

The new platinum selenide luberoite Pt_5Se_4 from the Lubero region (Kivu Province, Zaire)

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Abstract : The new platinum selenide luberoite, identical with the synthetic compound Pt_5Se_4 , has been found in concentrates from placers worked for gold and platinum in the Lubero region (Kivu Province, Zaire). The mineral is present as loose crystals and fragments smaller than 0.5 mm, and as inclusions in platinum grains. It is composed of Pt = 75.76 and Se = 24.24 wt %. Its symmetry is monoclinic (space group $P 2_1/c$), with $a = 6.584 \text{ \AA}$; $b = 4.602 \text{ \AA}$; $c = 11.10 \text{ \AA}$; $a : b : c = 1.430 : 1 : 2.412$; $\beta = 101.6^\circ$; $V = 329.5 \text{ \AA}^3$. The three strongest diffraction lines are $1.875_{(100)}$, $2.93_{(80)}$ and $1.812_{(60)}$ \AA. The calculated density is 13.02 g cm^{-3} , and the stoichiometric formula is Pt_5Se_4 for $Z=2$. The mineral is opaque and the maximum and minimum reflectance values in air for the COM wavelengths (470, 546, 589, 650 nm) are, respectively : 48.6/42.6 ; 53.0/46.7 ; 55.0/48.6 ; 58.0/51.5. It has a mean microhardness (VHN₁₅) of 461 kg mm^{-2} . The minerals found associated with luberoite in the placers, as well as the minerals enclosed in the platinum grains, indicate that luberoite belongs to a platinum deposit, whose primary source-rocks are not yet definitively known, but are very likely of granodioritic affiliation.

Key-words : alluvial platinum minerals, luberoite, new mineral, platinum selenide, Zaire.

Introduction

Passau (1945) was the first to describe a group of 18 alluvial Pt deposits and prospects located in the region of Lubero (Northern Kivu Province, Zaire). They were partly explored by the Scrutton Mission in 1914 and worked for gold and platinum in the late 1930's. Later on, these occurrences were referred to briefly in the geological and mineralogical literature of African PGE (platinum group element) deposits, but their min-

eralogy and ore geology have never been studied (Buttgenbach, 1947 ; Mertie, 1969 ; Notice Explicative, 1974 ; Kampunzu *et al.*, 1986). However, the absence of ultrabasic rocks in the Lubero region, as well as the intriguing mineralogical features, already stressed by L. Duparc (who studied samples submitted to him by Passau), should have triggered keen interest. For instance, excerpts of Duparc's letters quoted in Passau's paper emphasize the peculiarity of the quartz inclusions in the Lubero nuggets, and their

similarity with the abnormal Waterberg deposit (Potgietersrus) in South Africa (Wagner, 1929).

The Lubero concentrates preserved in the collections of the Musée d'Afrique Centrale (Tervuren, Belgium) gave us the opportunity to undertake a mineralogical study with currently available methods. A wealth of interesting mineralogical and petrogenetic aspects have effectively been revealed, and will be dealt with elsewhere in greater detail. The present paper is limited to the description of a new platinum mineral found in the Lubero concentrates, the first natural Pt selenide ever described, and to a preliminary description of the paragenesis (Jedwab, 1990).

Origin of the studied materials

The township of Lubero is located in the NE corner of Zaire, very close to the equator, at 29°14'E 0°10'S. It lies to the south of a vast region, belonging to the gold-platinum mining concession formerly known as « Concession Nord de la Minière des Grands Lacs Africains (MGL) », which covers an area of 558,845 ha. Passau (1945) states that platinum had been found in this area in about 10 rivers (High and Middle Lubero, Lwaia, Kanabiro, Tayna, Lower Lianza, Epighe, between Ibina and Kitagoha, Higher Masosa) and at the localities of Mutushi and Ngele. At least 3 of the locations worked for gold were also worked for their platinum contents; however, the latter metal was a minor component in the metallic concentrates, according to the personal recollections of MGL's former engineers A. Culée and the late A. Prigogine.

Circumstances of the Pt₅Se₄ discovery

It is important to relate briefly these circumstances, since it is easy to overlook the new mineral when observing only with unpolarized light under the reflecting light microscope, or even when using the scanning electron-microscope (SEM) or electron-microprobe (EMP).

During the study of polished grains of native platinum (the main constituent of the concentrates) under the SEM in the back-scattered mode (BS) and coupled to the EMP (energy-dispersive spectrometer EDS), the presence was noted of an enclosed compound apparently containing only

Pt but with a much lower BS electron yield than the hosting Pt matrix. A closer examination of the spectrum nevertheless showed that there was a slight departure from the normal Pt spectrum: the L β Pt peak (at 11.38 keV) was of the same intensity as the L α peak, instead of having about two thirds the intensity. At the low energy end of the spectrum, a peak was also noticed at 1.38 keV, a region where several poorly resolved peaks of the elements Mg, Al, Se, As, Mg, Zn, Si pile up. The presence of selenium was thus considered a plausible explanation for the increased intensity of the L β Pt peak.

A spectrum obtained with the wavelength dispersive spectrometer (WDS) showed unambiguously that the purported EDS Pt L β peak at 11.38 keV was in fact the sum of the Pt L $\beta_1 + 2$ peaks ($\lambda = 1.11990$ and 1.10200 Å, respectively) plus the Se K α_{1+2} peaks ($\lambda = 1.10612$ Å). From there on, the new Pt-Se compound was easily recognized in its various habits and associations, each time an abnormally increased intensity of the EDS Pt L β peak was observed.

Methods

Studied samples and fractions

The studied samples were gram quantities of three concentrates, and three large nuggets unequivocally identifiable in Passau's (1945) paper from photographs. The concentrate vials were not accompanied by any documentation giving the place or circumstances of their collection. Only the weights, and sometimes a date, are given on the labels. However, it appears from available mining company documents that the concentrate samples are probably mixtures from several different prospects. The vial containing the nuggets has a label indicating « MUTUSHI » as the locality. Sifting the concentrates down to fractions <75 μ m showed that the proportions of gold and non-PGM minerals increase in the finer fractions: this probably indicates that the larger platinum particles had been extracted by hand from the larger grain size fractions. It is also clear that the samples have never been subjected to magnetic separation, since ferroplatinum grains could still be extracted with a hand magnet. This feature becomes important in the discussion of the paragenesis.

Splits of the sifted fractions were prepared as polished sections. Their study under the SEM

and the EMP/EDS led to the discovery of the platinum selenide included in the platinum grains, as described above. The unmounted granulometric fractions were then examined directly under the stereomicroscope, in order to find possible isolated grains of the same mineral. A dark-bronze metallic phase was eventually noticed and extracted, which was indeed the new mineral.

Instrumental methods

The following methods were used for most of the measurements :

Reflectance and colour values : Leitz MPV-2 photometric microscope. Spectral dispersion was obtained with a Leitz prism-monochromator. The photomultiplier was an S 20 cathode type. The immersion oil used was of Cargille type D/A, $n_{(589\text{nm})} = 1.516$. The standards used were for measurements in air : WC N°1, and for oil : WC N°48 by Zeiss (Oberkochen). Colour values, x , y , $Y\%$, λ_d and $Pe\%$ (CIE System) were calculated for a C illuminant with the Chroma/LMCP program, written by Cervelle *et al.* (1977).

Microhardness (VHN) : Leitz DURIMET. As the luberoite crystals cleave extremely easily, the measurements could only be made with a 15 g weight.

Chemical composition : Qualitative compositions were established by EMP/WDS (JEOL superprobe-733) and EDS (TRACOR NORTHERN TN-2000 spectrometer). The quantitative composition was established with the help of the EDS only, since several of the analysed particles were small inclusions in platinum, demanding a good resolution, difficult to obtain under the WDS. A series of Pt-Se standards (prepared by Dr S.R. Soendsen, Oslo), corresponding to $PtSe_{0.7}$, $PtSe_{0.8}$ and $PtSe_{0.9}$, and analytical and ZAF correction programs written by McCarthy (1979) were also used.

X-ray diffraction : Luberoite Weissenberg and precession spectra were obtained with a prismatic, b -elongated monocrystal. A powder pattern was obtained with a 114.6 mm Debye-Scherrer camera ($CuK\alpha$ radiation). Intensities were estimated visually. The identification of anatase and tourmaline was carried out with a 57.4 mm Debye-Scherrer camera, whereas Ti-hematite was identified with a Philips goniometer diffractometer.

Density : For this measurement alone, a new method was developed, due to the rarity of the

loose material and the small size of the individual grains :

1. a geometrically regular crystal of Pt_5Se_4 was photographed under the SEM (Fig. 1). Its homogeneity has been checked by EMP (EDS), since many of the other analysed grains are mechanical mixtures of luberoite and platinum.

2. the crystal was extracted from the mount and weighed on a gravity/electronic balance with a sensitivity of $2\ \mu\text{g}$ (METTLER-AT 20).

3. the crystal was then been brought back under the SEM, with its elongation axis parallel to the microscope axis, and photographed.

4. the nominal value displayed by the SEM scale bar was checked (and corrected) by measuring the same object (an electron microscope grid) under the SEM and under the light microscope with a filar ocular.

5. the surfaces of the crystal faces and the thicknesses along the three axes were measured on the SEM-photographs with the help of the (corrected) SEM scale bar. In one set of measurements an integrating planimeter was used, whereas in another, the measurements were made with a millimetric ruler. The crystal volume could thus be calculated.

6. the volume of the crystal and its weight were then used to calculate the density.

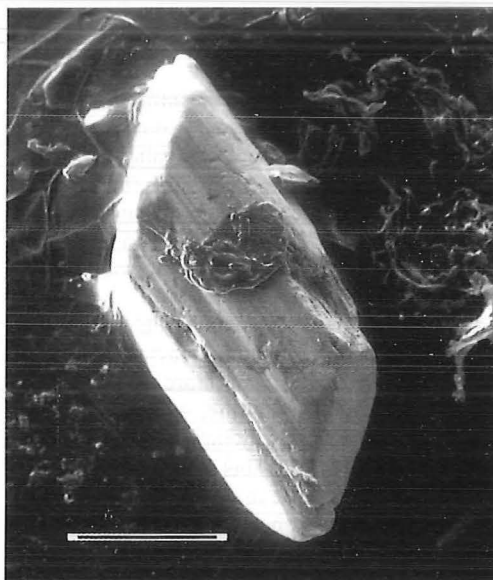


Fig. 1. Geometrically regular luberoite crystal. (This crystal has been used for the density measurement.) SEM, secondary mode. Scale bar = $100\ \mu\text{m}$.

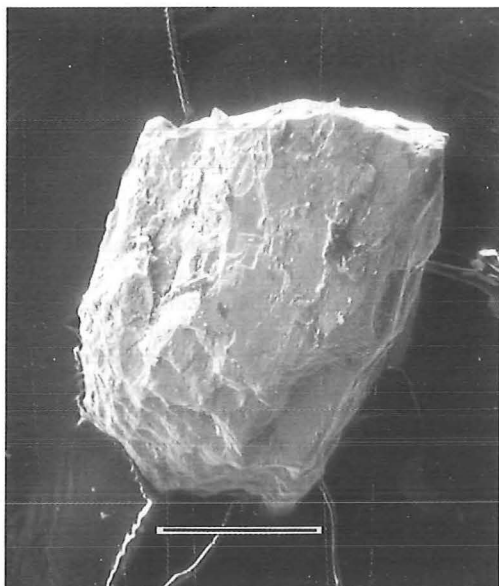


Fig. 2. Free fragment of luberoite with sharp edges and cleavages parallel to $\{001\}$. SEM, secondary mode. Scale bar = 100 μm .

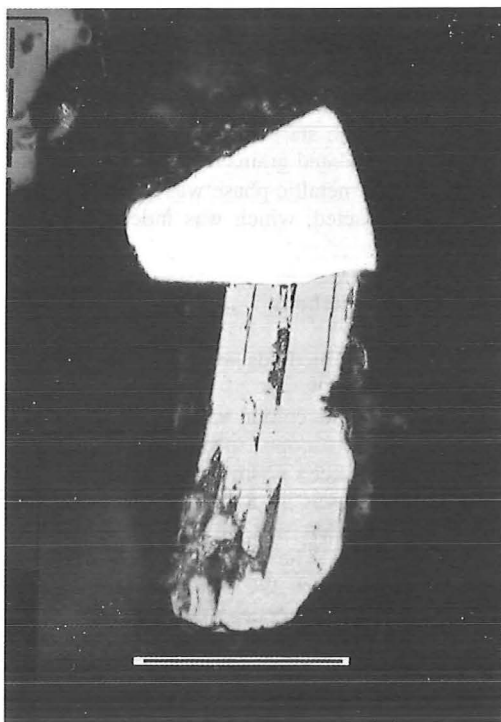


Fig. 3. Polished section of a group composed of a prismatic crystal of luberoite (grey) with cleavage traces, and of a trapezoidal crystal of platinum (white). Reflecting light microscope, unpolarized light, oil immersion. Scale bar = 50 μm .

Results

Physical properties

1.1. Morphology

In the unmounted grain concentrates, luberoite occurs as idiomorphic crystals, sometimes elongated (Fig. 1), or as monomineralic fragments, sometimes with a good cleavage (Fig. 2). According to X-ray diffraction, this cleavage is parallel to $\{001\}$. The fragmented grains may present sharp edges, as in Fig. 2, or be rounded and worn by alluvial transport (Fig. 4).

In polished mounts, the individual grains are sometimes prismatic, with a cleavage parallel to the elongation (Fig. 3), or more often rounded and possibly polycrystalline, as shown by the frequent polysynthetic twinning, visible under crossed nicols (Fig. 4). This last property may be used to locate luberoite in polished grain mounts.

When completely enclosed in platinum grains, luberoite displays rounded, irregular shapes, without preferential orientation. If such grains happen to occur close to the external border of the host platinum grain, they may be preferentially altered, mainly along cleavage directions

(Fig. 5). The fill products are the same as those observed in the platinum grains themselves: anatase, florencite, gorceixite, kaolinite and chlorite (*cf.* paragenetic observations). This differential behaviour is a clear indication of luberoite's relatively easy alterability, as compared to that of platinum.

1.2. Dimensions

Rare loose grains of up to 0.5 mm were found under the stereomicroscope. Most of the 10 odd free particles found by this means were in the 150 - 350 μm size range. Luberoite enclosed in platinum may be observed down to a few tens of micrometers.

1.3. Density

Due to the uniqueness of the selected crystal (Fig. 1), and to the small number of measure-



Fig. 4. Polished section of a rounded luberoite grain, displaying polysynthetic twinnings on (001) and polishing holes (black). Reflecting light microscope, polarized light, crossed nicols, oil immersion. Scale bar = 100 μm .



Fig. 5. Polished section of a platinum grain (light grey), including luberoite (dark grey). The latter, located at the border of the platinum, displays cleavages filled with anatase. Reflecting light microscope, unpolarized light, oil immersion. Scale bar = 100 μm .

ments, it is not possible to claim any standard error on the proposed value(s). Only range values may be given.

The weight of the crystal was $48 \pm 2 \mu\text{g}$. The volume calculated from surface measurements with the planimeter was equal to $4.304 \cdot 10^6 \mu\text{m}^3$, which gives a density range of 10.68 to 11.61 g cm^{-3} . The volume calculated from ruler measurements was $3.910 \cdot 10^6 \mu\text{m}^3$, giving a corresponding density range of 11.76 to 12.78 g cm^{-3} . The theoretical density, calculated from the structure, is 13.02 g cm^{-3} . The pycnometric density of the synthetic material has been established at 12.79 by Grønvdal *et al.* (1960). If the extreme weight values are used to fix the range, the minimum measured density is 10.68 with a maximum of 12.78 g cm^{-3} .

1.4. Light microscope observations and reflectance measurements

1.4.1. Stereomicroscope observations of the loose concentrates sometimes allow the visual recognition of luberoite, due to its shiny dark-

bronze colour in contrast to the grey platinum and yellow gold grains. But when random grain mounts were brought under the SEM/EMP after luberoite has already been extracted under the binocular, further particles were discovered. Thus, it is not always possible to distinguish unequivocally the luberoite grains from platinum under the stereomicroscope. According to a systematic search for luberoite in a mount of about 200 shiny grains, selected under the binocular in the 250 - 125 μm fraction, the concentration of luberoite grains is about 1%.

1.4.2. Optical properties and measurements under the reflecting polarizing microscope :

The results of the reflectance measurements and calculations of colour values are presented in Tables 1, 2 and 3, and Fig. 6. The mineral is opaque under transmitted light, since no internal reflexions are visible under crossed nicols. The visual properties of the mineral under reflected white light are as follows :

Pleochroism : low.

Bireflectance : very high ($R_{\text{max}} - R_{\text{min}} = 20.6\%$ at 589 nm).

Table 1. Reflectance values of luberoite.

λ (nm)	R max (air)	R min (air)	R max (oil)	R min (oil)
400	44.8	39.0	34.0	28.0
410	45.2	39.4	34.8	28.7
420	45.8	40.0	35.2	29.4
430	46.4	40.4	35.8	30.0
440	47.0	41.0	36.5	30.6
450	47.5	41.5	37.0	31.2
460	48.0	42.0	37.7	31.9
470	48.6	42.6	38.3	32.5
480	49.2	43.0	39.0	33.1
490	49.8	43.6	39.5	33.8
500	50.2	44.2	40.2	34.4
510	50.8	44.8	40.9	35.0
520	51.6	45.2	41.5	35.7
530	52.2	45.8	42.0	36.0
540	52.8	46.3	42.4	36.6
550	53.2	47.0	42.9	37.0
560	53.8	47.5	43.5	37.3
570	54.1	47.8	43.9	37.8
580	54.5	48.2	44.2	38.0
590	55.0	48.6	44.5	38.2
600	55.5	49.2	44.9	38.4
610	56.0	49.8	45.1	38.7
620	56.6	50.2	45.5	39.0
630	57.2	50.8	46.0	39.5
640	57.7	51.0	46.7	40.2
650	58.0	51.5	47.4	40.8
660	58.6	52.0	48.2	41.6
670	59.0	52.3	49.0	42.2
680	59.2	52.5	50.0	43.0
690	59.6	52.8	50.8	44.0
700	59.8	52.9	51.7	44.6
710	60.0	53.1	52.4	45.2
720	60.2	53.3	53.2	46.2
730	60.3	53.4	53.9	46.9
740	60.5	53.6	54.5	47.6
750	60.6	53.7	55.2	48.1
760	60.7	53.8	55.9	48.6
770	60.8	53.9	56.6	49.1

Table 2. Reflectance values of luberoite at the 4 Com-wavelengths

λ (nm)	R max (air)	R min (air)	R max (oil)	R min (oil)
470	48.6	42.6	38.3	32.5
546	53.0	46.7	42.7	36.8
589	55.0	48.6	44.5	38.2
650	58.0	51.5	47.4	40.8

Visual impression : white with a greenish-yellow hue.

Distinctly greenish-grey against Pt, Pt(Cu) and Pt(Fe).

Twinning : polysynthetic twins frequent.

1.5. Microhardness (VHN)

The diamond imprints obtained with a 15 g weight (9 measurements) show a strong anisotropy : the shortest diagonal (highest hardness) is parallel to the cleavages, whereas the longest is perpendicular. The minimum and maximum measured values are 322 and 620 kg mm⁻², and the mean is 461 kg mm⁻². Compared with platinum, the polishing hardness of luberoite is near that of the former. It polishes rather well.

2. Chemical composition

Twelve polished grains and inclusions in platinum, were analysed qualitatively and quantitatively by EMP (EDS). The qualitative composi-

Anisotropism : very high ($R_{max}-R_{min} = 1.51$ at 589 nm).

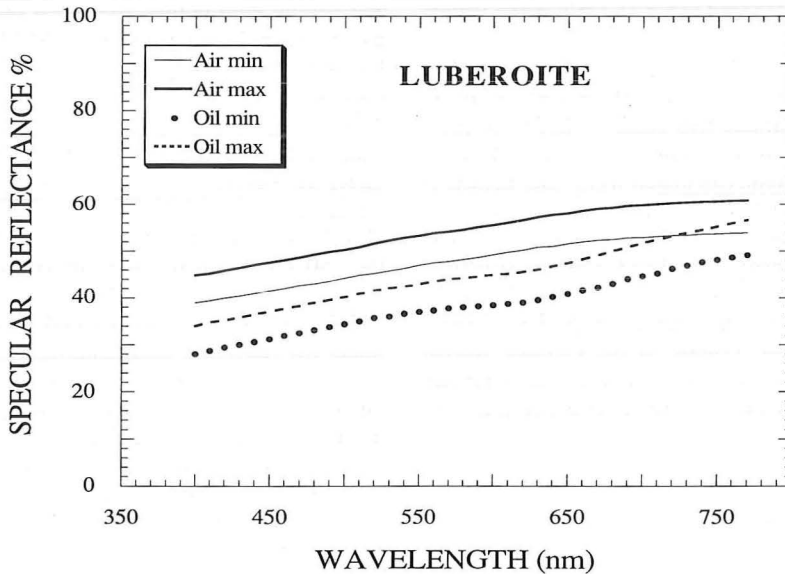


Fig. 6. Reflectance dispersion curves of luberoite in air and in immersion oil, for maximum and minimum reflectance directions.

Table 3. Colour values relative to reflectance, and Helmholtz coordinates

	COLOUR VALUES RELATIVE TO :			
	R max (air)	R min (air)	R max (oil)	R min (oil)
Chromaticity coordinate x	0.3243	0.3254	0.3269	0.3281
Chromaticity coordinate y	0.3289	0.3298	0.3226	0.3349
Luminance Y (%)	53.48	47.14	43.09	37.00
HELMHOLTZ COORDINATES				
Dominant wavelength (λ_d)	579.1	579.3	577.9	577.1
Excitation purity P _e (%)	7.23	7.76	8.91	9.85

tion is that of pure Pt and Se. Other PGEs and elements with $Z > 12$ were not detected. The quantitative analyses show figures that are close to those of the PtSe_{0.8} synthetic standard : Luberoite ($n = 12$) : Pt = 75.76 wt% and Se = 24.24 wt% \pm 1.22 (on Se).

PtSe_{0.8} standard (theoretical composition) : Pt = 75.54 wt% and Se = 24.46 wt%.

The corresponding stoichiometric ratios lie between 0.72 and 0.87 for Se, with a mean value of 0.79. The formula thus corresponds fairly well to PtSe_{0.8}, or Pt₅Se₄ (cf. X-ray diffraction).

3. X-ray diffraction and crystal structure

The powder pattern of luberoite (Table 4) is very similar to that of the corresponding synthetic compound Pt₅Se₄ (JCPDS File 31-950). Single crystal spectra were obtained with a prismatic *b*-elongated crystal. Lateral faces are {001} but irregular (width varying between 0.2 and 0.5 mm), and {100}, fluted (width 0.24 mm). The two terminations are non-planar fractures.

Rotation-oscillation (around *b*), Weissenberg (*h0l* and *h1l*) and precession (*hk0* and *0kl*) spectra show a monoclinic symmetry, space group *P*2₁/*c*. Unit-cell parameters were refined by a least square method from 18 reflexions of the powder pattern, obtained with the same single crystal. The cell dimensions are : $a = 6.584(5) \text{ \AA}$, $b = 4.602(3) \text{ \AA}$, $c = 11.10(1) \text{ \AA}$. $\beta = 101.6(1)^\circ$ $V = 329.5(3) \text{ \AA}^3$. Density = 13.02 g cm⁻³, calculated for $Z = 2$ (Pt₅Se₄).

Similar data have been obtained from the synthetic compound Pt₅Se₄ by Matkovic & Schubert (1977) : *P*2₁/*c*, $a = 6.577(1) \text{ \AA}$, $b = 4.610(1) \text{ \AA}$, $c = 11.122(1) \text{ \AA}$, $\beta = 101.59(1)^\circ$, $V = 330.3 \text{ \AA}^3$, $Z = 2$, density = 12.98 g cm⁻³. The crystal structure of the synthetic compound PtSe_{0.8} has been determined by Grønvdal *et al.* (1960). But Matkovic & Schubert (1977) have shown that Pt

and Se atoms occupy entirely different sites and that there is no exchange between them. The formula Pt₅Se₄ is therefore more appropriate than the PtSe_{0.8} formula, proposed by Grønvdal *et al.* (1960).

Table 4. X-ray powder diffraction values

hkl : Miller indices

d_{calc} : calculated interplanar spacings in \AA

d_{obs} : observed interplanar spacings in \AA

I_{vis} : visually estimated intensities

B : broad line

<i>hkl</i>	d_{calc}	d_{obs}	I_{vis}
002	5.44	5.45	60
-102	4.64	4.66	10
102	3.80	3.78	10
110	3.75		
012	3.51	3.51	5
111	3.43	3.43	10
-112	3.27	3.27	60
112	2.93	2.93	80
-113	2.77	2.78	60
210	2.641	2.648	60B
-212	2.546	2.546	40
113	2.465	2.465	60
-114	2.333	2.330	50
-302	2.153	2.151	2
114	2.087	2.083	15
-115	1.984	1.975	20B
122	1.968		
-123	1.918	1.916	20
-221	1.883		
-304	1.880	1.875	100B
302	1.874		
-215	1.833	1.832	1
006	1.812	1.812	70
214	1.755	1.754	40
-216	1.624	1.625	2B
-412	1.543	1.543	20B
031	1.519	1.519	20
-	-	1.450	1
-	-	1.390	2
-	-	1.347	10
-	-	1.270	2
-	-	1.253	2
-	-	1.236	1
-	-	1.227	10
-	-	1.142	5
-	-	1.110	1
-	-	1.093	2B
-	-	1.063	1
-	-	1.055	1
-	-	0.9380	1
-	-	(+ 20 lines)	

4. Paragenetic observations

A complete study of the platinum concentrates and of the large nuggets (non destructive) described by Passau (1945) was undertaken in order to obtain some new information on the primary paragenesis, in the complete absence of modern petrographical observations. The full results of the study will be reported elsewhere, but the most striking observations, which emphasize the exceptional characteristics of the Lubero paragenesis, will be briefly described here :

4.1. Free minerals composing the gold-platinum concentrates

4.1.1. Precious metal minerals, alloys and mechanical mixtures : platinum, sperrylite, gold, electrum, luberoite, (Au, Cu), (Au, Pd), (Au, Cu, Pd), (Au, Pt, Cu), (Au, Sn, Pb) and (Au, Sn, Pd, Pt).

4.1.2. Non-precious metal minerals and alloys : Fe hydroxides (with residual inclusions of Pt/Au alloy, arsenopyrite, galena, Pb/Bi sulfides), native Bi, hydrocerussite, monazite, zircon, barite, thorianite, pyrite, cassiterite, Pb/Sn alloys (with galena inclusions), sillimanite, Ti-hematite, K- and Ca-feldspars. Chromite and magnetite are absent.

4.2. Minerals enclosed in the gold and in the platinum grains and nuggets

4.2.1. PGMs : several compounds of the metals Pt, Pd, Fe, Cu, Rh, Ir with S, Se, Te, As and Sb. Luberoite is of course included in this group, and can be considered a cogenetic member.

4.2.2. Non-precious metal minerals :

4.2.2.1. Primary minerals : ilmenite (without Mg), hematite, biotite, tourmaline (dravite, according to X-ray diffraction and EMP/WDS analyses), quartz, xenotime, K- and Ca-feldspars, calcite, anhydrite, Fe/Cu sulphides, Cu selenides.

Magnetite and chromite are entirely lacking. This is contrary to the determinations by Passau and Duparc (in Passau, 1945), who determined some black inclusions in the large nuggets as chromite or magnetite. We have analysed these inclusions again in the same large nuggets, and they turned all out to be Ti-hematite inclusions (*cf.* the later discussion on this paragenetically important point).

4.2.2.2. Alteration minerals affecting the secondary, cracked cupriferous rinds of many Pt grains, and luberoite inclusions (Fig. 5) : kaolinite, chlorite/biotite, anatase, Ba-REE and Al-REE phosphates (gorceixite and florencite, *cf.* Aleksandrov *et al.*, 1975).

4.3. Rock fragments

A dozen rounded, millimeter-size rock grains have been found. They are composed of the same K-feldspar and Ti-hematite, which occur as free grains and as inclusions in the Pt grains. Chromite, magnetite and olivine are absent from these rock fragments.

IMA acceptance and museum custody

The name luberoite (luberoite in French) is derived from the locality of Lubero. The mineral and the name have been approved by the Commission on New Minerals and Mineral Names of the International Mineralogical Association (Nr. 90-047). Type material (loose crystals and fragments, and polished mounts) has been deposited at the Institut Royal des Sciences Naturelles de Belgique, Brussels (Nr. RC-4215), with the approval of the Musée d'Afrique Centrale (Tervuren).

Discussion

The prospectors of the Scrutton Mission in 1914, as well as the geologists of the MGL-Company in the 1920's and 1930's, explored the Lubero Region, and apparently tested every river and creek for precious metals. After the discovery of platinum, they began to look more specifically for ultrabasic rocks, to which the platinum occurrences could be genetically connected according to the current hypotheses at that time, but to no avail (Passau, 1945). The only observed magmatic rocks were granodiorites (containing disseminated pyrite, chalcopyrite and pyrrhotite) and quartz-diorite dykes. Lower temperature veins were also observed in the region as granitic pegmatites and unmineralized quartz veins. Gold and platinum placers were observed in rivers only down-stream from granodiorite outcrops, but never up-stream (Passau, 1945).

Duparc (followed by Passau) thought that there existed two types of primary Pt deposits in the

Lubero region, considering the common minerals enclosed in the nuggets (in the larger ones in particular, which have been re-analysed by us) : one with an acidic affiliation (quartz inclusions), and the other with an ultrabasic affiliation (chromite and magnetite inclusions). The purported chromite and magnetite inclusions, however, are in fact Ti-hematite, as described above. These errors originated probably from the black colour displayed by the titanium content of the hematite (mimicking magnetite) and the absence of magnetism (mimicking chromite). The Passau-Duparc hypothesis of 2 kinds of deposits is thus now unsustainable, on the basis of the inclusions. Were magnetite originally present in the concentrates, but later extracted with a magnet by the primary authors, we should not have found ferromagnetic platinum in the same concentrates, as was the case. It may thus be concluded that magnetite was effectively absent from the pristine concentrates, and that the hypothesis of magnetite-bearing primary rocks is also unwarranted.

Since 1945, no geological or lithological map has been made of the Lubero Region. The primary reason is that the region is at the confines of the northern, well explored Kilo-Moto gold-district, and the southern Kivu tin-district. Additionally, the geology is very complicated, involving a collision between two continental units of different ages (Kampanzu *et al.*, 1986).

Until now, no well located samples of the various rock types have been studied, nor are they even available. For the time being, one must thus rely entirely on the evidence found in the platinum-gold concentrates themselves to form an opinion about the genesis of the PGMs in general, and about luberoite in particular.

The most noteworthy feature is, of course, the inclusion in the platinum minerals of quartz (which struck Passau and Duparc), and of other minerals of acidic affiliation observed in this work (tourmaline and K-feldspar). The widespread Ti-hematite (enclosed in, and associated with, the platinum) points to intermediate rock affiliations. The absence of chromite and magnetite, either as placer minerals or as inclusions in the PGMs is consistent with the lack of peridotitic and gabbroic rocks. All this precludes the association of the Lubero deposit(s) (or at least a part of them, according to Duparc) with ultrabasic rocks. Nevertheless, the presence of the enclosed quartz in the larger nuggets (which has been verified during this work) reminded Duparc (Passau, 1945) of the same feature observed at

the Waterberg (Potgietersrus) deposit in South Africa, where the Merensky Reef overlies a granitic pegmatite. Unfortunately, even this deposit has not been reassessed in modern times, and one still relies on Wagner's description and interpretation (Wagner, 1929) ; today, the Waterberg deposit is merely used as an example of hydrothermal transport of PGEs (Mountain & Wood, 1987). However, it is worth noting that both the Lubero and Waterberg deposits show the presence of peculiar rod-shaped platinum particles. In the Waterberg granitic pegmatite, they are formed by the deposition of the platinum in the prismatic voids left between the quartz crystals (Wagner, 1929). In the Lubero concentrates, Pt particles with an elongation factor of more than 5, but with worn edges, are also present.

Conclusions

The new mineral luberoite is part of a complex paragenesis, which has no or few equivalents among the vast array of PGM deposits, or the more restricted Au-PGM type. One possible equivalent system is the Waterberg (Potgietersrus) deposit.

The presence of luberoite in placer concentrates as free particulates, presenting sharp or worn shapes, indicates that it is a rather stable mineral in equatorial rivers, and thus may be found in other deposits. Its EMP/EDS spectral characteristics should be kept in mind when exploring the vast range of PGM inclusions.

Pending first-hand lithological observations on the Lubero primary rocks and on their associated mineralizations, we can only endorse the opinion of Passau regarding the granodioritic affiliation of the PGMs, and consequently of luberoite. But the hypothesis of another, chromite-bearing parent rock, as proposed by Duparc, must be discarded.

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