%**	**61.8**	**11.8**	**-**	**-**	**-**	**26.3**	**99.9**
				F. c.	4.86	1.06	-	-	-	4.07	10
8	45-1, 50	VYS+CHC+BORN	CHC	**Wt.%**	**76.1**	**1.6**	**-**	**-**	**-**	**20.7**	**98.4**
				F. c.	1.92	0.05	-	-	-	1.03	3
9	45-1, 52	(Pd,Au)Cu+$PdAuCu_2$+ CHC+BORN	CHC	**Wt.%**	**77.8**	**0.7**	**-**	**-**	**-**	**21.4**	**99.9**
				F. c.	1.94	0.02	-	-	-	1.04	3
10	45-1, 56	(Pd,Au)Cu+$PdAuCu_2$+ CHC+BORN	CHC	**Wt.%**	**77.2**	**1.0**	**-**	**-**	**-**	**21.1**	**99.3**
				F. c.	1.93	0.03	-	-	-	1.04	3
11	45-1, 64	(Pd,Au)Cu+CHC+CHL	CHC	**Wt.%**	**78.2**	**0.8**	**-**	**-**	**-**	**20.9**	**99.9**
				F. c.	1.95	0.02	-	-	-	1.03	3
12	45-1, 70	VYS+CHC	CHC	**Wt.%**	**76.6**	**1.1**	**-**	**-**	**-**	**20.9**	**98.6**
				F. c.	1.93	0.03	-	-	-	1.04	3
13	45-1, 72	PdCu+KTH+(Pd,Sn,Cu)+ COV?	COV?	**Wt.%**	**70.9**	**1.8**	**-**	**-**	**-**	**28.2**	**100.9**
				F. c.	1.10	0.03	-	-	-	0.87	2

Table 2 continued: Chemical composition and formulas of Cu-Fe-Ni-Co-sulphides in PGM-bearing aggregates of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain	Mineral		Cu	Fe	Ni	Co	Rh	S	Total
14	45-1, 74	PdCu+Au+CHC	CHC	**Wt.%**	**74.3**	**2.8**	**-**	**-**	**-**	**21.2**	**98.3**
				F. c.	1.87	0.08	-	-	-	1.05	3
15	45-1, 78	(Pd,Au)Cu(Au,Pd)Cu+ CHC	CHC	**Wt.%**	**77.7**	**1.3**	**-**	**-**	**-**	**20.6**	**99.6**
				F. c.	1.94	0.04	-	-	-	1.02	3
16	45-1, 82	(Pd,Cu,Sn)+CHC	CHC	**Wt.%**	**76.4**	**0.8**	**-**	**-**	**-**	**20.9**	**98.1**
				F. c.	1.93	0.02	-	-	-	1.05	3
17	45-1, 83	PdCu+CHC	CHC	**Wt.%**	**77.4**	**1.0**	**-**	**-**	**-**	**20.4**	**98.8**
				F. c.	1.95	0.03	-	-	-	1.02	3
18	45-1, 85	VYS+CHC+BORN	CHC	**Wt.%**	**77.2**	**1.7**	**-**	**-**	**-**	**19.4**	**98.3**
				F. c.	1.97	0.05	-	-	-	0.98	3
19	45-1, 89	VYS+(Pd,Sn,Fe)+CHC+ BORN	CHC	**Wt.%**	**77.0**	**1.3**	**-**	**-**	**-**	**20.4**	**98.7**
				F. c.	1.94	0.04	-	-	-	1.02	3
20	45-1, 95	(Pd,Cu,Sn)+CHC	CHC	**Wt.%**	**77.2**	**0.8**	**-**	**-**	**-**	**20.3**	**98.3**
				F. c.	1.96	0.02	-	-	-	1.02	3
21	45-1, 96	PdCu+CHC+BORN	CHC	**Wt.%**	**78.2**	**0.9**	**-**	**-**	**-**	**20.0**	**99.1**
				F. c.	1.97	0.03	-	-	-	1.00	10
22	45-1, 96	PdCu+CHC+BORN	BORN	**Wt.%**	**61.7**	**11.9**	**-**	**-**	**-**	**25.6**	**99.2**
				F. c.	4.90	1.07	-	-	-	4.03	10
23	45-1, 106	VYS+CHC	CHC	**Wt.%**	**77.4**	**1.2**	**-**	**-**	**-**	**20.3**	**98.9**
				F. c.	1.96	0.03	-	-	-	1.01	3
24	45-1, 110	VSL+CHC+BORN	CHC	**Wt.%**	**78.2**	**0.5**	**-**	**-**	**-**	**19.9**	**98.6**
				F. c.	1.99	0.01	-	-	-	1.00	3
25	45-2, 12	VYS+CHC+MT	CHC	**Wt.%**	**77.8**	**0.7**	**-**	**-**	**-**	**20.9**	**99.4**
				F. c.	1.95	0.02	-	-	-	1.03	3
26	75-1, 1	(Pd,Au)3Cu+(Au,Pd)Cu+ BORN	BORN	**Wt.%**	**61.6**	**12.1**	**-**	**-**	**-**	**25.9**	**99.6**
				F. c.	4.86	1.08	-	-	-	4.06	10
27	75-1, 15	VYS+(Au,Ag)+DGN	DGN	**Wt.%**	**76.2**	**0.6**	**-**	**-**	**-**	**21.7**	**98.5**
				F. c.	8.90	0.08	-	-	-	5.02	14

Table 2 continued: Chemical composition and formulas of Cu-Fe-Ni-Co-sulphides in PGM-bearing aggregates of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain	Mineral		Cu	Fe	Ni	Co	Rh	S	Total
28	75-2, 1	(Pd,Au)Cu+KTH+VYS +CHC	CHC	**Wt.%**	**77.4**	**0.4**	**-**	**-**	**-**	**21.0**	**98.8**
				F. c.	1.94	0.01	-	-	-	1.05	3
29	75-2, 2	(Pd,Au)Cu+VSL+KTH+ BORN+CHC	CHC	**Wt.%**	**77.4**	**1.8**	**-**	**-**	**-**	**19.6**	**98.8**
				F. c.	1.96	0.05	-	-	-	0.99	3
30	75-2, 5	VYS+PdCu+AT+COPN +CHC	CHC	**Wt.%**	**77.6**	**0.7**	**-**	**-**	**-**	**20.8**	**99.1**
				F. c.	1.95	0.02	-	-	-	1.03	3
31	75-2, 8	VYS+BORN+CHL	BORN	**Wt.%**	**62.1**	**11.7**	**-**	**-**	**-**	**25.6**	**99.4**
				F. c.	4.92	1.05	-	-	-	4.03	10
32	75-2, 9	PdCu+BORN	BORN	**Wt.%**	**62.2**	**11.8**	**-**	**-**	**-**	**24.4**	**98.4**
				F. c.	5.02	1.08	-	-	-	3.90	10
33	75-2, 10	(Pd,Au)$_3$Cu+VYS+BORN+ CHC	BORN	**Wt.%**	**63.1**	**11.4**	**-**	**-**	**-**	**24.1**	**98.6**
				F. c.	5.10	1.04	-	-	-	3.86	10
34	75-2, 10	(Pd,Au)$_3$Cu+VYS+BORN+ CHC	CHC	**Wt.%**	**76.6**	**1.1**	**-**	**-**	**-**	**20.1**	**99.8**
				F. c.	1.96	0.03	-	-	-	1.01	3
35	75-2, 11	VYS+BORN+CPX	BORN	**Wt.%**	**63.1**	**11.9**	**-**	**-**	**-**	**24.4**	**99.4**
				F. c.	5.00	1.09	-	-	-	3.91	10
36	75-2, 15	VYS+CHC	CHC	**Wt.%**	**79.0**	**-**	**-**	**-**	**-**	**20.8**	**99.8**
				F. c.	1.97	-	-	-	-	1.03	3
37	75-2, 16	VYS+BORN+BT	BORN	**Wt.%**	**61.7**	**11.6**	**-**	**-**	**-**	**25.2**	**98.5**
				F. c.	4.95	1.05	-	-	-	4.00	10
38	75-2, 17	VYS+BORN	BORN	**Wt.%**	**61.8**	**11.8**	**-**	**-**	**-**	**24.7**	**98.8**
				F. c.	4.94	1.07	-	-	-	3.99	10
40	75-2, 21	PdCu+(Pd,Cu,Sn)+CHC	CHC	**Wt.%**	**77.1**	**1.7**		**-**		**20.1**	**98.9**
				F. c.	1.94	0.05		-		1.01	3
41	75-2, 22	PdCu+BORN+CHC	CHC	**Wt.%**	**77.2**	**1.4**	**-**	**-**	**-**	**19.7**	**98.3**
				F. c.	1.96	0.04	-	-	-	1.00	3
42	75-2, 23	VYS+BORN+DGN+OPX	DGN	**Wt.%**	**75.3**	**1.7**	**-**	**-**	**-**	**21.9**	**98.8**
				F. c.	8.75	0.22	-	-	-	5.03	3

Table 2 continued: Chemical composition and formulas of Cu-Fe-Ni-Co-sulphides in PGM-bearing aggregates of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain	Mineral		Cu	Fe	Ni	Co	Rh	S	Total
43	75-2, 23	VYS+BORN+DGN+OPX	BORN	**Wt.%**	**63.0**	**10.2**	**-**	**-**	**-**	**25.2**	**98.4**
				F. c.	5.06	0.93	-	-	-	4.01	10
44	75-2, 24	VYS+BORN+CHC	BORN	**Wt.%**	**62.1**	**11.7**	**-**	**-**	**-**	**25.3**	**99.1**
				F. c.	4.94	1.06	-	-	-	4.00	10
45	75-2, 30	VYS+CHC	CHC	**Wt.%**	**78.3**	**1.1**	**-**	**-**	**-**	**20.4**	**99.8**
				F. c.	1.96	0.03	-	-	-	1.01	3
An.	Grain	Association of minerals in the grain	Mineral		Cu	Fe	Ni	Co	Rh	S	Total
46	75-2, 32	(Pd,Pt)Cu+(Pt,Cu,Fe)+ BORN	BORN	**Wt.%**	**62.8**	**11.8**	**-**	**-**	**-**	**25.3**	**99.9**
				F. c.	4.97	1.08	-	-	-	3.97	10
47	75-2, 5	VYS+PdCu+AT+COPN +CHC	COPN	**Wt.%**	**1.5**	**6.8**	**17.3**	**34.4**	**7.8**	**31.8**	**99.6**
				F. c.	0.20	0.99	2.40	4.74	0.61	0.06	17
48	75-2, 13	PdCu+AT+COPN+CHC +MT	COPN	**Wt.%**	**1.1**	**6.6**	**13.8**	**44.5**	**-**	**33.3**	**99.3**
				F. c.	0.13	0.93	1.85	5.94	-	8.15	17

Table 3: PGE and Au minerals of heavy concentrates of the sample 90-18, 1010

N	Mineral	General formula	Number of grains	Grain size (E.C.D), µm			Vol.%
				min	max	average	
1	Unnamed PdCu	(Pd,Au,Pt)(Cu,Fe,Zn)	100	1	46	18	63
2	Vysotskite	(Pd,Ni,Cu)S	46 (6*)	3	53	15	24
3	Vasilite	$Pd_{12}(Cu,Fe)_4S_7$	9 (6*)	2	22	14	3.2
4	Braggite	(Pd,Pt,Cu)(S,Te)	1	-	-	31	1.4
5	Keithconnite	$(Pd,Cu)_{3-x}(Te,Pb,Sn)$	3 (11*)	2	20	10	1.8
6	Atokite	$(Pd,Cu)_3Sn$	(8*)	2	10	5	0.5
7	Zvyagintsevite	Pd_3Pb	(5*)	1	4	3	0.1
8	Guanglinite	$Pd_3(As,Sn,Sb)$	1	-	-	12	0.2
9	Isomertieite	$(Pd,Cu)_{11}As_2(Sb,Sn)_2$	1	-	-	4	<0.1
10	Unnamed $PdAuCu_2$	$(Pd,Pt)Au(Cu,Fe)_2$	6	10	25	15	2.0
11	Tetra-auricupride	(Au,Pd,Pt)(Cu,Fe)	4 (1*)	2	25	15	1.6
12	Bogdanovite	$(Au,Pd,Pt)_3(Cu,Fe)$	2 (1*)	5	19	11	0.8
13	Au-Ag-alloy	(Au,Ag)	1 (1*)	1	3	2	<0.1
14	Unnamed Pd_3Cu	$(Pd,Au)_3(Cu,Fe)$	1 (3*)	3	15	8	0.5
15	Unnamed $PdCu_3$	$PdCu_3$	1	-	-	11	0.1
16	Pd-Cu-Sn-alloy	(Pd,Cu,Sn,Fe,Te,Pb)	2 (12*)	2	9	5	0.5
17	Pt-Fe-Cu-alloy	(Pt,Cu,Fe,Pd)	2 (1*)	4	8	6	0.1
	Total		180			16	100

*As inclusions in grains of other precious metal minerals.

Table 4: Chemical composition and formulas of the unnamed mineral phase PdCu, $PdCu_3$ and Pd_3Cu compositions in PGM-grains of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain		Pd	Pt	Au	Cu	Fe	Zn	Sn	Te	Pb	Total
1	45-1, 3	PdCu+AT+(Pd,Cu,Sn)	**Wt.%**	**59.5**	**-**	**1.5**	**31.3**	**1.5**	**-**	**1.5**	**-**	**3.6**	**98.9**
			F. c.	1.00	-	0.02	0.88	0.05	-	0.02	-	0.03	2
2	45-1, 4	(Pd,Pt)Cu+BORN	**Wt.%**	**46.4**	**15.0**	**-**	**28.5**	**6.4**	**2.4**	**-**	**-**	**-**	**98.7**
			F. c.	0.78	0.14	-	0.81	0.21	0.06	-	-	-	2
3	45-1, 5	PdCu+ZV+BORN+CHC	**Wt.%**	**60.8**	**-**	**2.3**	**31.2**	**2.4**	**3.3**	**-**	**0.6**	**-**	**100.6**
			F. c.	0.97	-	0.02	0.84	0.07	0.09	-	0.01	-	2
4	45-1, 6	(Pd,Au)Cu	**Wt.%**	**50.4**	**1.5**	**11.5**	**32.0**	**1.6**	**0.9**	**-**	**1.6**	**-**	**99.5**
			F. c.	0.86	0.01	0.11	0.92	0.05	0.03	-	0.02	-	2
5	45-1, 7	PdCu+KTH	**Wt.%**	**58.8**	**3.2**	**1.0**	**28.9**	**3.8**	**2.7**	**-**	**0.6**	**-**	**99.0**
			F. c.	0.97	0.03	0.01	0.79	0.12	0.07	-	0.01	-	2
6	45-1, 8	(Pd,Au)Cu+$PdAuCu_2$+ILM	**Wt.%**	**43.1**	**5.4**	**16.4**	**30.9**	**1.5**	**-**	**-**	**-**	**1.5**	**98.8**
			F. c.	0.78	0.05	0.16	0.94	0.05	-	-	-	0.02	2
7	45-1, 9	PdCu+BORN+CHC	**Wt.%**	**62.8**	**-**	**-**	**30.5**	**4.0**	**2.7**	**-**	**-**	**-**	**100.0**
			F. c.	1.00	-	-	0.81	0.12	0.07	-	-	-	2
8	45-1, 13	PdCu+BORN+CHC	**Wt.%**	**59.7**	**-**	**2.3**	**31.9**	**2.1**	**1.5**	**-**	**0.7**	**-**	**98.2**
			F. c.	0.98	-	0.02	0.88	0.07	0.04	-	0.01	-	2
9	45-1, 14	PdCu	**Wt.%**	**59.2**	**1.1**	**1.6**	**29.7**	**1.6**	**0.7**	**3.1**	**-**	**2.6**	**99.6**
			F. c.	1.00	0.01	0.01	0.84	0.05	0.02	0.05	-	0.02	2
10	45-1, 15	PdCu+AT+BORN+CHC	**Wt.%**	**55.4**	**3.3**	**3.0**	**33.6**	**1.3**	**-**	**-**	**-**	**2.3**	**98.9**
			F. c.	0.94	0.02	0.02	0.95	0.04	-	-	-	0.02	2
11	45-1, 16	PdCu+BORN	**Wt.%**	**48.2**	**7.1**	**8.5**	**30.7**	**2.7**	**-**	**2.0**	**-**	**-**	**99.2**
			F. c.	0.84	0.07	0.08	0.89	0.09	-	0.03	-	-	2
12	45-1, 17	(Pd,Au)Cu+(Pd,Au)3Cu	**Wt.%**	**51.8**	**1.7**	**11.2**	**29.2**	**4.2**	**0.8**	**-**	**-**	**-**	**98.9**
			F. c.	0.88	0.02	0.10	0.84	0.14	0.02	-	-	-	2
13	45-1, 19	PdCu+BORN	**Wt.%**	**61.4**	**-**	**-**	**31.2**	**2.1**	**1.3**	**-**	**-**	**3.9**	**99.9**
			F. c.	1.01	-	-	0.86	0.07	0.03	-	-	0.03	2
14	45-1, 20	PdCu+BORN	**Wt.%**	**57.0**	**-**	**4.7**	**30.5**	**3.5**	**1.9**	**-**	**1.5**	**-**	**99.1**
			F. c.	0.94	-	0.04	0.84	0.11	0.05	-	0.02	-	2
15	45-1, 21	PdCu+DGN	**Wt.%**	**61.8**	**-**	**-**	**31.9**	**4.5**	**-**	**-**	**-**	**-**	**98.2**
			F. c.	1.00	-	-	0.86	0.14	-	-	-	-	2

Table 4 continued: Chemical composition and formulas of the unnamed mineral phase PdCu, $PdCu_3$ and Pd_3Cu compositions in PGM-grains of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain		Pd	Pt	Au	Cu	Fe	Zn	Sn	Te	Pb	Total
16	45-1, 22	(Pd,Au)Cu	**Wt.%**	**46.5**	**1.0**	**16.9**	**31.8**	**1.5**	**0.8**	**-**	**0.9**	**-**	**99.4**
			F. c.	0.82	0.01	0.16	0.93	0.05	0.02	-	0.01	-	2
17	45-1, 23	PdCu+(Pd,Cu,Sn)+CHC	**Wt.%**	**60.2**	**-**	**1.2**	**28.4**	**3.8**	**0.8**	**4.5**	**-**	**-**	**98.9**
			F. c.	1.00	-	0.01	0.78	0.12	0.02	0.07	-	-	2
18	45-1, 24	(Pd,Pt)Cu+CHC+BORN	**Wt.%**	**53.2**	**9.5**	**-**	**29.3**	**5.0**	**1.8**	**-**	**-**	**-**	**98.8**
			F. c.	0.89	0.08	-	0.82	0.16	0.05	-	-	-	2
19	45-1, 25	(Pd,Pt)Cu+VSL+BORN+CP	**Wt.%**	**47.4**	**11.0**	**5.0**	**28.4**	**3.5**	**2.7**	**-**	**0.8**	**-**	**98.8**
			F. c.	0.82	0.10	0.05	0.83	0.12	0.07	-	0.01	-	2
20	45-1, 26	(Pd,Pt)Cu+BORN +CHC	**Wt.%**	**53.5**	**7.6**	**-**	**29.8**	**5.7**	**2.1**	**-**	**-**	**-**	**98.7**
			F. c.	0.88	0.07	-	0.82	0.18	0.05	-	-	-	2
21	45-1, 27	PdCu+DGN	**Wt.%**	**63.9**	**-**	**-**	**33.8**	**1.2**	**0.6**	**-**	**-**	**-**	**99.5**
			F. c.	1.03	-	-	0.91	0.04	0.02	-	-	-	2
22	45-1, 29	(Pd,Pt)Cu+ZV+BORN	**Wt.%**	**54.1**	**7.7**	**1.0**	**29.4**	**2.9**	**1.3**	**-**	**-**	**3.4**	**99.8**
			F. c.	0.92	0.07	0.01	0.84	0.09	0.04	-	-	0.03	2
23	45-1, 30	PdCu +BORN	**Wt.%**	**56.9**	**3.8**	**1.0**	**29.7**	**3.5**	**2.0**	**-**	**2.1**	**-**	**99.0**
			F. c.	0.94	0.03	0.01	0.82	0.11	0.06	-	0.03	-	2
24	45-1, 31	(Pd,Pt)Cu+BORN+CHC	**Wt.%**	**57.5**	**5.4**	**1.8**	**27.4**	**4.5**	**2.9**	**-**	**-**	**-**	**99.3**
			F. c.	0.95	0.05	0.02	0.76	0.14	0.08	-	-	-	2
25	45-1, 35	PdCu+CHC+BORN	**Wt.%**	**59.5**	**1.3**	**2.1**	**29.5**	**1.6**	**1.0**	**2.5**	**0.9**	**1.3**	**99.7**
			F. c.	1.00	0.01	0.02	0.83	0.05	0.03	0.04	0.01	0.01	2
26	45-1, 36	PdCu+CHC+BORN	**Wt.%**	**61.3**	**-**	**-**	**29.0**	**3.7**	**4.0**	**-**	**-**	**-**	**98.0**
			F. c.	0.99	-	-	0.79	0.11	0.11	-	-	-	2
27	45-1, 37	PdCu	**Wt.%**	**59.8**	**-**	**1.1**	**30.3**	**2.9**	**0.9**	**1.0**	**-**	**2.5**	**98.5**
			F. c.	0.99	-	0.01	0.84	0.09	0.02	0.02	-	0.02	2
28	45-1, 38	PdCu +(Pd,Cu,Sn)+BORN+MT	**Wt.%**	**59.7**	**1.00**	**1.3**	**29.0**	**1.7**	**1.0**	**4.7**	**-**	**1.4**	**98.8**
			F. c.	1.00	0.01	0.01	0.82	0.05	0.03	0.07	-	0.01	2
29	45-1, 39	PdCu	**Wt.%**	**61.3**	**-**	**1.0**	**31.3**	**1.7**	**2.3**	**-**	**1.3**	**-**	**98.9**
			F. c.	1.00	-	0.01	0.86	0.05	0.06	-	0.02	-	2

Table 4 continued: Chemical composition and formulas of the unnamed mineral phase PdCu, $PdCu_3$ and Pd_3Cu compositions in PGM-grains of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain		Pd	Pt	Au	Cu	Fe	Zn	Sn	Te	Pb	Total
30	45-1, 40	PdCu+ AT+BORN+CHC	**Wt.%**	**53.2**	**4.7**	**5.2**	**30.1**	**1.9**	**-**	**3.7**	**-**	**-**	**98.8**
			F. c.	0.92	0.04	0.05	0.87	0.06	-	0.6	-	-	2
31	45-1, 42	(Pd,Au)Cu	**Wt.%**	**43.8**	**2.7**	**19.2**	**30.9**	**1.4**	**0.5**	**-**	**-**	**-**	**98.5**
			F. c.	0.79	0.03	0.19	0.93	0.05	0.01	-	-	-	2
32	45-1, 48	PdCu+ZV+CHC	**Wt.%**	**55.0**	**1.1**	**6.2**	**31.1**	**2.7**	**1.7**	**-**	**1.3**	**-**	**99.1**
			F. c.	0.91	0.01	0.06	0.87	0.08	0.05	-	0.02	-	2
33	45-1, 49	PdCu	**Wt.%**	**54.7**	**2.5**	**6.2**	**30.0**	**3.6**	**0.5**	**-**	**1.8**	**-**	**99.3**
			F. c.	0.92	0.02	0.06	0.85	0.10	0.01	-	0.02	-	2
34	45-1, 52	PdCu+$PdAuCu_2$+CHC+BORN	**Wt.%**	**57.3**	**-**	**5.4**	**31.2**	**4.0**	**0.7**	**-**	**1.2**	**-**	**99.8**
			F. c.	0.94	-	0.05	0.85	0.12	0.02	-	0.02	-	2
35	45-1, 53	(Pd,Pt)Cu+BORN+OPX	**Wt.%**	**51.9**	**9.4**	**-**	**29.6**	**4.7**	**1.4**	**-**	**-**	**1.9**	**98.9**
			F. c.	0.87	0.09	-	0.83	0.15	0.04	-	-	0.02	2
36	45-1, 55	(Pd,Au)Cu+BORN	**Wt.%**	**39.9**	**2.1**	**23.9**	**32.1**	**0.7**	**0.7**	**-**	**-**	**-**	**99.4**
			F. c.	0.73	0.02	0.23	0.98	0.02	0.02	-	-	-	2
37	45-1, 56	(Pd,Au)Cu+$PdAuCu_2$+CHC+BORN	**Wt.%**	**41.8**	**2.0**	**21.7**	**31.7**	**0.9**	**0.5**	**-**	**0.6**	**-**	**99.2**
			F. c.	0.76	0.02	0.21	0.96	0.03	0.01	-	0.01	-	2
38	45-1, 57	(Pd,Pt)Cu+BORN	**Wt.%**	**44.5**	**16.7**	**-**	**28.7**	**7.6**	**1.2**	**-**	**-**	**-**	**98.7**
			F. c.	0.75	0.16	-	0.81	0.25	0.03	-	-	-	2
39	45-1, 58	(Pd,Pt)Cu+BORN	**Wt.%**	**55.1**	**6.2**	**-**	**29.5**	**4.2**	**2.2**	**-**	**-**	**1.3**	**98.5**
			F. c.	0.92	0.06	-	0.82	0.13	0.06	-	-	0.01	2
40	45-1, 59	PdCu+(Pd,Cu,Sn)+BORN+CHC	**Wt.%**	**56.8**	**3.6**	**-**	**31.1**	**2.5**	**0.7**	**4.4**	**-**	**-**	**99.1**
			F. c.	0.94	0.03	-	0.86	0.08	0.02	0.07	-	-	2
41	45-1, 60	PdCu+VSL+BORN	**Wt.%**	**59.8**	**2.8**	**-**	**28.8**	**5.5**	**1.8**	**-**	**0.8**	**-**	**99.5**
			F. c.	0.97	0.02	-	0.78	0.17	0.05	-	0.01	-	2
42	45-1, 61	(Pd,Au)Cu	**Wt.%**	**50.2**	**1.7**	**10.7**	**31.6**	**1.6**	**0.9**	**-**	**1.5**	**1.2**	**99.4**
			F. c.	0.87	0.02	0.10	0.91	0.05	0.02	-	0.02	0.01	2
43	45-1, 63	(Pd,Au)Cu+OPX	**Wt.%**	**43.8**	**2.1**	**19.0**	**32.7**	**0.8**	**0.7**	**-**	**-**	**-**	**99.1**
			F. c.	0.78	0.02	0.18	0.97	0.03	0.02	-	-	-	2

Table 4 continued: Chemical composition and formulas of the unnamed mineral phase PdCu, $PdCu_3$ and Pd_3Cu compositions in PGM-grains of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain		Pd	Pt	Au	Cu	Fe	Zn	Sn	Te	Pb	Total
44	45-1, 64	(Pd,Pt)Cu+CHC+CHL	**Wt.%**	**46.3**	**15.7**	**-**	**29.2**	**5.5**	**1.6**	**-**	**-**	**1.3**	**99.6**
			F. c.	0.79	0.15	-	0.83	0.18	0.04	-	-	0.01	2
45	45-1, 65	PdCu +CHC+BORN	**Wt.%**	**57.2**	**4.7**	**-**	**30.9**	**4.3**	**2.2**	**-**	**-**	**-**	**99.3**
			F. c.	0.93	0.04	-	0.84	0.13	0.06	-	-	-	2
46	45-1, 66	PdCu+BORN	**Wt.%**	**57.5**	**-**	**3.9**	**29.5**	**3.4**	**3.0**	**-**	**1.3**	**-**	**99.6**
			F. c.	0.95	-	0.03	0.81	0.11	0.08	-	0.02	-	2
47	45-1, 67	PdCu	**Wt.%**	**58.9**	**-**	**2.7**	**28.9**	**4.6**	**3.4**	**-**	**0.8**	**-**	**99.3**
			F. c.	0.95	-	0.03	0.78	0.14	0.09	-	0.01	-	2
48	45-1, 68	(Pd,Au)Cu+AT+BORN+CHC+CHL	**Wt.%**	**54.7**	**-**	**6.5**	**33.6**	**0.7**	**0.8**	**-**	**-**	**1.9**	**98.8**
			F. c.	0.92	-	0.06	0.95	0.02	0.01	-	-	0.02	2
49	45-1, 69	PdCu+CHC	**Wt.%**	**56.0**	**2.5**	**3.5**	**29.9**	**2.7**	**2.4**	**-**	**2.6**	**-**	**99.6**
			F. c.	0.93	0.02	0.03	0.83	0.08	0.07	-	0.04	-	2
50	45-1, 72	PdCu+ (Pd,Sn,Cu)+KTH+COV?	**Wt.%**	**57.6**	**2.1**	**3.1**	**28.9**	**4.2**	**1.8**	**1.4**	**-**	**-**	**99.1**
			F. c.	1.00	0.02	0.03	0.80	0.13	0.05	0.02	-	-	2
51	45-1, 73	PdCu+AT+BORN	**Wt.%**	**62.4**	**2.2**	**1.3**	**27.2**	**1.2**	**0.4**	**1.8**	**-**	**3.1**	**99.6**
			F. c.	1.07	0.02	0.01	0.79	0.04	0.01	0.03	-	0.03	2
52	45-1, 74	PdCu+Au+CHC	**Wt.%**	**61.0**	**-**	**2.0**	**29.2**	**3.5**	**2.9**	**-**	**-**	**-**	**98.6**
			F. c.	0.99	-	0.02	0.80	0.11	0.08	-	-	-	2
53	45-1, 77	PdCu+VYS+KTH+BORN	**Wt.%**	**58.8**	**1.4**	**1.8**	**29.9**	**3.1**	**3.0**	**-**	**-**	**1.0**	**99.0**
			F. c.	0.97	0.01	0.01	0.82	0.10	0.08	-	-	0.01	2
54	45-1, 78	(Pd,Au)Cu+(Au,Pd)Cu+CHC	**Wt.%**	**52.8**	**-**	**8.8**	**31.3**	**3.0**	**2.9**	**-**	**0.7**	**-**	**99.5**
			F. c.	0.87	-	0.08	0.87	0.09	0.08	-	0.01	-	2
55	45-1, 79	PdCu+(Pd,Sn,Cu)+BORN	**Wt.%**	**60.7**	**-**	**1.4**	**29.6**	**1.5**	**1.1**	**4.1**	**-**	**-**	**98.4**
			F. c.	1.02	-	0.01	0.83	0.05	0.03	0.06	-	-	2
56	45-1, 83	PdCu +CHC	**Wt.%**	**61.3**	**-**	**-**	**29.7**	**3.6**	**3.0**	**-**	**-**	**1.5**	**99.1**
			F. c.	0.99	-	-	0.81	0.11	0.08	-	-	0.01	2
57	45-1, 86	PdCu+BORN	**Wt.%**	**61.4**	**-**	**-**	**31.9**	**1.9**	**1.4**	**1.5**	**-**	**1.1**	**99.2**
			F. c.	1.00	-	-	0.87	0.06	0.04	0.02	-	0.01	2

Table 4 continued: Chemical composition and formulas of the unnamed mineral phase PdCu, $PdCu_3$ and Pd_3Cu compositions in PGM-grains of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain		Pd	Pt	Au	Cu	Fe	Zn	Sn	Te	Pb	Total
58	45-1, 87	(Pd,Au)Cu+VSL	**Wt.%**	**43.4**	**3.1**	**17.2**	**32.0**	**1.7**	**-**	**-**	**-**	**2.2**	**99.6**
			F. c.	0.77	0.03	0.17	0.95	0.06	-	-	-	0.02	2
59	45-1, 88	(Pd,Pt)Cu	**Wt.%**	**47.8**	**15.7**	**-**	**28.0**	**5.6**	**1.5**	**-**	**-**	**-**	**98.6**
			F. c.	0.82	0.15	-	0.81	0.18	0.04	-	-	-	2
60	45-1, 90	(Pd,Pt)Cu+BORN	**Wt.%**	**52.1**	**8.6**	**1.3**	**30.2**	**4.1**	**1.9**	**-**	**0.6**	**1.0**	**99.8**
			F. c.	0.87	0.08	0.01	0.84	0.13	0.05	-	0.01	0.01	2
61	45-1, 92	PdCu+OPX	**Wt.%**	**58.3**	**2.5**	**1.3**	**31.0**	**2.2**	**2.0**	**0.8**	**-**	**1.0**	**99.1**
			F. c.	0.97	0.02	0.01	0.86	0.07	0.05	0.01	-	0.01	2
62	45-1, 93	PdCu	**Wt.%**	**59.0**	**-**	**1.9**	**30.5**	**3.8**	**1.5**	**-**	**1.4**	**-**	**98.1**
			F. c.	0.97	-	0.02	0.84	0.12	0.04	-	0.02	-	2
63	45-1, 94	PdCu+BORN+CHC	**Wt.%**	**59.6**	**-**	**2.9**	**31.4**	**2.7**	**2.2**	**-**	**1.0**	**-**	**99.8**
			F. c.	0.97	-	0.03	0.85	0.08	0.06	-	0.01	-	2
64	45-1, 96	PdCu +CHC+BORN	**Wt.%**	**60.6**	**-**	**1.8**	**30.7**	**3.7**	**2.5**	**-**	**-**	**-**	**99.3**
			F. c.	0.98	-	0.02	0.83	0.11	0.06	-	-	-	2
65	45-1, 97	PdCu +AT+BORN	**Wt.%**	**57.8**	**1.2**	**3.4**	**31.1**	**3.7**	**1.3**	**-**	**-**	**-**	**98.5**
			F. c.	0.95	0.01	0.03	0.86	0.12	0.03	-	-	-	2
66	45-1, 98	(Pd,Au)Cu+$PdAuCu_2$+VSL+VYS	**Wt.%**	**42.7**	**4.4**	**16.9**	**32.1**	**0.9**	**0.7**	**-**	**-**	**1.9**	**99.6**
			F. c.	0.77	0.04	0.16	0.96	0.03	0.02	-	-	0.02	2
67	45-1, 100	(Pd,Au)Cu +BORN	**Wt.%**	**40.4**	**2.3**	**21.3**	**33.3**	**0.9**	**0.5**	**-**	**0.8**	**-**	**99.5**
			F. c.	0.72	0.02	0.31	1.00	0.03	0.01	-	0.01	-	2
68	45-1, 102	PdCu +BORN	**Wt.%**	**59.3**	**3.4**	**-**	**27.9**	**6.0**	**2.1**	**-**	**-**	**-**	**98.7**
			F. c.	0.97	0.03	-	0.76	0.18	0.06	-	-	-	2
69	45-1, 104	(Pd,Au)Cu+$PdAuCu_2$+KTH+VSL+ ILM+MT	**Wt.%**	**49.7**	**2.6**	**13.0**	**29.4**	**4.3**	**-**	**-**	**-**	**-**	**99.0**
			F. c.	0.86	0.03	0.12	0.85	0.14	-	-	-	-	2
70	45-1, 105	(Pd,Au)Cu	**Wt.%**	**51.8**	**1.6**	**9.7**	**31.8**	**1.9**	**1.1**	**-**	**2.3**	**-**	**100.2**
			F. c.	0.88	0.01	0.09	0.90	0.06	0.03	-	0.03	-	2
71	45-1, 107	(Pd,Pt)Cu+VSL+BORN	**Wt.%**	**53.1**	**7.1**	**2.6**	**34.4**	**0.9**	**0.7**	**-**	**-**	**-**	**98.8**
			F. c.	0.89	0.07	0.02	0.97	0.03	0.02	-	-	-	2

Table 4 continued: Chemical composition and formulas of the unnamed mineral phase PdCu, $PdCu_3$ and Pd_3Cu compositions in PGM-grains of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain		Pd	Pt	Au	Cu	Fe	Zn	Sn	Te	Pb	Total
72	45-1, 109	PdCu+ZV+BORN	Wt.%	60.1	-	2.3	30.1	3.8	2.8	-	-	-	99.1
			F. c.	0.97	-	0.02	0.82	0.12	0.07	-	-	-	2
73	45-1, 111	(Pd,Au)Cu+AP+ILM	Wt.%	56.2	-	7.7	33.0	1.4	0.9	-	-	-	99.2
			F. c.	0.94	-	0.07	0.92	0.05	0.02	-	-	-	2
74	45-1, 112	(Pd,Pt)Cu+CHC +BORN	Wt.%	51.8	11.3	-	29.5	4.8	0.8	-	-	1.0	99.2
			F. c.	0.88	0.10	-	0.83	0.16	0.02	-	-	0.01	2
75	45-1, 113	(Pd,Pt)Cu++BORN CHC	Wt.%	54.9	9.6	1.4	26.5	3.0	-	3.4	-	-	98.8
			F. c.	0.96	0.09	0.01	0.78	0.10	-	0.06	-	-	2
76	45-1, 114	(Pd,Pt)Cu+(Pt,Fe,Pd,Cu) +CHC +BORN	Wt.%	48.6	12.8	2.2	28.5	4.7	1.3	-	-	-	98.1
			F. c.	0.84	0.12	0.02	0.83	0.15	0.04	-	-	-	2
77	45-2, 2	PdCu+PN+OPX	Wt.%	59.7	-	3.5	29.1	4.0	0.7	-	1.4	-	98.4
			F. c.	0.99	-	0.03	0.81	0.13	0.02	-	0.02	-	2
78	45-2, 8	PdCu+BORN	Wt.%	52.1	5.2	4.2	29.3	5.3	2.1	-	-	-	98.2
			F. c.	0.87	0.05	0.04	0.82	0.16	0.06	-	-	-	2
79	45-2, 10	PdCu+$PdCu_3$+(Pd,Au)Cu+BORN	Wt.%	60.0	-	-	32.4	4.0	1.8	-	-	-	98.2
			F. c.	0.96	-	-	0.87	0.12	0.05	-	-	-	2
80	45-2, 10	PdCu+$PdCu_3$+(Pd,Au)Cu+BORN	Wt.%	46.9	-	17.3	32.6	0.7	-	-	0.7	1.1	99.3
			F. c.	0.83	-	0.17	0.96	0.02	-	-	0.01	0.01	2
81	45-2, 13	(Pd,Pt)Cu+BORN	Wt.%	54.4	6.6	1.7	29.1	3.4	1.4	-	1.3	1.5	99.4
			F. c.	0.92	0.06	0.02	0.82	0.11	0.04	-	0.02	0.01	2
82	75-1, 3	(Pd,Au)Cu+CHC+BORN	Wt.%	40.3	-	23.9	33.8	0.9	0.4	-	-	-	99.3
			F. c.	0.72	-	0.23	1.01	0.03	0.01	-	-	-	2
83	75-1, 4	PdCu+BORN	Wt.%	61.8	-	1.3	28.8	4.4	1.9	1.1	-	-	99.3
			F. c.	1.00	-	0.01	0.78	0.14	0.05	0.02	-	-	2
84	75-1, 5	PdCu+(Pd,Cu,Sn)+CHC+BORN+ MT	Wt.%	61.9	-	-	28.6	5.3	2.2	-	-	-	98.0
			F. c.	1.00	-	-	0.78	0.16	0.06	-	-	-	2
85	75-1, 8	PdCu+BORN	Wt.%	62.1	-	-	30.3	3.6	0.5	1.9	-	-	98.4
			F. c.	1.02	-	-	0.83	0.11	0.02	0.02	-	-	2

Table 4 continued: Chemical composition and formulas of the unnamed mineral phase PdCu, $PdCu_3$ and Pd_3Cu compositions in PGM-grains of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain		Pd	Pt	Au	Cu	Fe	Zn	Sn	Te	Pb	Total
86	75-1, 10	(Pd,Au)Cu+$(Pd,Au)_3Cu$+MT+OPX	**Wt.%**	**50.9**	**1.7**	**11.2**	**29.4**	**3.7**	**-**	**-**	-	**1.4**	**98.3**
			F. c.	0.89	0.02	0.10	0.86	0.12	-	-	-	0.01	2
87	75-1, 13	PdCu+CP	**Wt.%**	**58.2**	**2.3**	**1.2**	**29.7**	**5.7**	**-**	-	**1.8**	-	**99.1**
			F. c.	0.96	0.02	0.01	0.81	0.18	-	-	0.02	-	2
88	75-1, 14	(Pd,Pt)Cu+CHC+BORN+AP	**Wt.%**	**52.2**	**10.7**	-	**31.8**	**3.7**	**0.7**	**-**	-	**-**	**99.1**
			F. c.	0.87	0.10	-	0.89	0.12	**0.02**	-	-	-	2
89	75-1, 16	PdCu+BORN	**Wt.%**	**59.3**	-	**2.0**	**31.3**	**3.4**	**2.5**	-	**0.7**	-	**99.2**
			F. c.	0.97	-	0.02	0.84	0.10	0.06	-	0.01	-	2
90	75-2, 1	(Pd,Au)Cu+KTH+VYS+CHC	**Wt.%**	**47.9**	**3.1**	**15.7**	**31.8**	**1.5**	**1.6**	-	-	-	**101.6**
			F. c.	0.82	0.03	0.14	0.91	0.05	0.05	-	-	-	2
91	75-2, 4	PdCu	**Wt.%**	**59.1**	**-**	**1.1**	**31.9**	**2.8**	**1.2**	-	**2.2**	-	**98.3**
			F. c.	0.97	-	0.01	0.87	0.09	0.03	-	0.03	-	2
92	75-2, 5	PdCu+VYS+AT+COPN+CHC	**Wt.%**	**55.2**	**1.9**	**4.3**	**31.4**	**0.7**	**-**	**1.4**	**-**	**3.2**	**98.1**
			F. c.	0.96	0.02	0.04	0.91	0.02	-	0.02	-	0.03	2
93	75-2, 6	(Pd,Pt)Cu+ILM	**Wt.%**	**52.8**	**8.0**	**-**	**29.3**	**4.3**	**1.8**	-	**-**	**1.8**	**98.0**
			F. c.	0.89	0.07	-	0.83	0.14	0.05	-	-	0.02	2
94	75-2, 9	(Pd,Pt)Cu+BORN	**Wt.%**	**49.7**	**11.6**	**1.7**	**27.3**	**7.1**	**1.8**	**-**	**-**	**-**	**99.2**
			F. c.	0.83	0.11	0.01	0.77	0.23	0.05	-	-	-	2
95	75-2, 12	PdCu+BORN	**Wt.%**	**61.8**	**-**	**-**	**29.5**	**5.0**	**2.7**	**-**	**-**	**-**	**99.0**
			F. c.	0.99	-	-	0.79	0.15	0.07	-	-	-	2
96	75-2, 13	PdCu+AT+COPN+CHC+MT	**Wt.%**	**60.3**	**-**	**1.8**	**29.5**	**3.8**	**1.8**	**1.6**	**-**	**-**	**98.8**
			F. c.	0.99	-	0.01	0.81	0.12	0.05	0.02	-	-	2
97	75-2, 14	PdCu+(Pd,Cu,Sn)	**Wt.%**	**60.0**	**-**	**1.6**	**29.3**	**3.7**	**2.0**	**1.4**	**-**	**-**	**98.0**
			F. c.	0.99	-	0.01	0.81	0.12	0.05	0.02	-	-	2
98	75-2, 21	PdCu+(Pd,Cu,Sn)+CHC	**Wt.%**	**60.6**	**-**	**1.3**	**29.2**	**4.5**	**2.5**	**-**	**-**	**-**	**98.1**
			F. c.	0.99	-	0.01	0.79	0.14	0.07	-	-	-	2
99	75-2, 22	PdCu+VSL+BORN+CHC	**Wt.%**	**61.3**	**-**	**-**	**32.5**	**3.2**	**2.1**	**-**	**-**	**-**	**99.1**
			F. c.	0.98	-	-	0.87	0.10	0.05	-	-	-	2

Table 4 continued: Chemical composition and formulas of the unnamed mineral phase PdCu, $PdCu_3$ and Pd_3Cu compositions in PGM-grains of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain		Pd	Pt	Au	Cu	Fe	Zn	Sn	Te	Pb	Total
100	75-2, 31	PdCu+BORN	**Wt.%**	**60.2**	**-**	**1.7**	**29.7**	**5.3**	**1.9**	**-**	**-**	**-**	**98.8**
			F. c.	0.98	-	0.01	0.81	0.16	0.05	-	-	-	2
101	75-2, 32	(Pd,Pt)Cu+(Pt,Cu,Fe)+BORN	**Wt.%**	**51.0**	**8.4**	**-**	**31.6**	**2.2**	**0.8**	**-**	**-**	**5.8**	**99.8**
			F. c.	0.87	0.08	-	0.90	0.07	0.02	-	-	0.05	2
102	125-2, 1	PdCu+CHC+ BORN+MT	**Wt.%**	**61.2**	**-**	**1.2**	**30.9**	**3.0**	**3.2**	**-**	**-**	**-**	**99.5**
			F. c.	0.98	-	0.01	0.83	0.09	0.09	-	-	-	2
103	125-1, 1	PdCu+BORN +CHC	**Wt.%**	**58.5**	**-**	**3.3**	**30.2**	**3.7**	**2.1**	**-**	**0.7**	**-**	**98.5**
			F. c.	0.96	-	0.03	0.83	0.12	0.05	-	0.01	-	2
104	125-1, 3	(Pd,Pt)Cu+CHC+BORN+PL	**Wt.%**	**53.5**	**6.8**	**1.4**	**30.3**	**3.7**	**2.1**	**-**	**0.6**	**-**	**98.4**
			F. c.	0.90	0.06	0.01	0.85	0.12	0.05	-	0.01	-	2
105	45-2, 10	PdCu+$PdCu_3$+(Pd,Au)Cu+BORN	**Wt.%**	**36.7**	**1.1**	**-**	**60.5**	**0.6**	**-**	**-**	**-**	**-**	**98.9**
			F. c.	1.05	0.02	-	2.90	0.03	-	-	-	-	4
106	75-2, 10	$(Pd,Au)_3Cu$+VYS+BORN+CHC	**Wt.%**	**66.4**	**1.0**	**11.0**	**12.2**	**1.0**	**-**	**-**	**3.8**	**3.7**	**99.1**
			F. c.	2.65	0.02	0.24	0.81	0.08	-	-	0.12	0.08	4
107	45-1, 17	(Pd,Au)Cu+$(Pd,Au)_3Cu$	**Wt.%**	**33.8**	**1.9**	**45.9**	**11.2**	**2.5**	**-**	**-**	**-**	**-**	**98.8**
			F. c.	1.60	0.05	1.26	0.87	0.22	-	-	-	-	4
108	75-1, 10	(Pd,Au)Cu+$(Pd,Au)_3Cu$+MT+OPX	**Wt.%**	**33.7**	**1.1**	**51.6**	**11.1**	**2.1**	**-**	**-**	**-**	**-**	**99.6**
			F. c.	1.59	0.03	1.32	0.87	0.19	-	-	-	-	4

Table 5. Chemical composition and formulas of vysotskite, vasilite and braggite in PGM-grains of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain		Pd	Pt	Cu	Fe	Ni	Te	S	Total
1	45-1, 12	VYS(zone 1)+BORN+DGN	**Wt.%**	**64.0**	**-**	**1.6**	**0.5**	**7.6**	**-**	**24.7**	**98.4**
			F. c.	0.79	-	0.03	0.01	0.17	-	1.00	2
2	45-1, 12	VYS(zone 2)+BORN+DGN	**Wt.%**	**70.6**	**-**	**2.1**	**0.5**	**2.3**	**-**	**23.7**	**99.2**
			F. c.	0.90	-	0.04	0.01	0.05	-	1.00	2
3	45-1, 32	VYS+BORN	**Wt.%**	**67.5**	**-**	**1.9**	**0.6**	**4.8**	**-**	**24.2**	**99.0**
			F. c.	0.84	-	0.04	0.01	0.11	-	1.00	2
4	45-1, 33	VYS+KTH+BORN+CHL	**Wt.%**	**73.8**	**-**	**0.7**	**0.6**	**0.4**	**-**	**23.6**	**99.1**
			F. c.	0.95	-	0.02	0.01	0.01	-	1.00	2
5	45-1, 41	VYS+PdAuCu$_2$+BORN	**Wt.%**	**73.6**	**-**	**1.0**	**0.5**	**0.5**	**-**	**23.6**	**99.1**
			F. c.	0.95	-	0.02	0.01	0.01	-	1.01	2
6	45-1, 46	VYS+BORN	**Wt.%**	**63.1**	**-**	**1.3**	**0.7**	**8.6**	**-**	**25.2**	**98.9**
			F. c.	0.76	-	0.03	0.02	0.19	-	1.01	2
7	45-1, 47	VYS+DGN+BORN	**Wt.%**	**74.1**	**-**	**2.2**	**0.5**	**-**	**-**	**22.9**	**99.7**
			F. c.	0.96	-	0.05	0.01	-	-	0.98	2
8	45-1, 50	VYS+CHC+BORN	**Wt.%**	**73.5**	**-**	**0.8**	**0.4**	**0.5**	**-**	**23.7**	**98.9**
			F. c.	0.95	-	0.02	0.01	0.01	-	1.01	2
9	45-1, 51	VYS+BORN	**Wt.%**	**62.8**	**-**	**3.1**	**1.4**	**7.3**	**-**	**25.3**	**99.9**
			F. c.	0.75	-	0.06	0.03	0.11	-	1.00	2
10	45-1, 62	(Au,Pd)Cu+BGD+VYS+BORN	**Wt.%**	**74.1**	**-**	**0.5**	**0.5**	**1.1**	**-**	**23.6**	**99.8**
			F. c.	0.95	-	0.01	0.01	0.03	-	1.00	2
11	45-1, 70	VYS+CHC	**Wt.%**	**74.4**	**-**	**0.6**	**0.4**	**0.5**	**-**	**23.7**	**99.6**
			F. c.	0.96	-	0.01	0.01	0.01	-	1.01	2
12	45-1, 71	VYS+CHC	**Wt.%**	**74.6**	**-**	**0.4**	**0.4**	**0.5**	**-**	**23.9**	**99.8**
			F. c.	0.96	-	0.01	0.01	0.01	-	1.01	2
13	45-1, 75	VYS+(Pt,Fe,Pd,Cu)+KTH+CHC+ BORN	**Wt.%**	**73.7**	**-**	**1.4**	**0.4**	**-**	**-**	**22.9**	**98.4**
			F. c.	0.96	-	0.03	0.01	-	-	0.99	2
14	45-1, 76	VYS+BORN+MT	**Wt.%**	**74.0**	**-**	**0.9**	**-**	**-**	**-**	**23.3**	**98.2**
			F. c.	0.97	-	0.02	-	-	-	1.01	0.02
15	45-1, 77	PdCu+VYS+KTH+BORN	**Wt.%**	**74.1**	**-**	**0.9**	**0.6**	**0.4**	**-**	**23.3**	**99.3**
			F. c.	0.96	-	0.02	0.01	0.01	-	1.00	2

Table 5 continued. Chemical composition and formulas of vysotskite, vasilite and braggite in PGM-grains of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain		Pd	Pt	Cu	Fe	Ni	Te	S	Total
16	45-1, 80	VYS+BORN+CHC	**Wt.%**	**73.8**	**-**	**1.1**	**0.7**	**0.6**	**-**	**23.2**	**99.4**
			F. c.	0.95	-	0.02	0.02	0.02	-	0.99	2
17	45-1, 81	VYS+CHC+BORN	**Wt.%**	**73.2**	**-**	**1.5**	**0.8**	**-**	**-**	**23.1**	**98.6**
			F. c.	0.95	-	0.03	0.02	-	-	1.00	2
18	45-1, 84	VYS+BORN	**Wt.%**	**74.5**	**-**	**0.6**	**0.5**	**-**	**-**	**23.0**	**98.6**
			F. c.	0.98	-	0.01	0.01	-	-	1.00	2
19	45-1, 85	VYS+CHC+BORN	**Wt.%**	**73.1**	**-**	**2.4**	**0.4**	**0.5**	**-**	**22.6**	**99.0**
			F. c.	0.95	-	0.05	0.01	0.01	-	0.98	2
20	45-1, 89	VYS+(Pd,Sn,Fe)+CHC+BORN	**Wt.%**	**73.0**	**-**	**1.2**	**0.5**	**1.1**	**-**	**23.1**	**98.9**
			F. c.	0.95	-	0.02	0.01	0.02	-	0.99	2
21	45-1, 91	VYS+CHC+BORN	**Wt.%**	**72.0**	**-**	**1.4**	**1.3**	**0.7**	**-**	**22.8**	**98.2**
			F. c.	0.94	-	0.03	0.03	0.01	-	0.99	2
22	45-1, 98	(Pd,Au)Cu+$PdAuCu_2$+VSL+VYS	**Wt.%**	**74.4**	**-**	**0.9**	**0.5**	**-**	**-**	**22.8**	**98.6**
			F. c.	0.98	-	0.02	0.01	-	-	0.99	2
23	45-1, 106	VYS+CHC	**Wt.%**	**75.0**	**-**	**-**	**-**	**0.9**	**-**	**23.0**	**98.9**
			F. c.	0.98	-	-	-	0.02	-	1.00	2
24	45-1, 108	VYS+BORN	**Wt.%**	**74.5**	**-**	**-**	**-**	**1.3**	**-**	**23.1**	**98.9**
			F. c.	0.97	-	-	-	0.03	-	1.00	2
25	45-2, 4	VYS+KTH+VSL+DGN	**Wt.%**	**75.3**	**-**	**-**	**-**	**0.7**	**-**	**22.9**	**98.9**
			F. c.	0.99	-	-	-	0.01	-	1.00	2
26	45-2, 7	VYS+BORN	**Wt.%**	**70.5**	**-**	**0.9**	**-**	**5.8**	**-**	**24.4**	**101.6**
			F. c.	0.86	-	0.02	-	0.13	-	0.99	2
27	45-2, 12	VYS+CHC+MT	**Wt.%**	**72.0**	**-**	**-**	**0.5**	**3.6**	**-**	**22.8**	**98.9**
			F. c.	0.93	-	-	0.01	0.08	-	0.98	2
28	75-1, 2	VYS+BORN+CHC	**Wt.%**	**71.7**	**-**	**2.6**	**0.4**	**0.4**	**-**	**23.7**	**98.8**
			F. c.	0.92	-	0.05	0.01	0.01	-	1.01	2
29	75-1, 9	VYS+CHC+BORN	**Wt.%**	**66.3**	**-**	**3.1**	**0.5**	**6.2**	**-**	**23.8**	**99.9**
			F. c.	0.82	-	0.06	0.01	0.14	-	0.97	2

Table 5 continued. Chemical composition and formulas of vysotskite, vasilite and braggite in PGM-grains of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain		Pd	Pt	Cu	Fe	Ni	Te	S	Total
30	75-1. 11	VYS+CHC+BORN	**Wt.%**	**72.2**	**-**	**2.9**	**-**	**1.4**	**-**	**23.5**	**100.0**
			F. c.	0.92	-	0.06	-	0.03	-	0.99	2
31	75-1, 15	VYS+(Au,Ag)+DGN	**Wt.%**	**73.1**	**-**	**1.1**	**-**	**1.6**	**-**	**23.7**	**99.5**
			F. c.	0.94	-	0.02	-	0.04	-	1.01	2
32	75-2, 1	(Pd,Au)Cu+KTH+VYS+CHC	**Wt.%**	**74.6**	**-**	**1.4**	**-**	**-**	**-**	**22.9**	**98.9**
			F. c.	0.98	-	0.03	-	-	-	0.99	2
33	75-2, 5	PdCu+VYS+AT+COPN+CHC	**Wt.%**	**73.7**	**-**	**1.0**	**-**	**0.4**	**-**	**23.7**	**98.8**
			F. c.	0.95	-	0.02	-	0.01	-	1.02	2
34	75-2, 6	VYS+BORN+CHC	**Wt.%**	**71.4**	**-**	**2.2**	**0.8**	**0.9**	**-**	**23.6**	**98.9**
			F. c.	0.91	-	0.05	0.02	0.02	-	1.00	2
35	75-2, 8	VYS+BORN+CHL	**Wt.%**	**68.5**	**-**	**1.5**	**0.8**	**4.7**	**-**	**24.4**	**99.9**
			F. c.	0.84	-	0.03	0.02	0.11	-	1.00	2
36	75-2, 10	VYS+$(Pd,Au)_3Cu$+BORN+CHC	**Wt.%**	**73.7**	**-**	**1.3**	**0.5**	**0.5**	**-**	**23.1**	**99.1**
			F. c.	0.96	-	0.03	0.01	0.01	-	0.99	2
37	75-2, 11	VYS+BORN+CPX	**Wt.%**	**71.1**	**-**	**3.2**	**0.7**	**0.5**	**-**	**23.4**	**98.9**
			F. c.	0.91	-	0.07	0.02	0.01	-	0.99	2
38	75-2, 17	VYS+BORN	**Wt.%**	**65.8**	**-**	**4.4**	**0.8**	**4.6**	**-**	**24.1**	**99.7**
			F. c.	0.81	-	0.09	0.02	0.10	-	0.98	2
39	75-2, 23	VYS+BORN+DGN+OPX	**Wt.%**	**64.6**	**-**	**5.2**	**1.0**	**3.6**	**-**	**24.3**	**98.7**
			F. c.	0.80	-	0.11	0.02	0.08	-	0.99	2
40	75-2, 24	VYS+BORN+CHC	**Wt.%**	**69.3**	**-**	**4.1**	**1.1**	**1.5**	**-**	**23.0**	**99.0**
			F. c.	0.88	-	0.09	0.03	0.03	-	0.97	2
41	75-2, 27	VYS+BORN	**Wt.%**	**74.2**	**-**	**0.6**	**0.5**	**1.5**	**-**	**24.0**	**100.8**
			F. c.	0.97	-	0.01	0.01	0.04	-	1.00	2
42	75-2, 28	VYS+BORN	**Wt.%**	**73.4**	**-**	**0.4**	**0.4**	**1.2**	**-**	**24.5**	**99.9**
			F. c.	0.93	-	0.01	0.01	0.03	-	1.02	2
43	125-2, 2	VYS+KTH+BORN+OPX	**Wt.%**	**72.1**	**-**	**1.4**	**-**	**2.9**	**-**	**23.2**	**99.6**
			F. c.	0.92	-	0.03	-	0.07	-	0.98	2

Table 5 continued. Chemical composition and formulas of vysotskite, vasilite and braggite in PGM-grains of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain		Pd	Pt	Cu	Fe	Ni	Te	S	Total
44	125-1, 2	VYS+BORN+CHC	**Wt.%**	**73.0**	**-**	**1.7**	**-**	**1.2**	**-**	**22.3**	**98.2**
			F. c.	0.96	-	0.04	-	0.03	-	0.97	2
45	45-1, 11	VSL+KTH+BORN	**Wt.%**	**71.7**	**-**	**13.8**	**-**	**-**	**-**	**12.8**	**98.3**
			F. c.	12.00	-	3.87	-	-	-	7.13	23
46	45-1, 25	(Pd,Pt)Cu+VSL+BORN+CP	**Wt.%**	**70.6**	**-**	**16.2**	**0.6**	**-**	**-**	**12.7**	**100.1**
			F. c.	11.52	-	4.42	0.19	-	-	6.87	23
47	45-1, 28	BGD+VSL	**Wt.%**	**72.1**	**-**	**13.8**	**0.5**	**-**	**-**	**12.4**	**98.8**
			F. c.	12.08	-	3.86	0.16	-	-	6.88	23
48	45-1, 34	VSL+BORN	**Wt.%**	**71.6**	**-**	**14.4**	**0.7**	**-**	**-**	**12.6**	**99.3**
			F. c.	11.87	-	3.99	0.22	-	-	6.93	23
49	45-1, 87	(Pd,Au)Cu+VSL	**Wt.%**	**72.4**	**-**	**12.7**	**0.8**	**-**	**-**	**12.7**	**98.6**
			F. c.	12.11	-	3.57	0.25	-	-	7.07	23
50	45-1, 98	(Pd,Au)Cu+ $PdAuCu_2$+VSL+VYS	**Wt.%**	**72.4**	**-**	**13.8**	**0.5**	**-**	**-**	**12.9**	**99.6**
			F. c.	11.99	-	3.82	0.16	-	-	7.03	23
51	45-1, 104	(Pd,Au)Cu+PdAuCu2+KTH+VSL+ ILM+MT	**Wt.%**	**72.4**	**-**	**13.2**	**0.5**	**-**	**-**	**12.7**	**98.8**
			F. c.	12.10	-	3.69	0.16	-	-	7.05	23
52	45-1, 110a	VSL+CHC+BORN	**Wt.%**	**71.1**	**-**	**14.7**	**-**	**-**	**-**	**12.2**	**98.0**
			F. c.	12.00	-	4.16	-	-	-	6.84	23
53	75-1, 12	VSL+CHC+BORN	**Wt.%**	**71.8**	**-**	**14.1**	**-**	**-**	**-**	**12.3**	**98.2**
			F. c.	12.14	-	3.98	-	-	-	6.88	23
54	75-2, 12	(Pd,Au)Cu+KTH+VSL+CHC+BORN	**Wt.%**	**71.2**	**-**	**14.3**	**-**	**-**	**-**	**12.6**	**98.1**
			F. c.	11.98	-	4.01	-	-	-	7.01	23
55	75-2, 29	BRG+BORN	**Wt.%**	**33.6**	**33.7**	**6.1**	**1.6**	**-**	**6.4**	**17.2**	**98.6**
			F. c.	0.52	0.29	0.16	0.05	-	0.08	0.90	2

Table 6. Chemical composition and formulas of atokite, alloy (Pd,Cu,Sn), keithconnite, isomertieite and guanglinite in PGM-grains of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain	Mineral		Pd	Pt	Au	Cu	Fe	Sn	Te	Pb	As	Sb	Total
1	45-1, 3	PdCu+AT+(Pd,Cu,Sn)	AT	Wt.%	74.5	-	-	0.7	0.9	21.6	0.9	1.6	-	-	100.3
				F. c.	3.02	-	-	0.05	0.08	0.79	0.03	0.03	-	-	4
2	45-1, 15	PdCu+AT+BORN+CHC	AT	Wt.%	73.2	-	-	1.5	0.4	23.7	-	-	-	-	98.8
				F. c.	3.00	-	-	0.10	0.03	0.87	-	-	-	-	4
3	45-1, 40	PdCu+AT+BORN+CHC	AT	Wt.%	72.6	-	-	1.4	0.7	25.1	-	-	-	-	99.8
				F. c.	2.94	-	-	0.10	0.05	0.91	-	-	-	-	4
4	45-1, 73	PdCu+AT+BORN	AT	Wt.%	71.2	-	-	1.7	0.7	25.5	-	-	-	-	99.1
				F. c.	2.90	-	-	0.11	0.06	0.93	-	-	-	-	4
5	45-1, 97	PdCu+AT+BORN	AT	Wt.%	71.6	-	-	4.0	1.1	22.9	-	-	-	-	99.6
				F. c.	2.84	-	-	0.26	0.08	0.82	-	-	-	-	4
6	75-2, 5	VYS+PdCu+AT+COPN+ CHC	AT	Wt.%	76.6	-	-	-	-	22.0	-	-	-	-	99.8
				F. c.	3.15	-	-	-	-	0.85	-	-	-	-	4
7	45-1, 3	PdCu+AT+(Pd,Cu,Sn)	(Pd,Cu,Sn)	Wt.%	65.9	-	-	14.7	0.8	15.9	-	1.1	-	-	98.4
				F. c.	0.62	-	-	0.23	0.01	0.13	-	0.01	-	-	1
8	45-1, 10	(Pd,Cu,Sn)+BORN	(Pd,Cu,Sn)	Wt.%	56.9	2.7	9.0	10.6	1.3	16.8	1.7	-	-	-	99.0
				F. c.	0.57	0.01	0.05	0.18	0.03	0.15	0.01	-	-	-	1
9	45-1, 23	PdCu+(Pd,Sn,Cu)+CHC	(Pd,Sn,Cu)	Wt.%	68.9	-	-	9.7	1.8	18.6	-	-	-	-	99.0
				F. c.	0.66	-	-	0.15	0.03	0.16	-	-	-	-	1
10	45-1, 38	PdCu+(Pd,Sn,Cu)+BORN +MT	(Pd,Sn,Cu)	Wt.%	68.3	-	1.6	9.2	-	18.3	1.2	-	-	-	98.6
				F. c.	0.67	-	0.01	0.15	-	0.16	0.01	-	-	-	1
11	45-1, 59	PdCu+(Pd,Sn,Cu)+BORN +CHC	(Pd,Sn,Cu)	Wt.%	78.0	-	-	4.0	1.3	14.8	-	-	-	-	98.1
				F. c.	0.78	-	-	0.07	0.02	0.13	-	-	-	-	1
12	45-1, 68	PdCu+(Pd,Sn,Cu)+CHC+ CHL	(Pd,Sn,Cu)	Wt.%	76.0	-	1.4	2.6	0.6	13.2	0.9	4.5	-	-	99.2
				F. c.	0.79	-	0.01	0.04	0.01	0.12	0.01	0.02	-	-	1
13	45-1, 72	PdCu+(Pd,Sn,Cu)+KTH+ COV?	(Pd,Sn,Cu)	Wt.%	71.3	-	-	5.9	0.6	21.8	-	-	-	-	99.6
				F. c.	0.70	-	-	0.10	0.01	0.19	-	-	-	-	1
14	45-1, 79	PdCu+(Pd,Sn,Cu)+BORN	(Pd,Sn,Cu)	Wt.%	73.7	-	-	7.3	0.5	16.8	1.5	-	-	-	99.8
				F. c.	0.71	-	-	0.12	0.01	0.15	0.01	-	-	-	1

Table 6 continued. Chemical composition and formulas of atokite, alloy (Pd,Cu,Sn), keithconnite, isomertieite and guanglinite in PGM-grains of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain	Mineral		Pd	Pt	Au	Cu	Fe	Sn	Te	Pb	As	Sb	Total
15	45-1, 89	VYS+(Pd,Sn,Fe)+CHC +BORN	(Pd,Sn,Fe)	**Wt.%**	**69.8**	**-**	**-**	**1.1**	**8.5**	**20.1**	**-**	**-**	**-**	**-**	**99.5**
				F. c.	0.66	-	-	0.02	0.15	0.17	-	-	-	-	1
16	45-1, 95	(Pd,Cu,Sn)+CHC	(Pd,Cu,Sn)	**Wt.%**	**68.5**	**1.3**	**-**	**11.8**	**0.6**	**7.1**	**3.3**	**7.1**	**-**	**-**	**99.7**
				F. c.	0.67	0.01	-	0.19	0.01	0.06	0.03	0.03	-	-	1
17	75-2, 14	PdCu+(Pd,Sn,Cu)	(Pd,Sn,Cu)	**Wt.%**	**71.0**	**-**	**-**	**5.1**	**1.6**	**20.7**	**-**	**-**	**-**	**-**	**98.4**
				F. c.	0.70	-	-	0.09	0.03	0.18	-	-	-	-	1
18	75-2, 21	PdCu+(Pd,Cu,Sn)+CHC	(Pd,Cu,Sn)	**Wt.%**	**70.5**	**-**	**-**	**10.9**	**2.8**	**15.2**	**-**	**-**	**-**	**-**	**99.4**
				F. c.	0.66	-	-	0.17	0.05	0.13	-	-	-	-	1
19	45-1, 7	PdCu+KTH	KTH	**Wt.%**	**71.2**	**-**	**-**	**0.7**	**0.5**	**-**	**26.2**	**-**	**-**	**-**	**98.6**
				F. c.	2.99	-	-	0.05	0.04	-	0.92	-	-	-	4
20	45-1, 11	VSL+KTH+BORN	KTH	**Wt.%**	**72.0**	**-**	**-**	**1.6**	**0.7**	**3.6**	**13.6**	**7.0**	**-**	**-**	**98.8**
				F. c.	3.05	-	-	0.11	0.06	0.14	0.49	0.15	-	-	4
21	45-1, 18	KTH	KTH	**Wt.%**	**70.7**	**-**	**-**	**-**	**0.8**	**-**	**28.2**	**-**	**-**	**-**	**98.8**
				F. c.	2.95	-	-	-	0.07	-	0.98	-	-	-	4
22	45-1, 54	BGD+KTH+(Au,Pd)Cu+ BORN	KTH	**Wt.%**	**73.3**	**-**	**-**	**-**	**-**	**5.0**	**13.5**	**7.3**	**-**	**-**	**99.2**
				F. c.	3.16	-	-	-	-	0.20	0.48	0.16	-	-	4
23	45-1, 75	VYS+(Pt,Fe,Pd,Cu)+ KTH+BORN+CHC	KTH	**Wt.%**	**70.1**	**-**	**-**	**1.1**	**-**	**1.5**	**24.4**	**1.2**	**-**	**-**	**98.3**
				F. c.	2.98	-	-	0.08	-	0.05	0.86	0.03	-	-	4
24	45-1, 104	(Pd,Au)Cu+PdAuCu$_2$+ KTH+VSL+ILM+MT	KTH	**Wt.%**	**70.4**	**-**	**-**	**-**	**0.9**	**0.6**	**26.9**	**-**	**1.0**	**-**	**99.8**
				F. c.	2.92	-	-	-	0.07	0.02	0.93	-	0.06	-	4
25	45-2, 4	VYS+VSL+KTH+ DGN	KTH	**Wt.%**	**67.5**	**-**	**-**	**1.6**	**-**	**-**	**30.4**	**-**	**-**	**-**	**99.5**
				F. c.	2.83	-	-	0.11	-	-	1.06	-	-	-	4
26	45-2, 5	(Au,Pd)Cu+KTH	KTH	**Wt.%**	**68.3**	**-**	**-**	**-**	**2.0**	**3.1**	**26.2**	**-**	**-**	**-**	**99.6**
				F. c.	2.82	-	-	-	0.17	0.11	0.90	-	-	-	4
27	75-2, 1	(Pd,Au)Cu+KTH+VYS +CHC	KTH	**Wt.%**	**67.8**	**-**	**-**	**4.6**	**-**	**2.0**	**25.1**	**-**	**-**	**-**	**99.5**
				F. c.	2.76	-	-	0.31	-	0.08	0.85	-	-	-	4
28	75-2, 2	(Pd,Au)Cu+KTH9zone1) +VSL+CHC+BORN	KTH	**Wt.%**	**71.2**	**-**	**-**	**0.6**	**-**	**2.2**	**25.1**	**-**	**-**	**-**	**99.1**
				F. c.	3.00	-	-	0.04	-	0.08	0.88	-	-	-	4

Table 6 continued. Chemical composition and formulas of atokite, alloy (Pd,Cu,Sn), keithconnite, isomertieite and guanglinite in PGM-grains of the heavy concentrates (sample 90-18, 1010)

An.	Grain	Association of minerals in the grain	Mineral		Pd	Pt	Au	Cu	Fe	Sn	Te	Pb	As	Sb	Total
29	75-2, 2	(Pd,Au)Cu+KTH9zone2)+ VSL+CHC+BORN	KTH	**Wt.%**	**72.6**	**-**	**-**	**0.9**	**-**	**5.1**	**13.6**	**6.2**		**-**	**98.4**
				F. c.	3.12	-	-	0.06	-	0.20	0.49	0.14		-	4
30	75-2, 18	KTH(zone1)+BORN+ CHC	KTH	**Wt.%**	**67.2**	**-**	**-**	**2.9**	**0.6**	**-**	**24.9**	**2.7**		**1.2**	**98.5**
				F. c.	2.79	-	-	0.20	0.05	-	0.86	0.06	-	0.04	4
31	75-2, 18	KTH(zone2)+BORN+ CHC	KTH	**Wt.%**	**68.2**	**-**	**-**	**2.8**	**-**	**-**	**25.3**	**2.4**		**-**	**98.7**
				F. c.	2.86	-	-	0.20	-	-	0.89	0.05		-	4
32	125-2, 2	VYS+KTH+BORN+OPX	KTH	**Wt.%**	**66.0**	**-**	**-**	**4.6**	**-**	**-**	**25.5**	**2.7**		**-**	**98.8**
				F. c.	2.74	-	-	0.32	-	-	0.88	0.06		-	4
33	45-1, 101	ISM+BORN	ISM	**Wt.%**	**70.4**	**1.5**	**-**	**3.1**	**1.0**	**4.1**	**-**	**-**	**9.6**	**9.3**	**99.0**
				F. c.	10.17	0.12	-	0.76	0.27	0.53	-	-	1.97	1.18	15
34	45-1, 103	GNG+BORN	GNG	**Wt.%**	**72.8**	**1.9**	**-**	**-**	**0.7**	**5.1**	**1.8**	**-**	**12.4**	**4.0**	**98.7**
				F. c.	2.85	0.04	-	-	0.05	0.18	0.05	-	0.69	0.14	4

Table 7. Chemical composition and formulas of Au-Pd-Cu-Pt and Pt-Fe-Pd-Cu alloys in PGM-grains of the heavy concentrates (sample 90-18 1010)

An.	Grain	Association of minerals in the grain		Pd	Pt	Au	Cu	Fe	Ni	Total
1	45-1,8	PdAuCu$_2$+(Pd,Au)Cu+ILM	**Wt.%**	**25.0**	**3.3**	**40.6**	**29.5**	**0.8**	**-**	**99.2**
			F.c.	1.00	0.07	0.88	1.98	0.07	-	4
2	45-1, 8	PdAuCu$_2$+(Pd,Au)Cu+ILM	**Wt.%**	**23.6**	**3.2**	**41.6**	**29.6**	**0.9**	**-**	**98.9**
			F.c.	0.95	0.07	0.91	2.00	0.07	-	4
3	45-1, 4	PdAuCu$_2$+VYS+BORN	**Wt.%**	**19.4**	**3.7**	**48.2**	**28.0**	**-**	**-**	**99.3**
			F.c.	0.82	0.09	1.10	1.99	-	-	4
4	45-1, 56	PdAuCu$_2$+(Pd,Au)Cu+CHC +BORN	**Wt.%**	**26.6**	**2.6**	**39.4**	**30.0**	**-**	**-**	**98.6**
			F.c.	1.07	0.06	0.85	2.02	-	-	4
5	45-1, 98	PdAuCu$_2$+(Pd,Au)Cu+VSL +VYS	**Wt.%**	**23.9**	**2.1**	**43.6**	**29.2**	**0.6**	**-**	**99.1**
			F.c.	0.96	0.05	0.96	1.99	0.02	-	4
6	45-1, 104	PdAuCu$_2$+(Pd,Au)Cu+KTH +VSL+ILM+MT	**Wt.%**	**25.2**	**-**	**45.6**	**24.9**	**2.3**	**-**	**98.0**
			F.c.	1.05	-	1.03	1.74	0.18	-	4
7	45-1, 28	BGD+VSL	**Wt.%**	**26.7**	**2.7**	**55.2**	**13.6**	**1.1**	**-**	**99.3**
			F.c.	1.29	0.07	1.44	1.10	0.10	-	4
8	45-1, 54	BGD+(Au,Pd)Cu+KTH+ BORN	**Wt.%**	**18.2**	**3.5**	**64.1**	**12.7**	**-**	**-**	**98.5**
			F.c.	0.96	0.10	1.82	1.12	-	-	4
9	45-1, 62	BGD+(Au,Pd)Cu+VYS+ BORN	**Wt.%**	**19.9**	**2.6**	**63.6**	**12.7**	**-**	**-**	**98.8**
			F.c.	1.03	0.07	1.79	1.10	-	-	4
10	45-1, 54	BGD+(Au,Pd)Cu+KTH+ BORN	**Wt.%**	**18.2**	**4.0**	**51.9**	**24.8**	**-**	**-**	**98.9**
			F.c.	0.40	0.05	0.62	0.92	-	-	2
11	45-1, 62	BGD+(Au,Pd)Cu+VYS+ BORN	**Wt.%**	**19.2**	**3.8**	**48.3**	**27.6**	**-**	**-**	**98.9**
			F.c.	0.41	0.04	0.56	0.99	-	-	2
12	45-1, 5	(Au,Pd)Cu +KTH	**Wt.%**	**18.8**	**1.1**	**51.4**	**27.3**	**0.5**	**-**	**99.1**
			F.c.	0.40	0.01	0.59	0.98	0.02	-	2
13	75-1, 1	(Au,Pd)Cu+(Pd,Au)$_3$Cu+ BORN	**Wt.%**	**23.3**	**3.3**	**44.5**	**28.1**	**-**	**-**	**99.2**
			F.c.	0.48	0.04	0.50	0.98	-	-	2
14	45-1, 75	VYS+(Pt,Fe,Pd,Cu)+ KTH+BORN+CHC	**Wt.%**	**19.1**	**61.1**	**-**	**5.1**	**13.3**	**-**	**98.1**
			F.c.	0.22	0.39	-	0.10	0.29	-	1
15	45-1,114	(Pd,Pt)Cu+(Pt,Fe,Pd,Cu) +CHC+BORN	**Wt.%**	**19.7**	**61.1**	**-**	**4.9**	**13.1**	**0.4**	**99.2**
			F.c.	0.23	0.38	-	0.09	0.29	0.01	1
16	45-2, 6	(Pt,Fe,Pd,Cu)+BORN	**Wt.%**	**16.2**	**64.8**	**-**	**5.9**	**11.0**	**0.4**	**98.3**
			F.c.	0.20	0.42	-	0.12	0.25	0.01	1

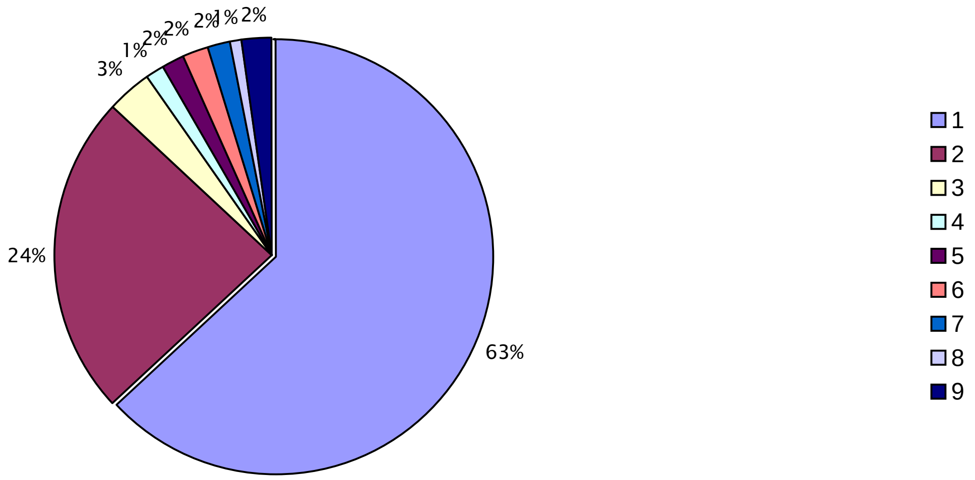

Fig. 1. PGE, Au and Ag minerals relative contents of the sample 90-18, 1010.
1: unnamed PdCu, 2: vysotskite, 3: vasilite, 4: braggite, 5: keithconnite,
6: unnamed $PdAuCu_2$, 7: tetraauricupride, 8: bogdanovite, 9: others.

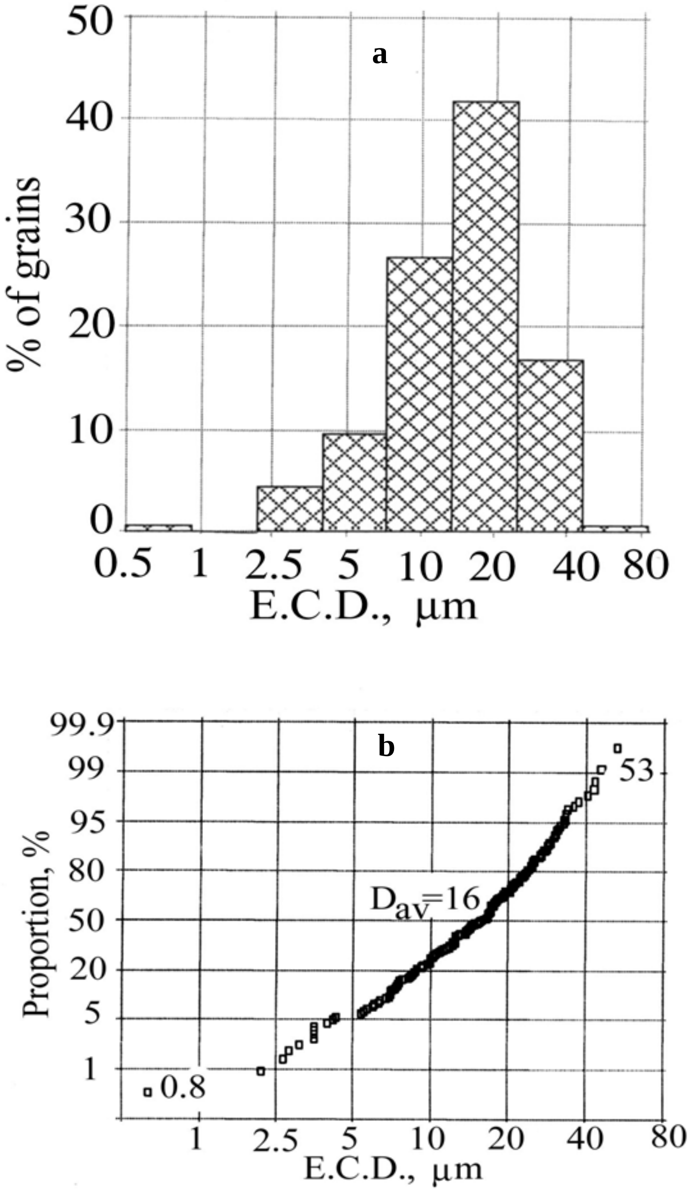

Fig. 2. Grain sizes of precious metal mineral grains (N=180), extracted in the heavy concentrates of the sample 90-18, 1010.
a: histogram, b: lognormal probability plot.

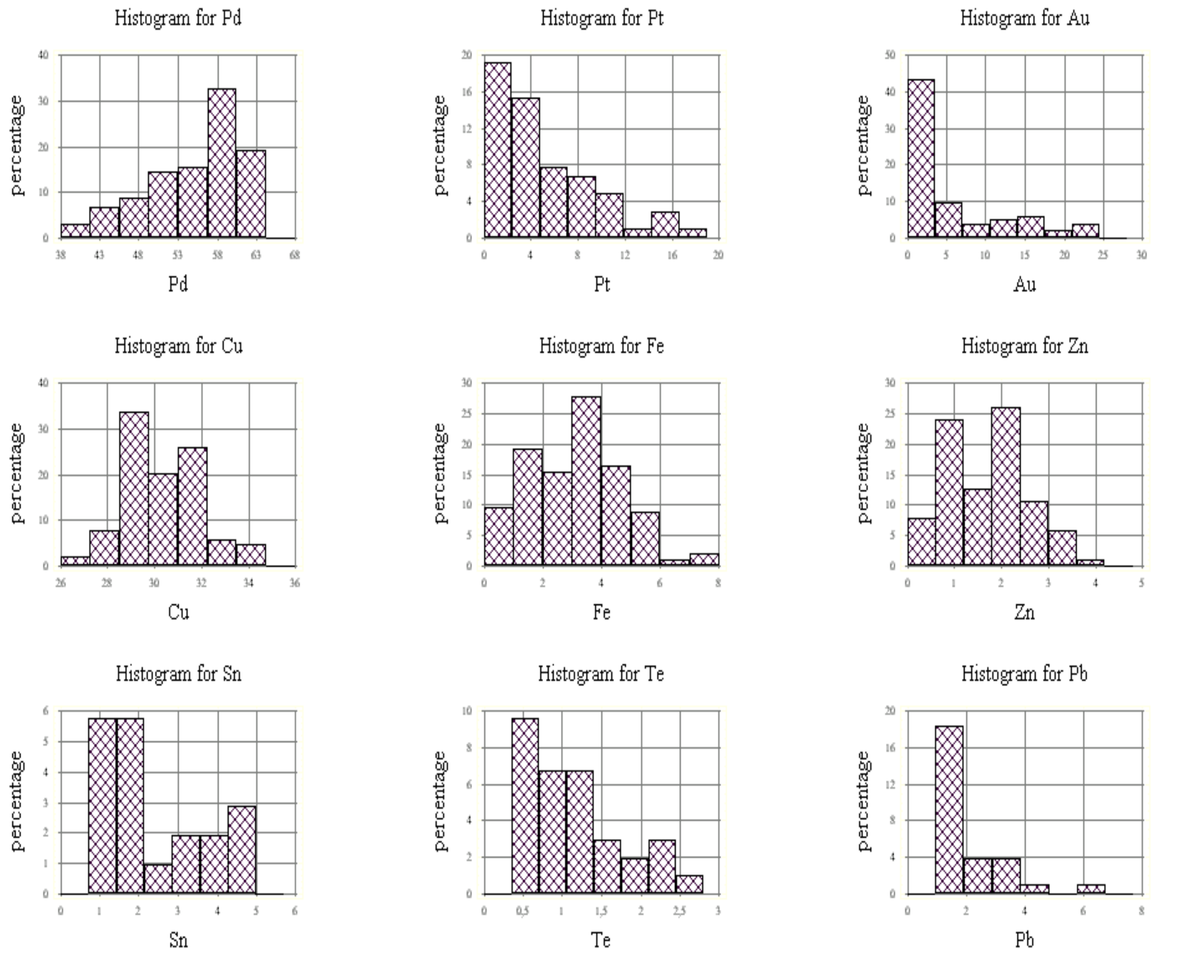

Fig. 3. Histograms of PdCu mineral-forming elements for data of the Table 4, n = 108.

Appendix

Sample 90-18 1010.48

Electron microprobe analyses of sulphides and precious metal phases.

Analyses collected at Department of Geology, University of Copenhagen Denmark using a GEOL Superprobe and metal and sulphide standarts at 20 kV and 15nA.
by H. Rasmussen.

Cu-sulphides

Thin section	level	type	grain	mineral	Cu	Fe	S	Au	Pd	Pt	Sn	Bi	Zn	Te	Sb	As	Ag	Ni	TOTAL
18-1010.48	Pd5	S	2Sc	bornite	64,27	9,62	25,74	0,20	0,09	0,01	0,04	n.a.	n.a.	0,03	0,02	0,01	0,01	0,01	100,05
18-1010.48	Pd5	S	2Sd	bornite	63,30	10,47	26,05	0,25	0,01	0,01	0,05	n.a.	n.a.	0,01	0,01	0,01	0,01	0,01	100,19
18-1010.48	Pd5	S	4Sa	bornite	62,74	11,49	26,32	0,07	0,02	0,09	0,01	n.a.	n.a.	0,01	0,01	0,01	0,01	0,01	100,79
18-1010.48	Pd5	S	4Sb	bornite	62,59	11,65	26,28	0,01	0,04	0,11	0,01	n.a.	n.a.	0,01	0,01	0,01	0,01	0,01	100,74
18-1010.48	Pd5	S	10Sa	bornite	62,58	10,98	26,39	0,01	0,03	0,07	0,01	n.a.	n.a.	0,01	0,01	0,01	0,39	0,01	100,51
18-1010.48	Pd5	S	7Sa	bornite	62,36	10,45	26,26	0,10	0,01	0,02	0,01	n.a.	n.a.	0,01	0,02	0,01	0,01	0,01	99,27
18-1010.48	Pd5	S	1Sa	bornite	62,12	11,82	25,83	0,15	0,01	0,06	0,03	n.a.	n.a.	0,01	0,02	0,01	0,01	0,01	100,09
18-1010.48	Pd5	S	1Sb	bornite	62,10	11,65	25,73	0,21	0,01	0,07	0,02	n.a.	n.a.	0,01	0,01	0,01	0,01	0,01	99,85
18-1010.48	Pd5	S	3Sb	bornite	61,69	10,70	25,90	0,04	0,01	0,11	0,03	n.a.	n.a.	0,01	0,01	0,01	0,24	0,01	98,76
18-1010.48	Pd5	S	14Sb	bornite	61,67	11,96	26,05	0,10	0,01	0,20	0,01	n.a.	n.a.	0,03	0,02	0,01	0,20	0,01	100,27
18-1010.48	Pd5	S	3Sa	bornite	61,58	10,59	25,59	0,01	0,01	0,39	0,05	n.a.	n.a.	0,01	0,04	0,01	0,24	0,01	98,52
18-1010.48	Pd5	S	5Sa	bornite	61,15	11,40	25,40	0,33	0,02	0,03	0,01	n.a.	n.a.	0,01	0,01	0,01	0,01	0,01	98,39
18-1010.48	Pd5	S	14Sa	bornite	58,17	12,35	24,23	0,01	0,03	0,07	0,03	n.a.	n.a.	0,07	0,01	0,01	0,01	0,03	95,02
18-1010.48	Pd5	S	1Sd	digenite	77,34	1,98	22,69	0,01	0,07	0,14	0,01	n.a.	n.a.	0,01	0,01	0,01	0,19	0,01	102,47
18-1010.48	Pd5	S	1Sc	digenite	77,05	1,88	22,68	0,01	0,01	0,01	0,01	n.a.	n.a.	0,01	0,01	0,01	0,01	0,01	101,70
18-1010.48	Pd5	S	2Sa	digenite	78,09	0,56	22,88	0,01	0,11	0,11	0,01	n.a.	n.a.	0,03	0,02	0,01	0,01	0,01	101,86
18-1010.48	Pd5	S	2Sb	digenite	77,54	0,58	22,92	0,01	0,01	0,09	0,09	n.a.	n.a.	0,01	0,04	0,01	0,01	0,01	101,33
18-1010.48	Pd5	S	4Sc	digenite	73,60	3,85	23,09	0,08	0,03	0,10	0,07	n.a.	n.a.	0,01	0,02	0,01	0,01	0,02	100,89

Precious metal phases

Thin section	level	type	grain	mineral	Cu	Fe	S	Au	Pd	Pt	Sn	Bi	Zn	Te	Sb	As	Ag	Ni	TOTAL
18-1010.48	Pd5	PGM	11PGM1	PdCu	31,97	2,48	0,06	15,12	44,99	4,84	0,01	n.a.	n.a.	0,74	0,01	0,30	0,01	0,01	100,54
18-1010.48	Pd5	PGM	11PGM3	PdCu	32,03	2,08	0,16	11,30	49,11	2,94	0,07	n.a.	n.a.	3,11	0,04	0,01	0,01	0,01	100,86
18-1010.48	Pd5	PGM/Pb?	14PGM1	PdCu	24,08	1,63	0,01	0,77	63,29	0,04	3,71	n.a.	n.a.	0,01	0,03	1,76	0,01	0,01	95,36
18-1010.48	Pd5	PGM	13PGM2	PdCu	30,68	8,80	0,06	1,65	61,49	0,09	0,02	n.a.	n.a.	0,01	0,01	0,01	0,01	0,01	102,84
18-1010.48	Pd5	PGM	13PGM1	PdCu	30,51	8,51	0,07	1,78	61,13	0,02	0,01	n.a.	n.a.	0,01	0,01	0,01	0,01	0,03	102,11
18-1010.48	Pd5	PGM	11PGM5	PdCu	29,33	6,61	0,01	4,67	59,03	1,13	0,07	n.a.	n.a.	0,31	0,01	0,24	0,01	0,02	101,44
18-1010.48	Pd5	PGM	11PGM4	PdCu	29,41	6,75	0,13	4,79	58,88	1,18	0,01	n.a.	n.a.	0,31	0,01	0,23	0,01	0,04	101,75
18-1010.48	Pd5	PGM	10PGM1	PdCu	32,09	1,52	0,63	0,39	58,81	0,01	0,36	n.a.	n.a.	0,08	0,14	2,26	0,01	0,01	96,32
18-1010.48	Pd5	PGM	13PGM3	PdCu	28,83	9,11	0,45	2,15	58,20	0,24	0,01	n.a.	n.a.	0,01	0,01	0,01	0,01	0,03	99,05
18-1010.48	Pd5	PGM	12PGM1	PdCu	40,28	5,92	1,53	7,17	44,49	0,63	0,02	n.a.	n.a.	0,08	0,01	0,01	0,01	0,01	100,18
18-1010.48	Pd5	PGM	13PGM4	PdCu	34,25	13,69	4,23	4,00	41,40	0,15	0,01	n.a.	n.a.	0,01	0,01	0,05	0,01	0,01	97,82
18-1010.48	Pd5	PGM	11PGM6	(Cu,Fe,Pd,Pt)-alloy	3,45	13,09	0,06	15,82	63,85	4,37	0,13	n.a.	n.a.	0,41	0,01	0,01	0,01	0,07	101,28
18-1010.48	Pd5	PGM	7PGM1	(Cu,Fe,Pd,Pt)-alloy	5,05	12,07	0,01	0,21	0,33	80,43	0,05	n.a.	n.a.	0,06	0,01	0,01	0,01	0,24	98,48
18-1010.48	Pd5	PGM	3PGM2	(Cu,Fe,Pd,Pt)-alloy	8,34	12,92	0,39	0,16	4,88	72,18	0,07	n.a.	n.a.	0,01	0,05	0,01	0,01	0,27	99,29
18-1010.48	Pd5	PGM	3PGM1	(Cu,Fe,Pd,Pt)-alloy	9,33	13,30	0,01	0,26	4,59	70,35	0,06	n.a.	n.a.	0,01	0,01	0,01	0,01	0,32	98,26
18-1010.48	Pd5	PGM	2PGM1	vysotskite	2,27	0,20	23,07	0,13	77,32	0,01	0,03	n.a.	n.a.	0,01	0,01	0,01	0,01	0,18	103,26
18-1010.48	Pd5	PGM	2PGM2	vysotskite	2,61	0,23	23,27	0,13	76,96	0,01	0,01	n.a.	n.a.	0,01	0,01	0,01	0,01	0,14	103,41
18-1010.48	Pd5	PGM	4PGM1	vysotskite	3,89	1,11	23,65	0,01	68,38	0,35	0,01	n.a.	n.a.	0,06	0,01	0,01	0,01	4,76	102,25
18-1010.48	Pd5	PGM	5PGM1/S	vysotskite	1,69	3,06	20,53	0,15	58,21	0,83	0,01	n.a.	n.a.	0,04	0,01	0,01	0,01	4,34	88,89
18-1010.48	Pd5	PGM	11PGM2	kotulskite	1,01	0,58	0,01	0,39	69,51	0,06	1,01	n.a.	n.a.	27,94	0,23	0,01	0,01	0,02	100,78

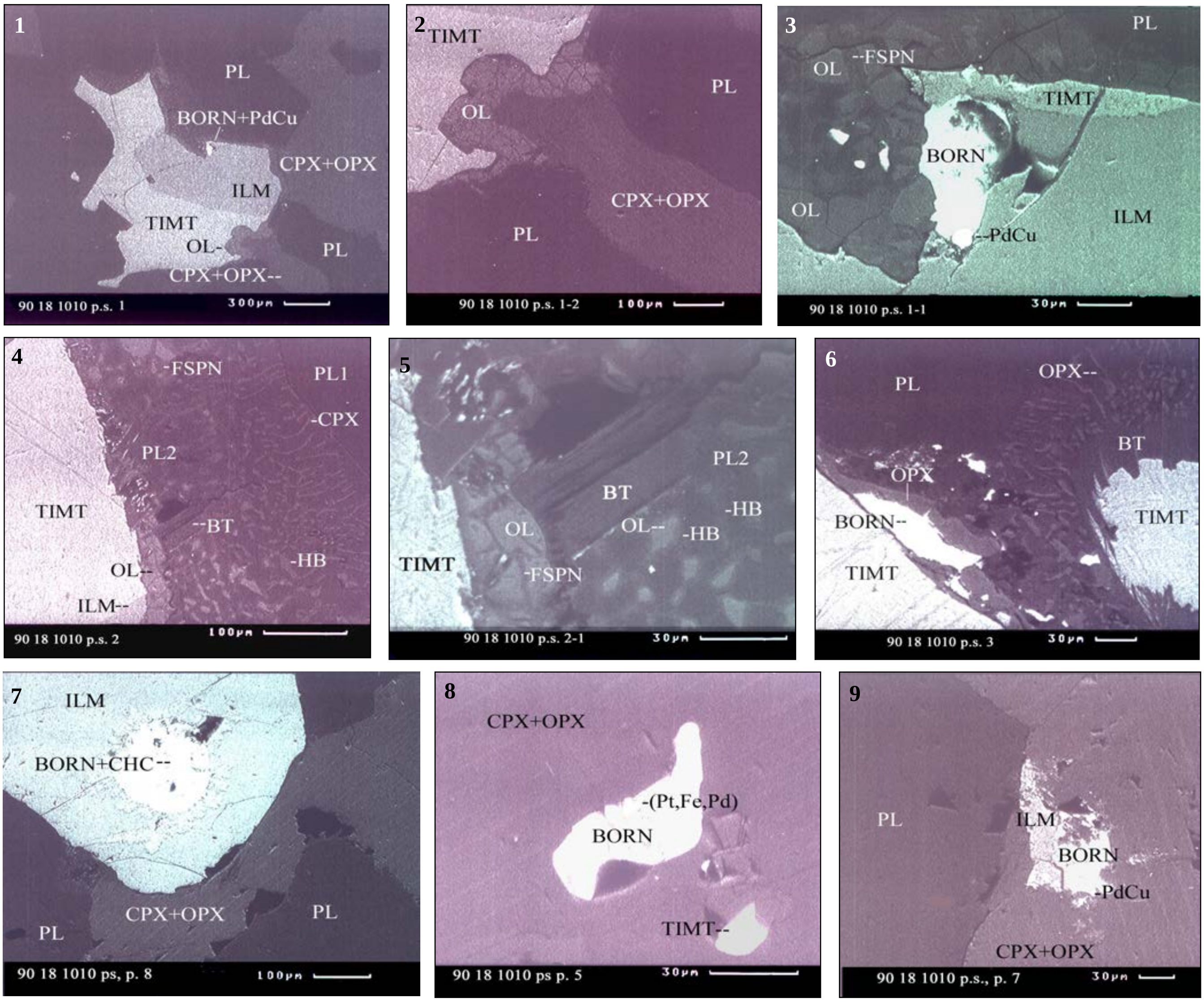

Plate 1. Relationships of rock-forming minerals, Fe-Ti-oxides, sulphides and PGMs of oxide-rich tholeiitic gabbros, the sample 90-18, 1010 (1-9); thin polished section # 18-1010.48, SEM-image (BIE).

2 and 3: parts of 1; 5: part of 4.

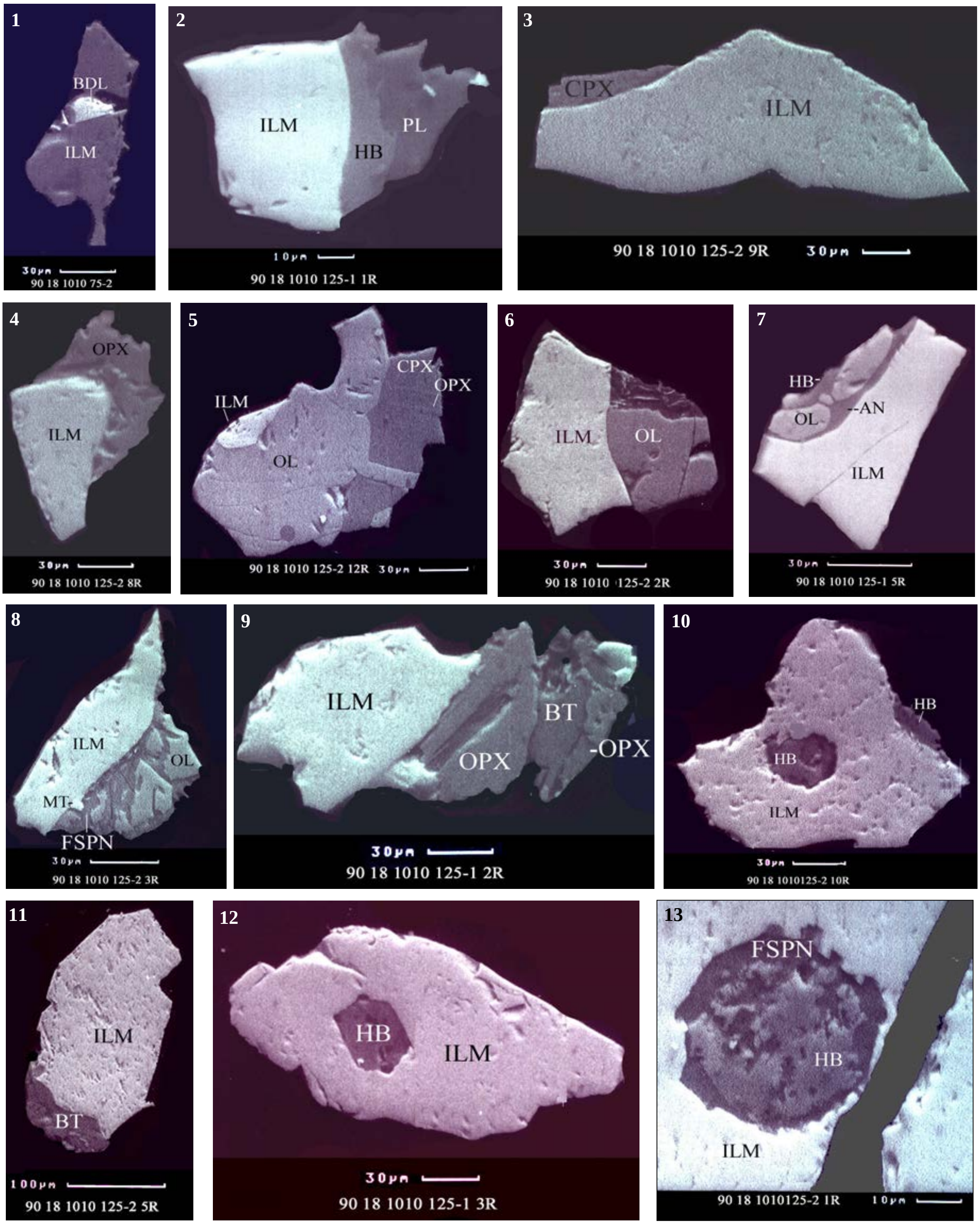

Plate 2. Relationships of Ti-oxide mineralization with rock-forming minerals of oxide-rich tholeiitic gabbros, the sample 90-18, 1010 (1-13); polished sections of grains, extracted in the heavy concentrates; SEM-image (BIE).

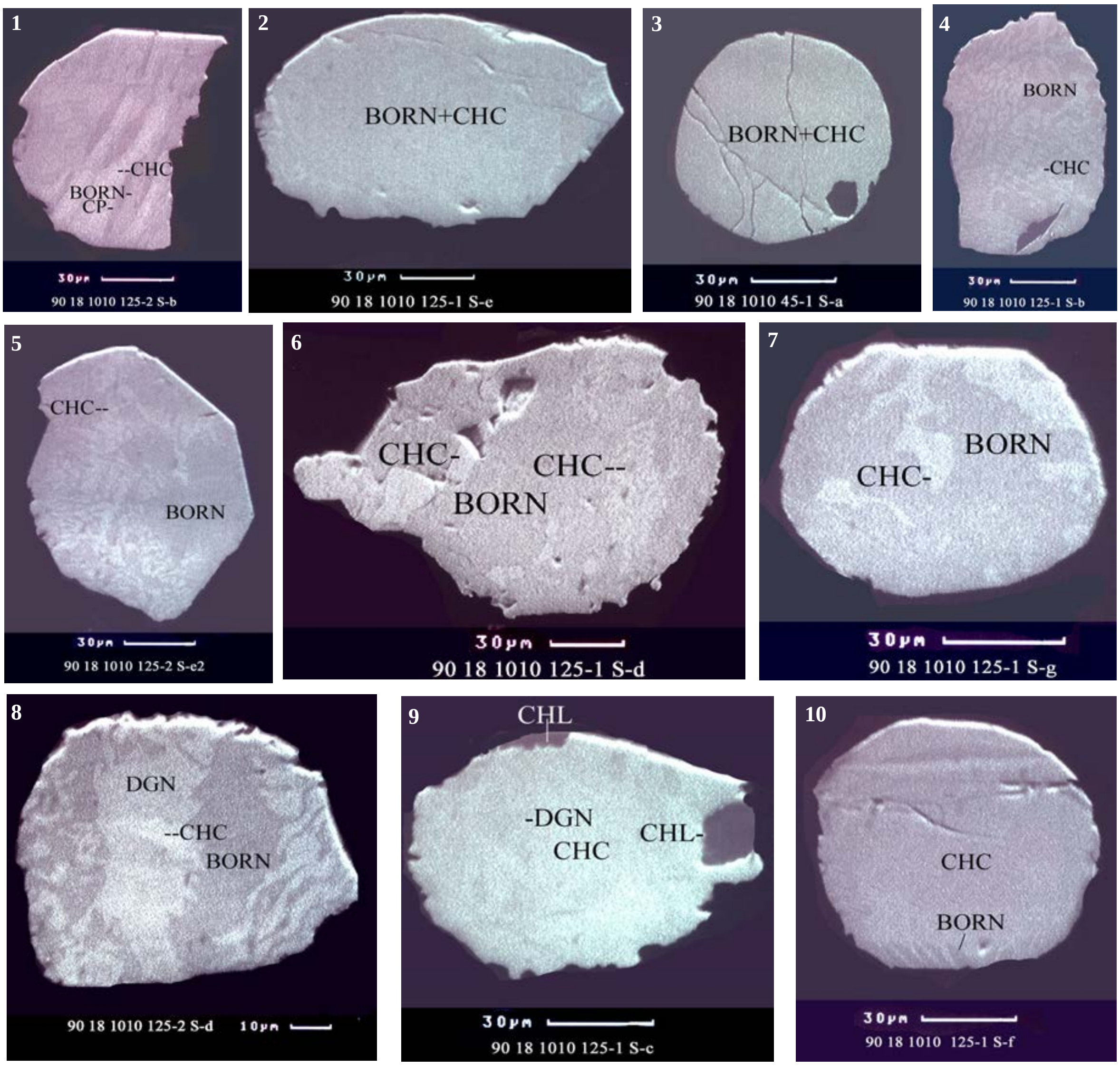

Plate 3.1. Globuls and grains of sulphide mineralisation from oxide-rich tholeiitic gabbros, the sample 90-18, 1010; polished sections of grains, extracted in the heavy concentrates; SEM-image (BIE).

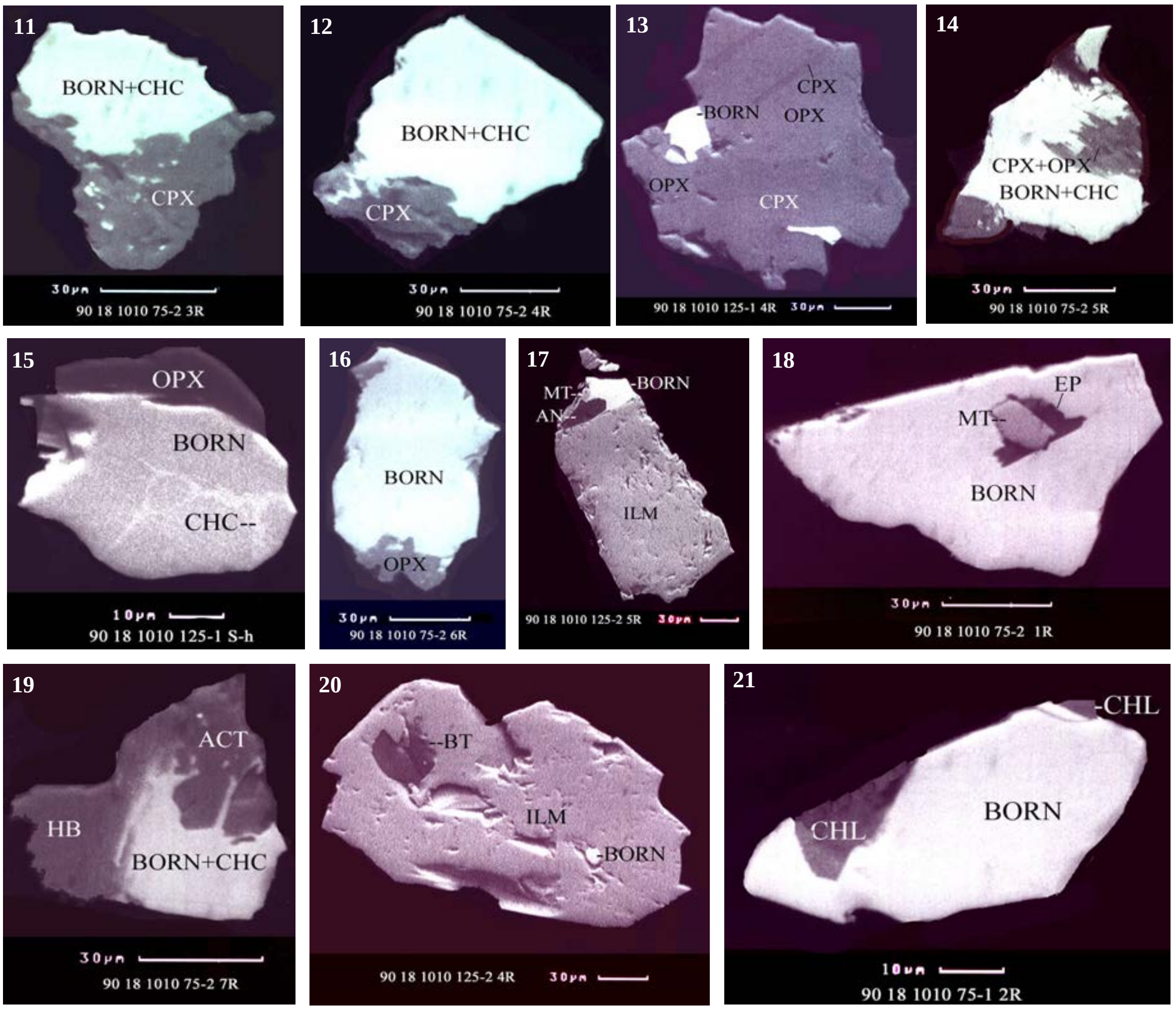

Plate 3.2. Globuls and grains of sulphide mineralisation from oxide-rich tholeiitic gabbros, the sample 90-18, 1010; polished sections of grains, extracted in the heavy concentrates; SEM-image (BIE).

Plate 4. Monomineral PGE mineralisation represented by grains of PdCu unnamed phase from heavy concentrates of the sample 90-18 1057 (1-68); polished sections, SEM-image (BIE).

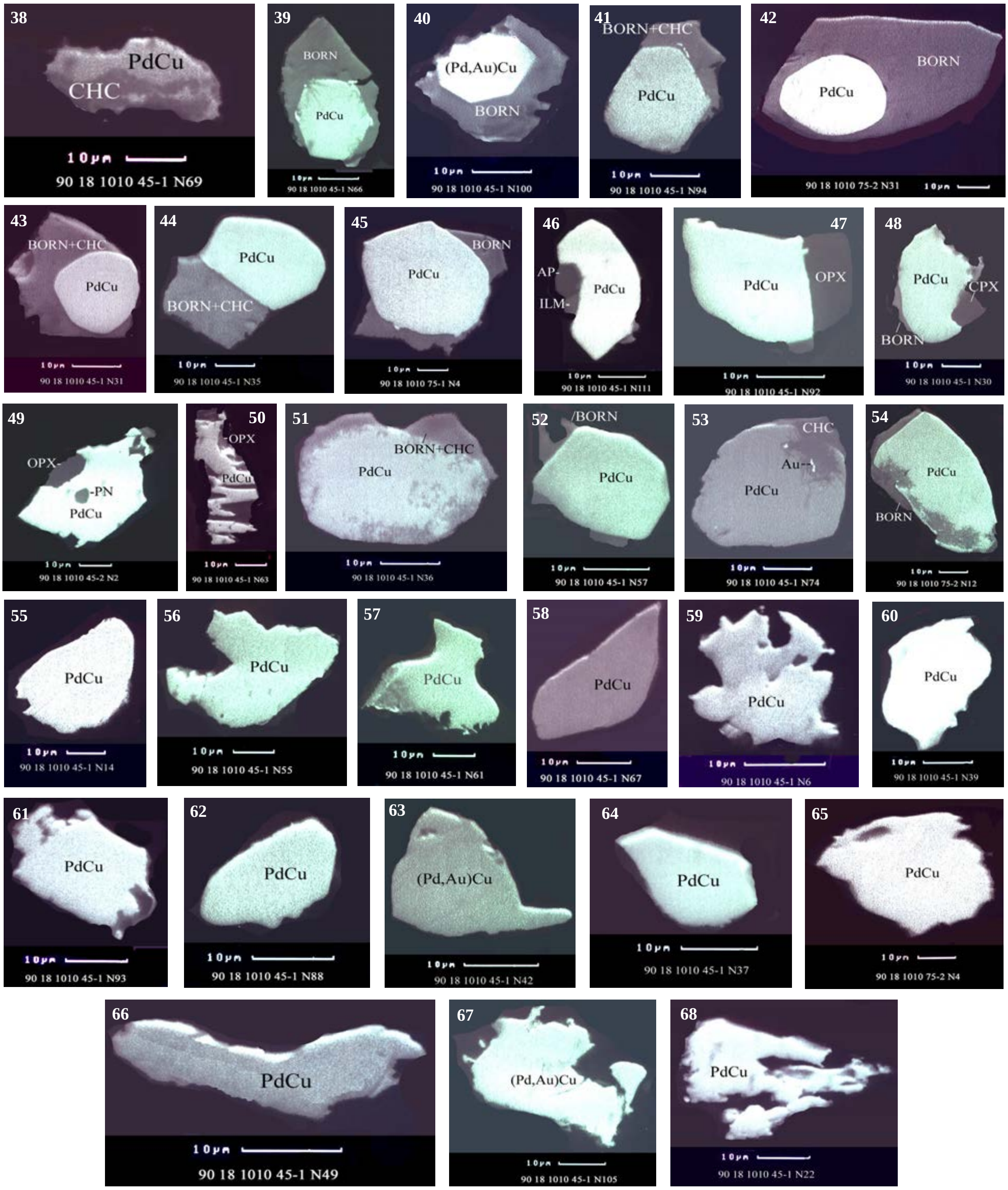

Plate 4 continued. Monomineral PGE mineralisation represented by grains of PdCu unnamed phase from heavy concentrates of the sample 90-18 1057 (1-68); polished sections, SEM-image (BIE).

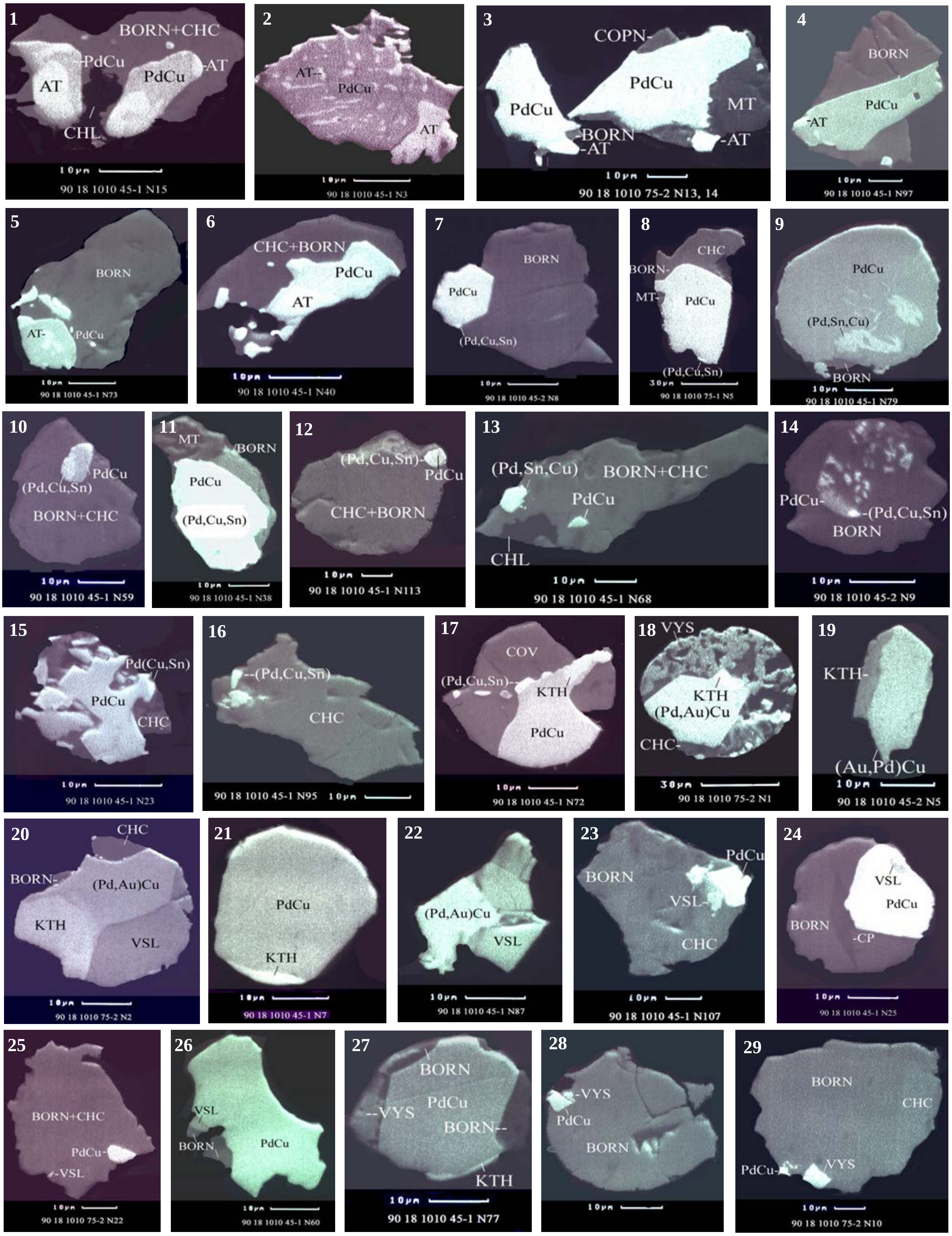

Plate 5. Grains of polymineral PGE mineralisation, represented by PdCu unnamed phase, atokite, Pd-Cu-Sn alloy, keithconnite, vasilite, vysotskite, Pt-Fe-Pd-Cu alloy and zvyagintsevite which were extracted in heavy concentrates of the sample 90-18 1057 (1-36); polished sections, SEM-image (BIE).

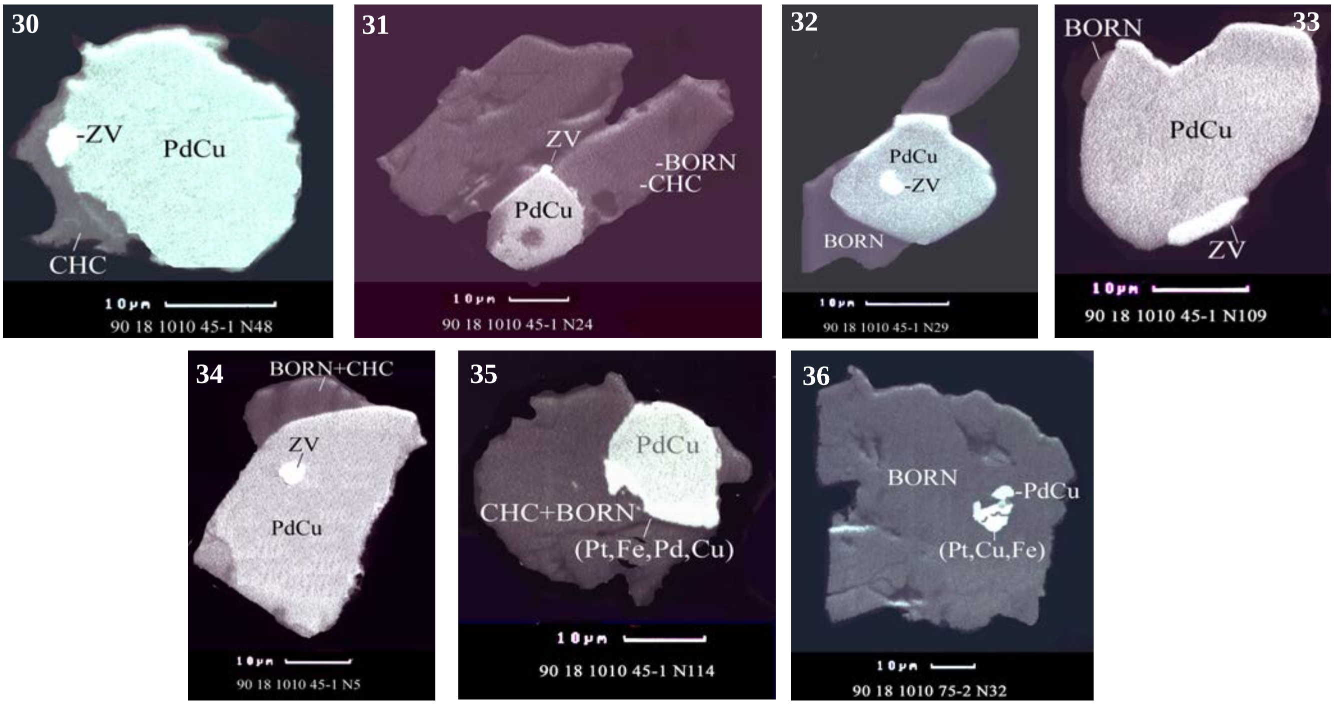

Plate 5 continued. Grains of polymineral PGE mineralisation, represented by PdCu unnamed phase, atokite, Pd-Cu-Sn alloy, keithconnite, vasilite, vysotskite, Pt-Fe-Pd-Cu alloy and zvyagintsevite which were extracted in heavy concentrates of the sample 90-18 1057 (1-36); polished sections, SEM-image (BIE).

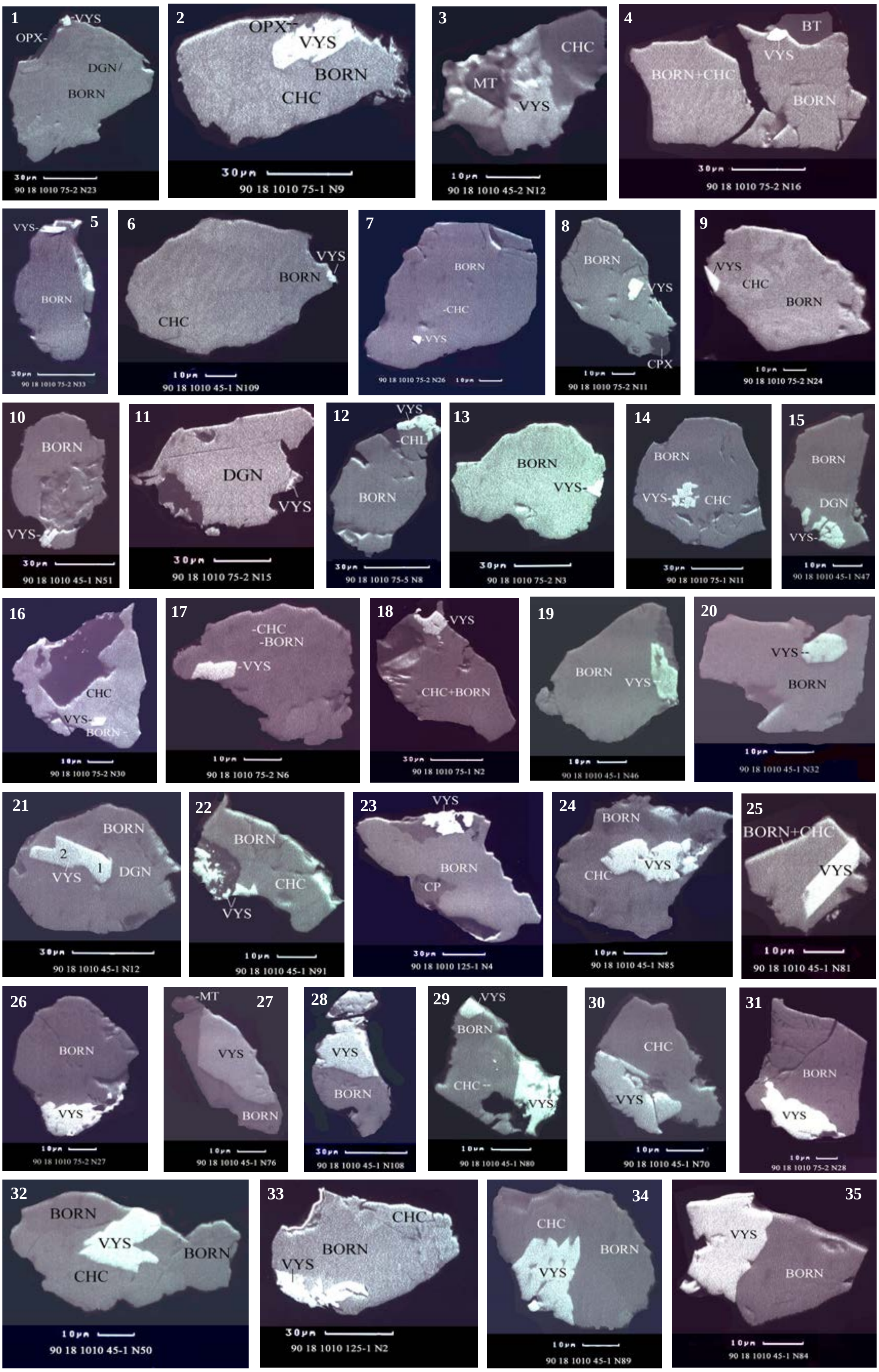

Plate 6. Grains of vysotskite, vasilite and braggite, extracted in heavy concentrates of the sample 90-18, 1010 (1-53); polished sections, SEM-image (BIE).

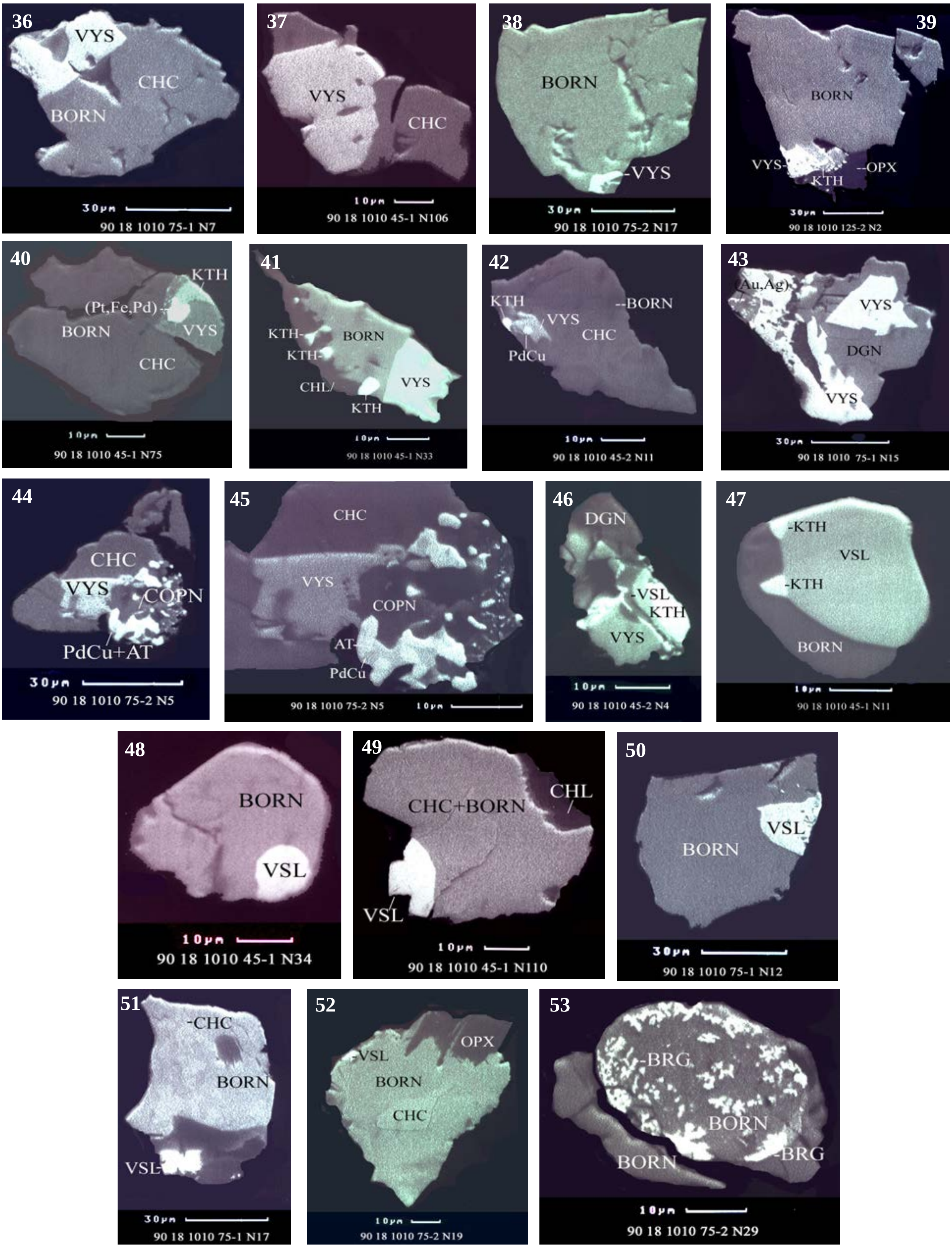

Plate 6 continued. Grains of vysotskite, vasilite and braggite, extracted in heavy concentrates of the sample 90-18, 1010 (1-53); polished sections, SEM-image (BIE).

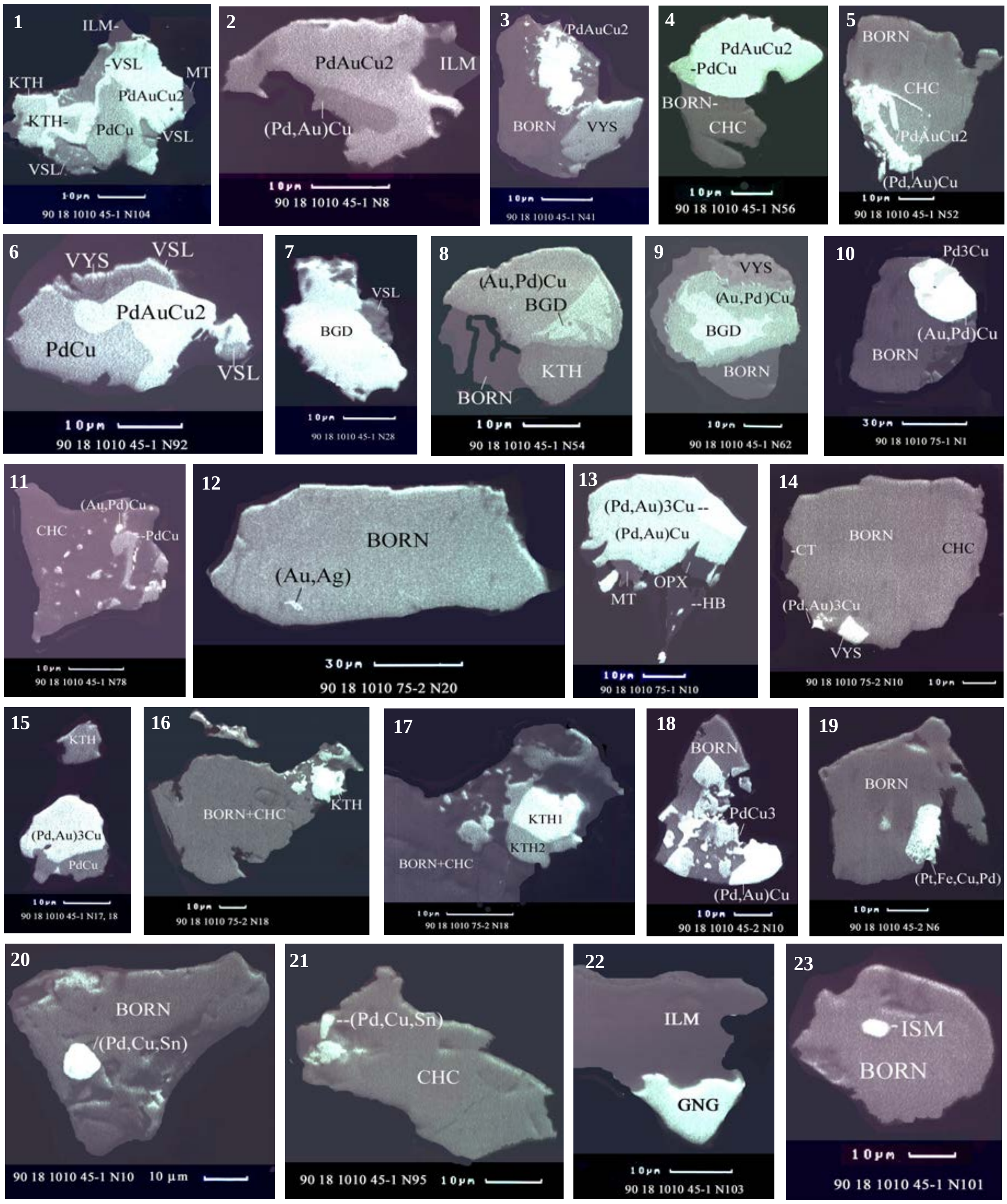

Plate 7. Grains of Au mineral phases (unnamed $PdAuCu_2$, bogdanovite, tetra-auricupride),unnamed minerals phases Pd_3Cu and $PdCu_3$, alloys (Au,Ag), (Pt,Fe,Cu,Pd) and (Pd,Cu,Sn), guanglinite and isomertieite, extracted in heavy concentrates of the sample 90-18, 1010 (1-23); polished sections, SEM-image (BIE).