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High form of pentlandite and its thermal stability

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For deposit: Tables 2,3,4,5,6,7,8,9

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TABLE 2. Analytical data obtained by EPMA for euhedral crystals of high-pentlandite by the KCl-NaCl flux method at 800 °C

No	wt %				at %			Atomic ratio*		
	Fe	Ni	S	Total	Fe	Ni	S	Fe	Ni	S
1	36.1	29.9	33.1	99.1	29.5	23.3	47.2	5.03	3.97	8.05
2	32.7	33.5	32.7	98.9	26.9	26.2	46.9	4.56	4.44	7.95
3	31.5	35.3	33.1	99.9	25.7	27.3	47.0	4.36	4.64	7.98
4	30.4	35.6	33.1	99.1	24.9	27.8	47.3	4.25	4.75	8.08
5	30.7	35.7	32.5	98.9	25.3	28.0	46.7	4.27	4.73	7.89

* Fe + Ni = 9.00

TABLE 3. EPMA data for euhedral high-pentlandite crystals synthesized
by the I₂ vapor transportation method at 770 °C ✓

No	wt %				at %			Atomic ratio*		
	Fe	Ni	S	Total	Fe	Ni	S	Fe	Ni	S
1	28.1	39.2	32.1	99.4	23.2	30.7	46.1	3.87	5.13	7.70
2	26.9	40.9	31.9	99.8	22.2	32.0	45.8	3.69	5.31	7.61
3	26.0	41.8	31.4	99.2	21.6	33.0	45.4	3.56	5.44	7.48
4	25.6	42.9	31.3	99.8	21.2	33.7	45.1	3.48	5.52	7.39
5	25.4	43.2	31.6	100.2	20.9	33.8	45.3	3.44	5.56	7.45
6	25.4	43.4	31.3	100.1	21.0	34.0	45.0	3.44	5.56	7.36
7	23.1	46.2	30.7	100.0	19.1	36.5	44.4	3.09	5.91	7.19

* Fe + Ni = 9.00

TABLE 4. The bulk compositions of starting materials formed a monophasic high-pentlandite by the evacuated silica-tube method at 850, 800 and 650°C.

	at %			Atomic ratio*			Heating Time (days)
	Fe	Ni	S	Fe	Ni	S	
850°C							
FNS2504	26.47	26.47	47.06	4.50	4.50	8.00	10
FNS4341	28.57	25.00	46.43	4.80	4.20	7.80	14
FNS4330	26.79	26.79	46.42	4.50	4.50	7.80	14
FNS4340	23.57	30.00	46.43	3.96	5.04	7.80	14
800°C							
FNS4874	26.47	26.47	47.06	4.50	4.50	8.00	5
FNS3880	28.57	25.00	46.43	4.80	4.20	7.80	8
FNS3886	26.63	26.63	46.74	4.50	4.50	7.90	6
FNS3885	26.79	26.79	46.42	4.50	4.50	7.80	6
FNS3879	23.57	30.00	46.43	3.96	5.04	7.80	8
FNS4711	22.17	32.10	45.73	3.67	5.33	7.10	16
FNS4195	19.85	34.85	45.30	3.27	5.73	7.45	16
FNS3878	18.57	35.00	46.43	3.12	5.88	7.80	8
FNS4196	13.24	43.24	43.52	2.11	6.89	6.94	16
650°C							
FNS3964	26.63	26.63	46.74	4.50	4.50	7.90	26
FNS3963	26.79	26.79	46.42	4.50	4.50	7.80	26
FNS3962	26.95	26.95	46.10	4.50	4.50	7.70	26
FNS3961	27.11	27.11	45.78	4.50	4.50	7.60	26
FNS4691	22.17	32.10	45.73	3.67	5.33	7.10	25
FNS4760	19.85	34.85	45.30	3.27	5.73	7.45	43
FNS4698	17.79	37.85	44.38	2.88	6.12	7.18	25
FNS4761	13.24	43.24	43.52	2.11	6.89	6.94	43
FNS4706	13.31	43.72	42.97	2.10	6.90	6.78	27

*Fe + Ni = 9.00

TABLE 5. EPMA data for high-pentlandite synthesized by the evacuated silica-tube method at 850, 800 and 650°C. High-pentlandite almost coexists with monosulfide ss, but sometimes with monosulfide ss and liquid or γ (Fe,Ni)

Run No	wt %				at %			Atomic ratio*			Coexisting phase
	Fe	Ni	S	Total	Fe	Ni	S	Fe	Ni	S	
850°C											
FNS4738	26.3	41.2	32.8	100.3	21.4	32.0	46.6	3.61	5.39	7.85	mss + liq
FNS5563	27.6	40.7	33.2	101.5	22.3	31.2	46.5	3.75	5.25	7.82	mss
FNS4344	36.9	30.0	32.8	99.8	30.1	23.3	46.6	5.07	3.93	7.85	mss + liq
800°C											
FNS4562	34.2	32.1	33.0	99.3	28.0	25.0	47.0	4.76	4.24	7.98	mss
FNS4563	28.0	38.8	33.2	100.0	22.8	30.1	47.1	3.88	5.12	8.01	mss
FNS3872	19.8	47.8	32.6	100.2	16.2	37.3	46.5	2.73	6.27	7.82	mss
FNS3877	17.1	50.8	32.5	100.4	14.0	39.6	46.4	2.35	6.65	7.79	mss
FNS3871	12.6	55.2	32.3	100.1	10.4	43.3	46.3	1.74	7.26	7.76	mss
FNS3870	6.0	62.1	31.6	99.7	5.0	49.2	45.8	0.83	8.17	7.61	mss
650°C											
FNS3998	38.9	27.6	32.8	99.3	31.8	21.5	46.7	5.37	3.63	7.89	mss + γ (Fe,Ni)
FNS3972	30.4	36.7	33.3	100.4	24.7	28.3	47.0	4.19	4.81	7.98	mss
FNS3974	28.8	38.9	33.1	100.8	23.3	30.0	46.7	3.93	5.07	7.89	mss

* Fe + Ni = 9.00. Abbreviations See Table 1. liq: liquid.

TABLE 7. The run data of the equilibrium experiments by the evacuated silica tube method at 850°C

Run No	at%			Heating time(days)	Products
	Fe	Ni	S		
FNS2514	23.50	27.50	49.00	16	mss + hpn
FNS2563	30.67	20.96	48.37	16	mss + hpn
FNS4329	10.00	42.00	48.00	15	mss + liq
FNS4328	6.00	46.00	48.00	15	mss + liq
FNS4327	3.00	49.00	48.00	15	mss + liq
FNS2501	26.16	26.16	47.67	10	hpn + mss
FNS2503	26.32	26.32	47.37	10	hpn + mss
FNS2504	26.47	26.47	47.06	10	hpn
FNS2515	26.47	26.47	47.06	16	hpn
FNS4344	38.57	15.00	46.43	14	mss + hpn + liq
FNS4343	33.57	20.00	46.43	14	mss + hpn
FNS4341	28.57	25.00	46.43	14	hpn
FNS4330	26.79	26.79	46.43	14	hpn
FNS4340	23.57	30.00	46.43	14	hpn
FNS4339	18.57	35.00	46.43	14	mss + liq
FNS4323	19.86	34.85	45.80	15	mss + liq
FNS4331	27.11	27.11	45.78	14	hpn + liq
FNS4332	27.44	27.44	45.12	14	hpn + liq
FNS4738	17.79	37.85	44.37	2	mss + hpn + liq
FNS4324	13.24	43.24	43.53	15	liq
FNS4325	6.62	51.62	41.77	15	liq
FNS4337	50.00	10.00	40.00	15	mss + γ (Fe,Ni)
FNS2564	42.50	17.50	40.00	16	mss + liq + γ (Fe,Ni)
FNS4336	35.00	25.00	40.00	15	liq
FNS4374	35.00	35.00	30.00	6	liq + γ (Fe,Ni)
FNS4375	60.00	10.00	30.00	6	mss + γ (Fe,Ni)
FNS4373	10.00	70.00	20.00	6	liq + γ (Fe,Ni)

Note: Abbreviation as Table 1. liq: liquid

TABLE 8. The analytical data by EPMA for phases produced by the equilibrium runs at 850°C.

Run No	Phases	wt%				at%		
		Fe	Ni	S	Total	Fe	Ni	S
FNS2514	hpn	26.2	41.0	32.8	100.0	21.4	31.9	46.7
	mss	31.5	31.6	36.9	100.0	25.0	23.9	51.1
FNS2563	hpn	27.6	40.7	33.2	101.5	22.3	31.2	46.5
	mss	44.7	18.9	37.4	101.0	34.9	14.1	50.8
FNS4329	mss	16.1	47.4	36.6	100.1	12.9	36.1	51.0
	liq	9.5	59.4	31.1	100.1	7.9	47.0	45.1
FNS4328	mss	9.4	55.5	36.4	101.2	7.5	42.1	50.5
	liq	5.4	64.9	30.6	100.9	4.5	51.3	44.2
FNS4327	mss	4.5	59.9	36.0	100.4	3.6	45.9	50.5
	liq	2.8	67.2	30.8	100.8	2.3	53.1	44.6
FNS4344	hpn	36.9	30.0	32.8	99.8	30.1	23.3	46.6
	mss	57.9	4.4	36.9	99.2	45.8	3.3	50.9
	liq	45.4	27.1	27.4	99.9	38.2	21.7	40.1
FNS4343	hpn	36.2	29.7	32.3	98.1	30.0	23.4	46.6
	mss	57.2	4.9	38.0	100.0	44.7	3.6	51.7
FNS4338	mss	24.5	38.2	36.9	99.6	19.6	29.0	51.4
	liq	12.0	57.4	30.4	100.1	10.0	45.5	44.5
FNS4323	mss	27.1	36.1	37.0	100.2	21.5	27.3	51.2
	liq	21.4	48.5	30.2	100.1	17.8	38.4	43.8
FNS4332	hpn	32.9	34.3	32.5	99.7	26.9	26.7	46.4
	liq	33.2	36.0	31.0	100.2	27.3	28.2	44.5
FNS4738	hpn	26.3	41.2	32.8	100.3	21.4	32.0	46.6
	mss	28.2	34.9	37.0	100.0	22.4	26.4	51.2
	liq	23.9	45.8	30.2	99.8	19.9	36.3	43.8
FNS4337	mss	61.5	0.0	36.7	98.2	49.1	0.0	50.9
	γ (Fe,Ni)	55.4	43.9	0.2	99.5	56.8	42.9	0.4
FNS2564	mss	61.2	1.6	37.4	100.2	47.9	1.2	50.9
	liq	45.1	27.2	27.4	99.6	38.0	21.8	40.2
	γ (Fe,Ni)	50.2	49.7	0.0	99.9	51.5	48.5	0.0
FNS4374	γ (Fe,Ni)	43.4	56.3	0.0	99.7	44.8	55.2	0.0
	liq	38.8	36.4	25.3	100.5	33.0	29.5	37.5
FNS4372	γ (Fe,Ni)	28.5	71.5	0.0	100.0	29.5	70.5	0.0
	liq	22.0	55.2	22.4	99.7	19.4	46.2	34.4
FNS4375	mss	63.1	0.0	37.4	100.5	49.2	0.0	50.8
	γ (Fe,Ni)	86.4	13.2	0.0	99.5	87.4	12.7	0.0
FNS4373	γ (Fe,Ni)	17.7	80.8	0.0	98.6	18.8	81.3	0.0
	liq	8.1	71.2	21.1	100.4	7.2	60.2	32.6

Note:

Abbreviation as Table 1. liq: liquid

TABLE 9. The data of the equilibrium runs in the S composition range
 from 35 to 48 at% of the (Fe_{0.5}Ni_{0.5}) - S join of the Fe-Ni-S
 system at temperatures from 1000 to 500°C

Run No	Fe	wt % Ni	S	at% Fe=Ni	S	Heating time(days)	Products
1000°C							
FNS4336	32.83	34.51	32.66	26.79	46.42	0.5	liq
900°C							
FNS2503	32.42	34.08	33.50	26.32	47.36	1	mss + liq
FNS3870	32.69	34.37	32.94	26.63	46.74	1	mss + liq
FNS4335	32.83	34.51	32.66	26.79	46.42	0.5	mss + liq
FNS4334	32.83	34.51	32.66	26.79	46.42	2	mss + liq
FNS2731	34.28	36.03	29.69	28.50	43.00	5	liq
FNS2732	34.71	36.49	28.79	29.03	41.94	7	liq
FNS2733	35.50	37.32	27.18	30.00	40.00	5	liq
FNS2734	36.32	38.18	25.50	31.03	37.94	7	liq
FNS2735	37.18	39.09	23.73	32.14	35.72	7	liq
880°C							
FNS4333	32.83	34.51	32.66	26.79	46.42	14	mss + liq
850°C							
FNS2501	32.28	33.94	33.78	26.16	47.68	10	hpn + mss
FNS2503	32.42	34.08	33.50	26.32	47.36	10	hpn + mss
FNS2504	32.55	34.22	33.23	26.47	47.06	10	hpn
FNS4330	32.83	34.51	32.66	26.79	46.42	14	hpn
FNS4331	33.10	34.80	32.10	27.11	45.78	14	hpn + liq
FNS4332	33.38	35.10	31.52	27.44	45.12	14	hpn + liq
800°C							
FNS3876	32.28	33.94	33.78	26.16	47.68	12	hpn + mss
FNS3875	32.42	34.08	33.50	26.32	47.36	8	hpn + mss
FNS4874	32.55	34.22	33.23	26.47	47.06	5	hpn
FNS3886	32.69	34.37	32.94	26.63	46.74	6	hpn
FNS3885	32.83	34.51	32.66	26.79	46.42	6	hpn
FNS3874	32.97	34.66	32.38	26.95	46.10	8	hpn + liq
FNS3873	33.10	34.80	32.10	27.11	45.78	12	hpn + liq
FNS3953	33.44	35.15	31.41	27.50	45.00	5	hpn + liq
FNS4188	34.28	36.03	29.69	28.50	43.00	5	hpn + liq
FNS4137	34.71	36.49	28.79	29.03	41.94	7	hpn + liq
FNS4013	35.50	37.32	27.18	30.00	40.00	5	liq
FNS3976	36.32	38.18	25.50	31.03	37.94	7	liq + γ (Fe,Ni)
FNS3975	37.18	39.09	23.73	32.14	35.72	7	liq + γ (Fe,Ni)

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TABLE 9, continue

650°C							
FNS3966	32.42	34.08	33.50	26.32	47.36	26	hpn + mss
FNS3965	32.55	34.22	33.23	26.47	47.06	26	hpn + mss
FNS3964	32.69	34.37	32.94	26.63	46.74	26	hpn
FNS3963	32.83	34.51	32.66	26.79	46.42	26	hpn
FNS3962	32.97	34.66	32.38	26.95	46.10	26	hpn
FNS3961	33.10	34.80	32.10	27.11	45.78	26	hpn
FNS3950	33.44	35.15	31.41	27.50	45.00	26	hpn + γ (Fe,Ni)
600°C							
FNS3914	32.28	33.94	33.78	26.16	47.68	52	pn + mss
FNS3913	32.42	34.08	33.50	26.32	47.36	52	pn
FNS3912	32.55	34.22	33.23	26.47	47.06	52	pn
FNS3911	32.69	34.37	32.94	26.63	46.74	52	pn
FNS4330	32.83	34.51	32.66	26.79	46.42	51	pn + hpn
FNS3909	32.97	34.66	32.38	26.95	46.10	52	hpn
FNS3908	33.10	34.80	32.10	27.11	45.78	52	hpn
FNS3915	33.44	35.15	31.41	27.50	45.00	52	hpn + γ (Fe,Ni)
FNS4022	35.50	37.32	27.18	30.00	40.00	40	hpn + γ (Fe,Ni)
550°C							
FNS2717	32.28	33.94	33.78	26.16	47.68	60	pn + mss
FNS2716	32.42	34.08	33.50	26.32	47.36	60	pn + mss
FNS2715	32.55	34.22	33.23	26.47	47.06	60	pn
FNS2714	32.69	34.37	32.94	26.63	46.74	60	pn
FNS2713	32.83	34.51	32.66	26.79	46.42	60	pn
FNS2712	32.97	34.66	32.38	26.95	46.10	60	pn + γ (Fe,Ni)
FNS2711	33.10	34.80	32.10	27.11	45.78	60	pn + γ (Fe,Ni)
FNS5710	33.44	35.15	31.41	27.50	45.00	60	pn + γ (Fe,Ni)
500°C							
FNS2726	32.28	33.94	33.78	26.16	47.68	100	pn + mss
FNS2725	32.42	34.08	33.50	26.32	47.36	100	pn + mss
FNS2724	32.55	34.22	33.23	26.47	47.06	100	pn
FNS2723	32.69	34.37	32.94	26.63	46.74	100	pn
FNS2722	32.83	34.51	32.66	26.79	46.42	100	pn
FNS2721	32.97	34.66	32.38	26.95	46.10	100	pn + γ (Fe,Ni)
FNS2720	33.44	35.15	31.41	27.50	45.00	100	pn + γ (Fe,Ni)

Note: Abbreviations as See Table 1. liq: liquid

End