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New Data of Daomanite and Hongshiite

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Abstract In 1974 the author preliminarily reported two new platinum group minerals—daomanite and hongshiite. The two minerals were accepted by the Commission on New Minerals and Minerals Names of the International Mineralogical Association in 1976 and 1982 respectively. Because of the conditions at that time, the work was preliminary, for example, there were only reflectance values of four wave bands. Recently the author again made measurements of reflectances, corrected cell parameters by the four-circle diffractometer and electron diffraction and supplemented their new occurrences and nomenclature.

Key words: daomanite, hongshiite, new data

1 Daomanite

1.1 Introduction

Daomanite and other platinum minerals were preliminarily reported in 1974 (Yu et al., 1974). In 1978 the results of a further study of the mineral were reported (Yu et al., 1978). This mineral was approved by the Commission on New Mineral and Minerals Names (CNMMN) of the International Mineralogical Association (IMA) in 1982 (CNMMN, 1976, 1982; Fleisher et al., 1976a, 1976b). Recently I have further studied the corrected cell parameters etc. with the four-circle diffractometer and reflectances and supplemented the new occurrences and nomenclature.

1.2 Occurrence

Daomanite occurs in platinum-bearing copper sulphide veins in hornblende pyroxenite and also in contact zones between pyroxenite and anorthosite or granite-gneiss a few hundred metres long and a few dozen metres thick. The platinum mineralization zone contains a significant amount of garnet (andradite) (which refutes predecessors' view that this kind of rock is eclogite—the product of regional metamorphism); pyroxenes are mostly diopside, augite and aegirinaugite (ferrosilite). This is the first case of platinum deposits of contact-metasomatic origin.

The dominant ore minerals are bornite, chalcopyrite and goethite with subordinate tetrahedrite, carrolite and limonite and minor alvorolite, galena and molybdenite. There are many platinum group minerals associated with daomanite, of which the principal ones are sperrylite, cooperite, moncheite, cobaltmalanite ($CuPtCoS_4$), yixunite (Pt_3In) and damiaoite (In_2Pt). The last three minerals together with daomanite have been accepted by the CNMMN. They are new types of platinum mineral resulting from a new mineralization mechanism. The (Pt+Pd) grade of ores collected from Sandao Village in 1997 is over ten times as high as that of the ores collected previously. The main platinum mineral is daomanite. This is a contribution to increasing the reserves of the deposit at the village and carrying out platinum exploration in the Yanshan Mountains area. Daomanite also occurs in platinum ore veins related to copper sulphides of peridotite-hornblende pyroxenite type. It is distributed in a zone from Chicheng eastwards to Qinglong, Hebei. The ore-bearing rock body is large and well differentiated. Peridotite occurs as a nucleus enclosed in the central part of the rock body. Sometimes lenticular platinum-bearing copper veins 2–3 m long and a few dozen centimetres wide may be found. The ore is composed dominantly of chalcopyrite with minor sperrylite, cooperite, moncheite and daomanite. Among them the crystals of daomanite are by far larger than those seen at Sandao Village.

1.3 Physical properties

Daomanite formed by replacement of bornite usually occurs as euhedral laths. They grow along {010} with the *b* (010), *a* (100) and *n* (011) crystal faces. The crystal faces are slightly curved. Sometimes elbow

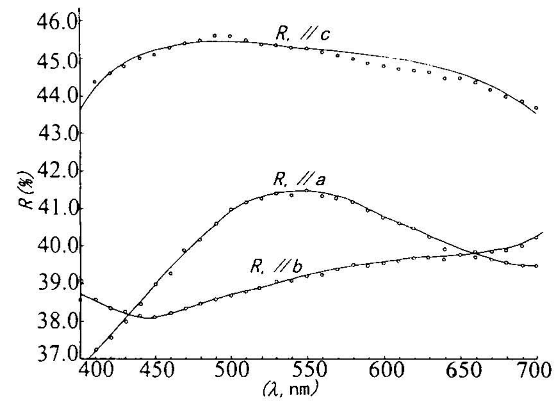

Fig. 1. Dispersion curves of the reflectances for Daomanite.

twins are observed. There are four sets of cleavages; they are parallel to {010}, {100}, {001} and {110}, with {010} being perfect and {110} less developed (Plate I-1-3). $D_{(cal)}$ 7.30 g/cm^3, $VHN_{10\text{-}20}$ 169–175 kg/mm^2, size 0.2–0.3 mm, brittle, non-magnetic, luster metallic, fragments steel-grey with a yellowish tinge and on fresh surface silver-grey, powder and streak black. Insoluble in HNO_3 and HCl.

1.4 Optical properties under the reflected light microscope

Reflection colour light yellow with a green tinge, anisotropism strong, under completely crossed nicols brilliant azure to grass-grey with a reddish tinge and under incompletely crossed nicols with 1–2° bluish green to pale red. Parallel-axial extinction, no internal reflection, pleochroism and bireflectance strong: // *c* light yellow with a green tinge and ⊥*c* light yellow. Well polished. No reaction to all the Murdoch etching reagent.

Reflectances (%) of daomanite were measured with a Zeiss MPM-400 microphotometer and compared with a set of reflectances of WTiC, which has been regarded as the measured standard, approved by the Commission on Ore Microscopy (COM) as the standard. The reflectances and dispersion curves of the reflectances of daomanite are shown in Table 1 and Fig. 1 respectively.

Table 1 Reflectances of daomanite

λ (nm)	// *c* R_1(%)	// *b* R_2 (%)	// *a* R_3 (%)	*c* : *b* : *a*
400	44.0	38.6	37.0	1.14 : 1.00 : 0.96
410	44.4	38.5	37.4	1.15 : 1.00 : 0.97
420	44.6	38.4	37.9	1.16 : 1.00 : 0.99
430	44.8	38.0	38.3	1.18 : 1.00 : 1.01
440	45.0	38.2	39.1	1.18 : 1.00 : 1.02
450	45.1	38.2	39.7	1.18 : 1.00 : 1.01
460	45.3	38.3	40.4	1.18 : 1.00 : 1.05
470	45.4	38.4	41.0	1.18 : 1.00 : 1.07
480	45.5	38.5	41.5	1.18 : 1.00 : 1.08
490	45.6	38.6	41.9	1.18 : 1.00 : 1.09
500	45.6	38.7	42.2	1.18 : 1.00 : 1.09
510	45.5	38.3	42.6	1.19 : 1.00 : 1.11
520	45.4	38.9	42.8	1.17 : 1.00 : 1.10
530	45.4	39.1	42.9	1.16 : 1.00 : 1.10
540	45.3	39.1	42.9	1.16 : 1.00 : 1.00
550	45.3	39.2	42.8	1.16 : 1.00 : 1.09
560	45.2	39.2	42.8	1.15 : 1.00 : 1.09
570	45.1	39.4	42.6	1.17 : 1.00 : 1.11
580	45.0	39.5	42.4	1.14 : 1.00 : 1.07
590	44.9	39.5	42.4	1.14 : 1.00 : 1.07
600	44.8	39.6	41.8	1.13 : 1.00 : 1.06
610	44.7	39.6	41.5	1.13 : 1.00 : 1.05
620	44.7	39.7	41.2	1.26 : 1.00 : 1.04
630	44.6	39.7	40.9	1.12 : 1.00 : 1.03
640	44.5	39.7	40.6	1.12 : 1.00 : 1.02
650	44.5	39.8	40.2	1.12 : 1.00 : 1.01
660	44.4	39.9	40.1	1.11 : 1.00 : 1.01
670	44.2	39.8	39.9	1.11 : 1.00 : 1.00
680	44.0	39.9	39.8	1.10 : 1.00 : 1.00
690	43.9	40.1	39.7	1.09 : 1.00 : 0.99
700	43.7	40.3	39.7	1.08 : 1.00 : 0.99

Note: $S_{(E)}R_{vis}$ (45.1, 39.3, 42.3), *x* (0.332, 0.336, 0.335), *y* (0.334, 0.366, 0.323), λ*d* (505, 583.1, 559) and *Pe* (0.0042, 0.015, 0.042); $S_{(A)}R_{vis}$ (49.1, 43.3, 45.6), *x* (0.446, 0.450, 0.443), *y* (0.409, 0.409, 0.413), λ*d* (505, 583.7, 559.2) and *Pe* (0.004, 0.027, 0.042); $S_{(C)}R_{vis}$ (44.0, 38.5, 40.6), *x* (0.309, 0.313, 0.312), *y* (0.317, 0.319, 0.325), λ*d* (497, 578.5, 597.6) and *Pe* (0.004, 0.015, 0.006).

1. 5 Crystal system and cell parameters

As determined by the *b*-axis Laue photography, daomanite is orthorhombic (i.e. X-rays are incident in a direction perpendicular to the crystal pinacoid). The cell dimensions corrected with a four-circle diffractometer by Wu Baimu and Dou Shiqi of the Institute of Biology, Chinese Academy of Sciences (Ding et al., 1981) are *a*=0.5852 nm, *b*=1.5876 nm and *c*=0.3756 nm. The indices of the crystal faces and strengths of X-ray powder diffraction lines on the X-ray diffraction patterns with copper radiation (Plate I-4) were both corrected by the values measured with the four-circle diffractometer. A comparison between the measured values and the theoretical values is presented

Table 2 X-ray powder diffraction data for daomanite

Line No.	d_{obs} (nm)	d_{cal} (nm)	I/I_o	*hkl*	Line No.	d_{obs} (nm)	d_{cal} (nm)	I/I_o	*hkl*
1	0.795	0.7938	5	020	26	0.132	0.1320	2	431
2	0.471	0.4710	3	120	27	0.128	0.1281	4	342
3	0.329	0.3285	6	140	28	0.125	0.1253	<1	451
4	0.306	0.3063	2	031	29	0.123	0.1236	2	391
5	0.293	0.2926	10	200	30	0.122	0.1221	1	113
6	0.272	0.2714	4	131	31	0.121	0.1218	3	033
7	0.240	0.2411	2	160	32	0.120	0.1206	1	2.12.0
8	0.235	0.2355	3	240	33	0.119	0.1193	3	133
9	0.224	0.2240	<1	151	34	0.118	0.1187	3	1.10.2
10	0.213	0.2116	<1	231	35	0.115	0.1154	≤1	402
11	0.198	0.1985	1	080	36	0.114	0.1142	2	422
12	0.196	0.1963	2	260	37	0.112	0.1123	2	540
13	0.194	0.1942	2	071	38	0.111	0.1113	3	1.14.0
14	0.189	0.1894	2	320	39	0.109	0.1093	2	531
15	0.186	0.1867	3	251	40	0.108	0.1079	3	2.13.1
16	0.182	0.1828	3	022	41	0.106	0.1064	<1	1.12.2
17	0.173	0.1744	4	122	42	0.105	0.1058	3	462
18	0.172	0.1721	2	311	43	0.105	0.1051	<1	313
19	0.170	0.1698	3	042	44	0.103	0.1030	≤1	3.10.2
20	0.163	0.1630	5	142	45	0.101	0.1019	2	0.15.1
21	0.158	0.1580	2	202	46	0.100	0.1006	5	193
22	0.153	0.1531	2	062	47	0.0998	0.09979	1	3.13.1
23	0.146	0.1463	2	400	48	0.0989	0.09856	4	522
24	0.139	0.1395	1	2.10.0	49	0.0963	0.09636	2	542
25	0.137	0.1373	1	440	50	0.0930	0.09299	5	562

in Table 2.

1.6 Chemical composition

The analyzed samples were taken from an orebody hosted in garnet-hornblende pyroxenite at Sandao Village in 1991. The analytic instrument was a JCMA-733 electron microprobe made in Japan. The measuring conditions were as follows: the working voltage was 20 kV and the analysis was carried out at a constant beam current of 10×10^{-8} amp. The pure metals platinum and copper were used as standards for comparison. (As)=$PtAs_2$ and (S)=FeS_2. The analytic results were corrected by ZAF. Three measurements were made and the means and ranges (%) of the values are as follows: S, 15.9 (15.1–16.5); Fe, 0.0 (0.0–0.0); Ni, 0.0 (0.0–0.0); Co, 0.0 (0.0–0.0); Cu, 15.2 (14.9–15.5); As, 20.1 (19.1–20.9); Rh 0.3 (0.2–0.4); Pd, 0.0 (0.0–0.0); Os, 0.0 (0.0–0.0); Ir, 0.0 (0.0–0.0); Pt, 48.5 (48.1–49.0); Pb, 0.2 (0.2–0.3); Bi, 0.0 (0.0–0.0); the total, 100.2 (99.6–100.9). The empirical formula (based on 5 atoms) is $Cu_{0.9649}Pt_{0.9407}Rh_{0.0117}As_{1.0823}S_{2.0004}$.

1.7 Discussion

Daomanite is a new mineral occurring in contact-metasomatic platinum deposits associated with garnet-hornblende pyroxenite—a new type of deposit. It is a principal platinum mineral in the ore, and in addition to its high economic value it is also a mineral with $ABCX_2$ structure—a new structural type in nature, and so has high academic value. New minerals discovered together with it also include yixunite, damiaoite and a new variety of cobaltmalanite. They all have high economic value and mineralogical significance. Daomanite was named from the second syllables of Sandao Village and Tiema Village, Luanping County, Hebei Province, where the mineral was first found in platinum-bearing bodies at the same time.

Minerals discovered simultaneously with daomanite also include hongshiite, malanite, yixunite, dayingite (cobaltmalanite), xingzhongite, guanglinite, fengluanite, yanzhongite and hongqiite. The discovery of these minerals was not estimated then and it took only two years (from 1972 to 1973). Because there were scarce samples and the research funds and instruments were lacking at that time, researchers only made a preliminary study and summing-up of the physical properties, structures and crystal systems of these minerals so that these data could be used for reference in the future work. These preliminary research results were published in 1974 (Yu et al., 1974). In 1978 I again went to the Yanshan Mountains area and conducted an intensive study of the platinum minerals. The study has continued for fully two decades. Among the above-mentioned new platinum minerals, except xingzhongite whose study has not been completed yet, the data of new studies of daomanite, malanite, yixunite and hongshiite have all been published (Yu et al., 1978; Yu, 1996, 1997a, 1997b). In addition, eight new minerals—shuangfengite, gaotaiite, mayingite, damiaoite, gubeiite, xifengite, changchengite and chengdeite—have also been found and approved by CNMMN. Thus a total of 12 new platinum group minerals and two new cosmic dust minerals have been found.

Daomanite has a special composition, a new crystal structure and a good crystal shape. Some institutions such as the Institute of Geology of the Chinese Academy of Sciences, the X-ray Laboratory of the China University of Geosciences have asked me to give them single-grain samples for structural analysis. The results of single-grain analysis have been published. Then the study of daomanite is finished.

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2 Hongshiite

2.1 Introduction

Hongshiite was first preliminarily reported together with other new minerals in 1974 (Yu et al., 1974). In 1978 the mineral was accepted by the CNMMN (CNMMN, 1976; Fleisher et al., 1976; Yavovlevskaya, 1977). Because the research time was short and the research work was initial, some supplementary work was done in 1979 (Yu, 1979). Recently I have undertaken a further study of the minerals. Here I am going to report the measurements of its reflectances in the the range of 400–700 nm, electron diffraction, mineral composition and further cell parameters and its new occurrence.

2.2 Occurrence

Hongshiite occurs in apatite-bearing actinotized diopsidite at Hongshi Village, Fengning County, Hebei Province. According to the variation of the relative contents of hornblende and pyroxene, the diopsidite, hornblende pyroxenite and diopside hornblendite facies zones may be distinguished. The more basic part is located in the central part of the intrusion, while the more acid part on both sides of the rock body. Platinum orebodies are distributed in the upper portion of the more basic part in the central part of the rock body. They occur as discontinuous lenses. The ores contain no useful components other than platinum-group elements in addition to accessory apatite. Among platinum-group elements, only platinum and palladium are useful. According to the statistics of some principal orebodies, Pt:Pd=5.7:1. The high-grade ores are hosted in diopsidite which has higher iron and lower hornblende contents and shows marked hydrothermal alteration. Platinum mineralizations are not spatially associated. The platinum deposit is a new type of platinum deposit that has not been reported up to now. Besides a minor amount of magnetite mineralization, the ores also contain such platinum minerals as sperrylite, cooperite and moncheite. Hongshiite is also a dominant mineral. It is mostly distributed in the interstices of diopside grains and usually occurs enclosed within other platinum minerals such as sperrylite. In addition, there are also minor cooperite and isoferroplatinum. As the ore is easy to crush, these platinum minerals are easily separated, thus facilitating the use of the ore. The hongshiite found in ores of a contact-metasomatic deposit under study at Sandao Village forms graphic intergrowths with a palladium mineral (?) (Plate I-10–12) that are associated with daomanite, sperrylite, cooperite and moncheite. Therefore, hongshiite is distributed more widely in platinum ores in the Yanshan Mountains.

2.3 Physical properties

Hongshiite occurs as granular-massive aggregates or irregular plates (Plate I-5). Colour steel-grey; luster metallic and in some cases a brown coating or iridescent coating present on the surface; slightly cutable and malleable; non-magnetic; streak black. It is generally 0.5×0.3×0.1 mm in size and usually encloses fengluanite (Plate I-7–9). The etching test shows that it is insoluble in HCl and HNO_3. The calculated density is d_{cal}=15.71. Reflected light brilliant white with a brownish tint; no internal reflection; reflection pleochroism not observed in air or in immersion oil; anisotropism moderate to weak; polarization colour dark grey to dark reddish brown. Under the crossed nicols the convergent polarization figure under the oil immersion high-resolution lenses shows a pair of clear hyperbolas, which are blue on the convex sides and yellow on the concave sides. After rotation of the analyzer, the two ends of isogyres become black and the middle is purple. The relative dispersion of reflection is masked due to the elliptical polarized light, and the ellipticity and elliptical dispersion are strong.

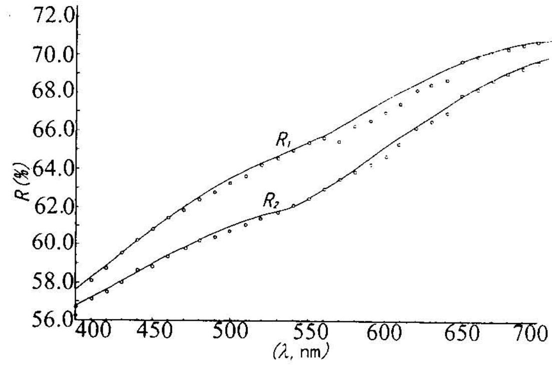

Fig. 2. Dispersion curves of the reflectances for Hongshiite.

The polishing degree is moderate and striations are often present on the polished surface, but less than those on native platinum and native copper. Under the high-resolution microscope complete cleavages $\{10\bar{1}0\}$ may be observed (Plate I-6) and moreover twins shown by two directions of symmetric cleavages may also be recognized. The twinning planes might be $\{11\bar{2}1\}$. The polished hardness is fengluanite<hongshiite<cooperite< sperrylite. All the tests of the Murdoch reagent etching yielded negative results. The microidentation hardness was measured with a МПТ-3 type instrument made in Russia, and the results are: // *a*, VHN_{50}=204.3 kg/mm^2, and // *c*, VHN_{50}=276.8 kg/mm^2, $D_{(cal)}$=15.7 g/cm^3. The corresponding Mohs hardness is ~ 4.0.

2.4 Mineral reflectances

The mineral reflectances were measured by a Zeiss MPM-400 microphotometer with respect to the WTiC standard of the COM. The measured reflectances (%) of hongshiite are given in Table 3 and the reflection dispersion curves are shown in Fig. 2.

2.5 Chemical composition

After qualitative analysis with an Edox-9900 energy dispersive spectrometer, the mineral was analyzed with a JCMA-733 electron microprobe. The working voltage was 20 kV. The analysis was carried out at a constant sample current and a beam current of 1.0×10^{-8} amp. The standards Fe, Co, Cu, Rh, Os, Ir and Pt used for comparison were pure metals and S was pyrite. The LiF crystal was used for measuring Fe*Ka*, Co*Ka*, Ni*Ka*, Cu*Ka*, Os*La*, Ir*La*, Pt*La* and Pb*La* and the Pet crystal for measuring Rh*La*, Pd*La* and Sk*a*. The average value and ranges (wt%) are: S, 0.0 (0.0–0.0); Fe, 0.0 (0.0–0.0); Ni, 0.0 (0.0–0.0); Co, 0.0 (0.0–0.0); Cu, 24.8

Table 3 Reflectances of hongshiite

λ (nm)	R_1	R_2	R_1/R_2	λ (nm)	R_1	R_2	R_1/R_2	λ (nm)	R_1	R_2	R_1/R_2
400	56.7	56.3	1.007	510	63.7	61.1	1.043	620	68.2	66.2	1.030
410	58.1	57.1	1.018	520	64.2	61.4	1.046	630	68.5	66.6	1.029
420	58.7	57.5	1.021	530	64.6	61.7	1.047	640	68.8	67.0	1.027
430	59.5	58.0	1.026	540	65.0	62.1	1.047	650	69.8	68.0	1.026
440	60.2	58.6	1.027	550	65.4	62.5	1.046	660	70.0	68.3	1.025
450	60.8	58.9	1.032	560	65.6	63.0	1.041	670	70.2	68.7	1.022
460	61.4	59.4	1.034	570	65.5	63.5	1.031	680	70.4	69.1	1.019
470	61.9	59.8	1.035	580	66.3	63.9	1.038	690	70.6	69.4	1.017
480	62.4	60.2	1.037	590	66.6	64.3	1.036	700	70.8	69.7	1.016
490	62.8	60.4	1.040	600	67.0	64.7	1.036				
500	63.3	60.7	1.043	610	67.5	65.4	1.032				

Note: $S_{(E)}R_{vis}$ (65.6,65.2), x (0.342,0.339), y (0.341,0.347), λd (580,568.5) and Pe (0.049, 0.143); $S_{(A)}R_{vis}$ (73.4,71.0), x (0.455,0.456), y (0.410,0.409), λd (587.2,492.8) and Pe (0.067, 0.020); $S_{(C)}R_{vis}$ (64.3,62.2), x (0.319,0.319), y (0.325,0.323), λd (578.6,582.3) and Pe (0.046, 0.041).

Table 4 X-ray powder diffraction data for hongshiite

Line No.	hkl_{hexa}	hkl_{rhom}	I	d_{obv}	θ	$\sin^2\theta_{obv}$	$\sin^2\theta_{cal}$	$\sin^2\theta_{obv}-\sin^2\theta_{cal}$	d_{cal}
1	021	$11\bar{1}$	3	4.35	10.20	0.0314	0.0310	0.0004	4.37
2	300	$2\bar{1}\bar{1}$	2	3.03	14.74	0.0647	0.0621	0.0026	3.09
3	205	311	1	2.295	19.62	0.1127	0.1129	-0.0002	2.293
4	006	222	10	2.199	20.52	0.1228	0.1229	-0.0001	2.193
5	404	400	8	1.895	24.00	0.1654	0.1651	0.0003	1.891
6	241	$31\bar{3}$	<1	1.738	26.33	0.1967	0.1967	0.0000	1.738
7	416	510	1	1.489	31.18	0.2681	0.2679	0.0002	1.489
8	048	440	5	1.350	34.82	0.3259	0.3290	-0.0031	1.344
9	309	522	5	1.325	35.58	0.3386	0.3387	0.0001	1.324
10	072	$33\bar{4}$	<1	1.290	36.69	0.3570	0.3519	0.0051	1.299
11	4.0.10	622	8	1.148	42.19	0.4510	0.4519	-0.0009	1.146
12	0.0.12	444	3	1.099	44.54	0.4920	0.4917	0.0003	1.099
13	823	$7\bar{1}\bar{3}$	2	0.986	51.43	0.6113	0.6106	0.0007	0.986
14	808	800	1	0.948	54.40	0.6611	0.6604	0.0007	0.948
15	0.0.15	555	3	0.879	61.29	0.7694	0.7683	0.0011	0.879
16	482	$62\bar{6}$	3	0.868	62.63	0.7886	0.7869	0.0017	0.869
17	930	$7\bar{2}\bar{5}$	5	0.856	64.24	0.8112	0.8077	0.0035	0.857
18	755	$81\bar{4}$	3	0.842	66.28	0.8381	0.8379	0.0002	0.842

Note: a=1.0713 nm, A=0.006904; c=1.3192 nm, C=0.003414.

(24.2–25.4); As, 0.0 (0.0–0.0); Rh, 0.2 (0.1–0.3); Pd, 0.0 (0.0–0.0); Os, 0.2 (0.1–0.4); Ir, 0.0 (0.0–0.0); Pt, 75.2 (74.6–75.9); Pb, 0.3 (0.1–0.5). The total is 100.6 (99.6–101.4). The empirical formula (based on 2 atoms) is $Cu_{1.0030}Pt_{0.9920}Os_{0.0028}Rh_{0.0049}$.

2.6 X-ray data

The X-ray powder diffraction pattern of hongshiite from the area was made using Cu Kα radiation, a working voltage of 20 kV, a specimen current of 20 mA, an exposure of 15 h, using a d ruler. The diffraction data obtained are listed in Table 4.

The spacing of the crystal faces of hongshiite is smaller than that of native platinum and there are more weak diffraction lines; so hongshiite is not cubic. If it becomes hexagonal or trigonal after ordering, then the [111] axis of the original lattice should be the c axis of the hexagonal or trigonal system, with $a=\sqrt{2}\cdot a_0$, a=0.536 nm or 0.536 nm×2 and 0.536 nm×3··· and $c=\sqrt{3}\cdot a_0/3$, c=0.219 nm or 0.219 nm×2 or 0.219

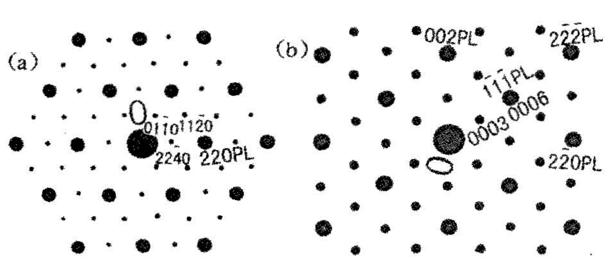

Fig. 3. Electron diffraction patters of hongshiite.
(a) [111] foil Lλ=19×0.6, (b) [$1\bar{1}0$] foil Lλ=19×1.15. ● PL–primary lattice spot; • SL–super-lattice spot.

Table 5 Values of α (kX) against composition from 0 to 100 atom % Pt for alloys annealed at 300 and 720℃

At. % Pt	α in kX		δ (when $\alpha=\pi/2+\delta$ radians)	
	Annealed 300°C	Annealed 720°C	Annealed 300°C	Annealed 720°C
39.0	7.510		0.0129	
45.0	7.542	7.542	0.0168	0.0141
50.0	7.574	7.568	0.0175	0.0135
54.1	7.594	7.592	0.0124	0.0106
58.3	7.614	7.613	0.0082	0.0057
62.7	7.635		0.004	
66.9	7.654		0.001	

nm×3⋯ . According to the trial and testing method, if a is 1.0713 nm and c 1.3192 nm, all the diffraction lines can be indexed, and it may be found that all the diffraction indexes of the crystal faces follow h–k+l=3n or –h+k+l=3n. Therefore, hongshiite is a superstructure mineral of the trigonal system with a rhombohedral class, and the space group is $R32$, $R\bar{3}m$ or $R3m$. When the cell parameters of the hexagonal system are converted to those of the trigonal system, the a_{rh}=0.7589 nm, a=89°47′34″ and Z=24.

2.7 Electron diffraction

The electron diffraction patterns (Fig. 3) were taken from the foils prepared by thinning the thin sections of hongshiite by the ion thinner. The measuring conditions were a H700 high-voltage electron microscope, a working voltage of 200 kV and a beam current of 20 μA. Spots of primary lattice and super-lattice may be seen on the crystal faces of the [111] and [110] zone axes of the primary lattice. On Fig. 2(a), if a regular triangle is present, then <001>$_{SL}$ // <001>$_{PL}$ and <2240>$_{SL}$ // <220>$_{PL}$, and if the 2240 super-lattice spot is located at 1/2 ($2\bar{2}0$)$_{PL}$, then $g_{(22\bar{4}0)} = \sqrt{8} \div 0.38/2 = 2 \bullet \sqrt{12}/\sqrt{3}\,a$, with a=1.075 nm.

On Fig. 3(b), if the (0003)$_{SL}$ super-lattice spot is located at 1/2 (111)$_{PL}$, then $g_{(0003)} = \sqrt{8} \div 0.38/2 = 3/c$, with c=1.316 nm. From the electron diffraction patterns of hongshiite, we obtain a=1.0748 nm and c=1.316 nm. And from the diffraction data, we obtain a=1.0713 nm and c=1.3192 nm.

2.8 Discussion

Platinum intermetallic compounds are widespread in nature. They tend to be combined with iron or nickel and iron, and the combination of hongshiite with a large amount of copper to form platinum minerals, as is the case in the study area, is very rare.

The occurrence of hongshiite is closely related to the geochemical environment of the orebodies. The associated components in the hongshiite ore in the area are simple. As the environment is more oxidizing, the iron in the ore is most trivalent magnetite and is separated from sulphur, while platinum may possibly combine with sulphur or arsenic to form a considerable amount of cooperite and sperrylite.

In foreign countries the research on the copper and platinum alloy series began as early as around the 1920s. At high temperatures above 1000℃ copper and platinum from a continuous solid-solution starting system mixed in any proportion, whereas when the temperature falls below 824℃ the solid-solution series begins ordering and in the series there appear the phase intervals of a PtCu (AB type) rhombohedral superstructure and a $PtCu_3$ (AB_3 type) face-centred cubic structure.

CuPt has an ordered rhombohedral type of structure with the space group $R\bar{3}m$. There are 32 atoms in a single cell. According to the introduction of a handbook by Pearson (1958), Lind (1937) made all the alloys of composition from 0 to 100 atom % Pt by annealing at 300 and 720℃. These alloys depend upon cell parameters, Pt atom % and annealing temperatures (Table 5). For the study area, the cell parameter a_{rh}=0.7589 nm. The Pt atom (%) (1:1) is equivalent to a quenching temperature of 300℃.

Hongshiite occurs in a platinum depos[illegible] f [illegible]dustrial value at Hongshi Village, Fengning County, Hebei Province, China. It is a principal platinum mineral in ore. The mineral is coarse-grained and easily separated or sorted from ore. This has certain theoretical and practical significance for platinum search and utilization in the study area.

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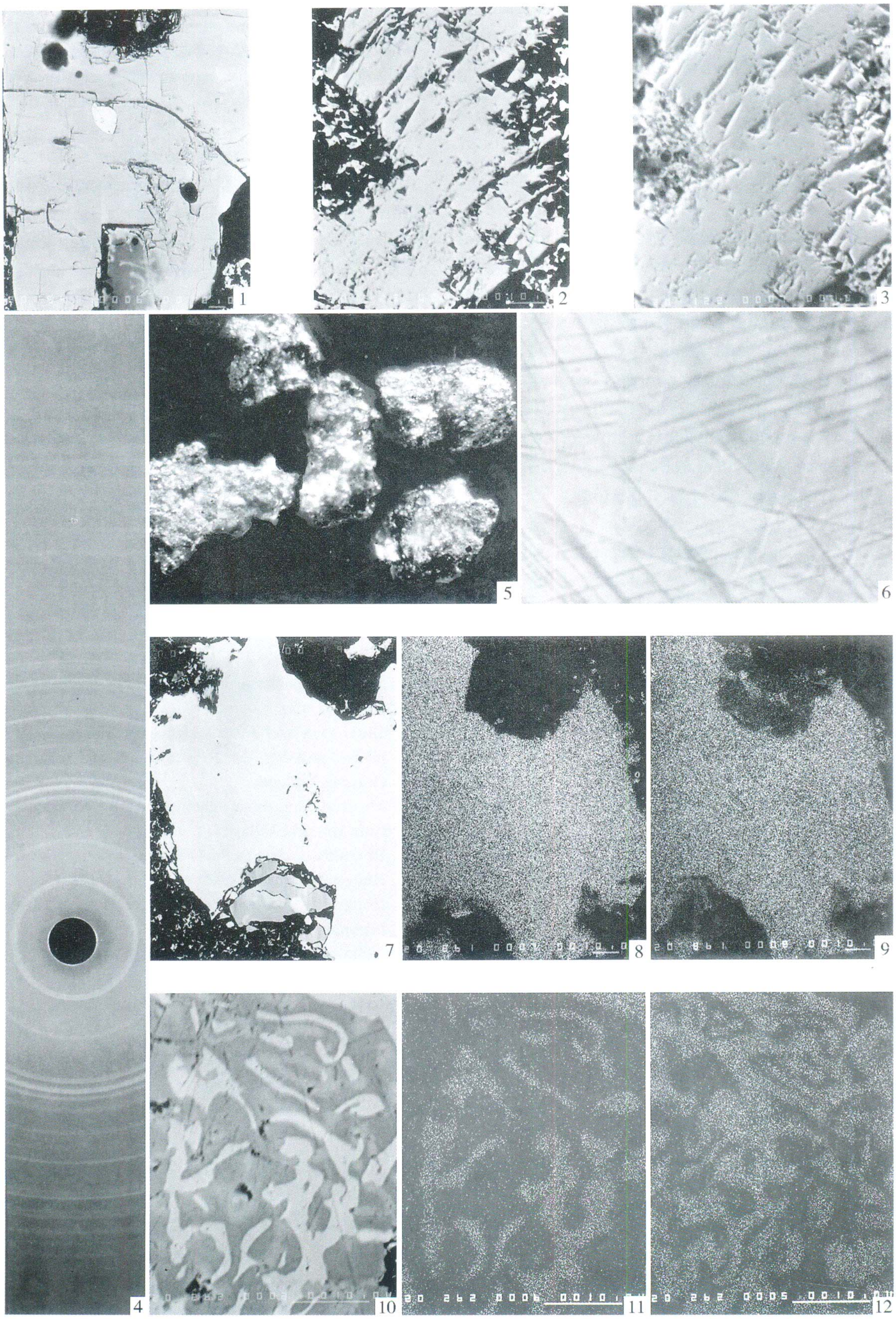
Explanation of Plate

1. Polished surface of daomanite prepared parallelly to {010} cleavages and two sets of cleavages // (010) and (100) observed.
2. Polished surface of daomanite ground obliquely to three sets of cleavages and a triangular gap formed by the three sets of cleavages observed; backscattered electron image (sample from Tiema Village).
3. Same as Photo 2; secondary electron image.
4. X-ray powder diffraction image of daomanite; CuKα, Φ 114.6 mm, 35 kV, 30 mA, exposure 12 h (sample from Tiema Village).
5. Massive-granular or platy hongshiite (sample from Hongshi Village), × 90.
6. Glide twin and { $10\bar{1}1$ } cleavages of hongshiite, twinning planes possibly { $11\bar{2}1$ }, × 1750 (in oil, sample from Hongshi Village).
7. Massive hongshiite, enclosing grey fengluanite (sample from Hongshi Village).
8. Hongshiite, same as Photo 3; CuKα, compositional image.
9. Hongshiite, same as Photo 3; PtLα, compositional image.
10. Hongshiite and a palladium mineral form graphic texture (sample from Sandao Village).
11. Same as Photo 3; CuKα, compositional image.
12. Same as Photo 3; PtLα, compositional image.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