지질온도계로써 황철석과 자류철석내의 Ni와 Co의 분배 계수

(Nickel and cobalt partition coefficients in pyrite-pyrrhotite as geothermometer.)

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Contents.

국 문 요 약

광화시기가 같은 유화광물중에서 상접(相接)하는 황철석과 자류철석 내에 함유되어 있는 코발트와 니켈의 함량을 정량분석하여 이들 원소들의 Partition Coefficients로부터 Bezmen method를 이용하여 광물의 생성온도를 구하였다(217 ~ 395°).

지질 연대가 같은 유화광물의 생성온도는 동시기에 생성된 인접한 석영내의 유체포유물의 filling temperature와 거의 일치한다 (255 ~ 398℃). 따라서 이들 광산내의 광물의 생성온도는 지질온도계로 사용이 가능하며 광물의 생성환경을 규명하는데도 유용할 것이다.

1. General Statements.

The distribution of elements among minerals and their relations to formation temperature of coexisting sulfides have been studied by many workers for a long periods. The thermodynamic principles of partition of elements among sulfides have been discussed in detail and many theoretically possible mineral thermometers have been developed by Loftus-Hills, Bezmen, Berg, Belcher, and others. The systematic and clear studies of elements partitioned between coexisting natural sulfides can provide information about the extent to which the distribution theory is applicable to natural sulfide systems and can give an ensight into the complexities.

The analytical data from detailed studies on the distribution of elements between coexisting pyrite-pyrrhotite are available.

The pyrite-pyrrhotite association is common in rocks and ore deposits. Geochemical studies of the distribution of cobalt and nickel in pyrites and pyrrhotites from different genetic types have been made by many geologists (Davidson, Hawley, tvalchrelidze, and others).

This study has generally pursued one following objective; determination of temperatures of ore formation.

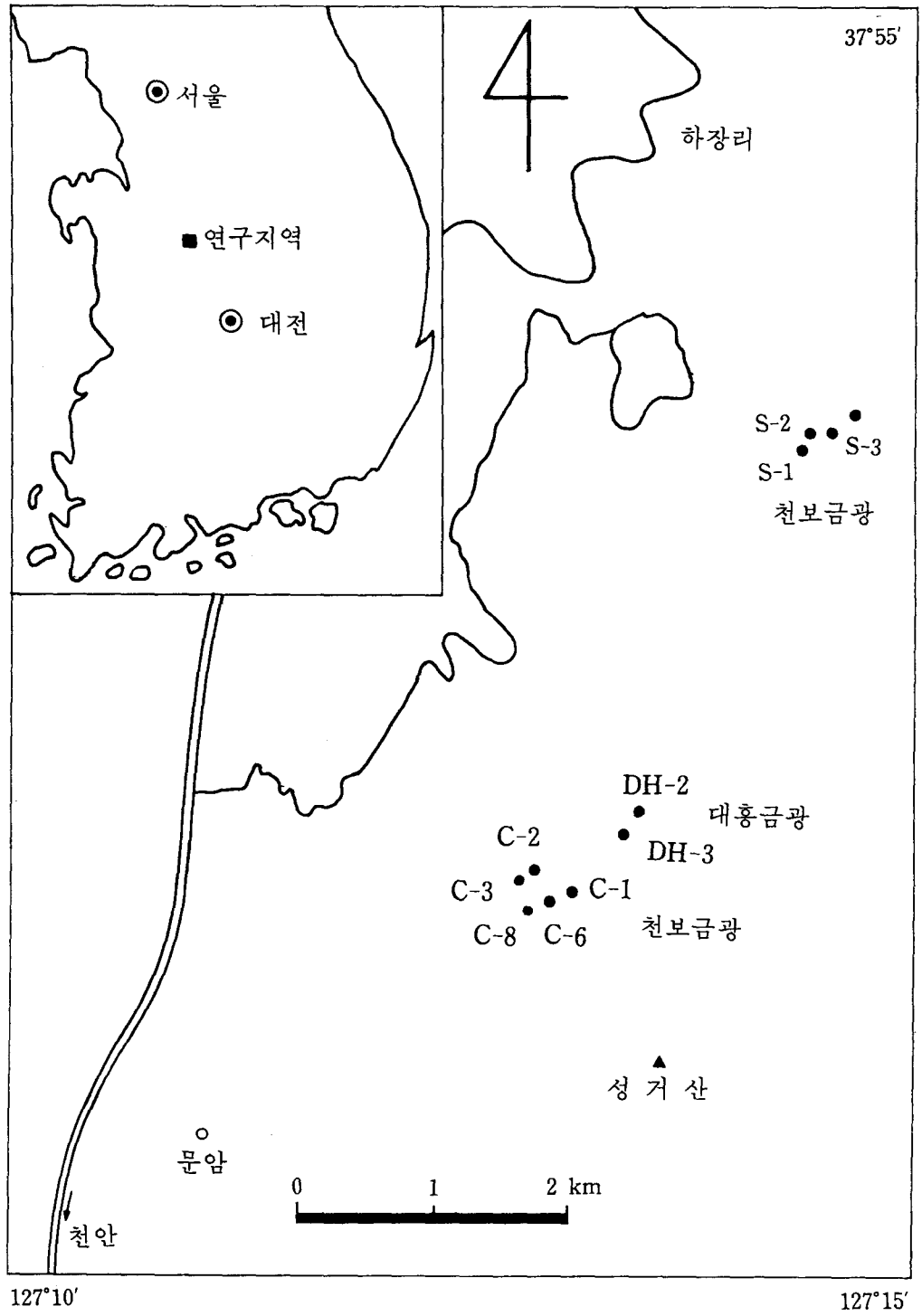

Fig.1. Sampling localities

2. Sampling

A total of ten coexisting pyrite-pyrrhotite samples were collected from the studied area. Sample numbers C-1, C-2, C-3, C-6, C-8, S-1, S-2, and S-3 are collected from Cheon-bo gold mine; DH-2 and DH-3 from Daeheung gold mine

From the samples, pyrite-pyrrhotite concentrates were taken from many processures, including cutting of exttranebus gangue with a diamond saw, crushing, grinding, hand-picking, heavy liquid separation, and the use of magnetic separation method. No any other minerals were observed.

3. Analitic method.

For the analysis, the emitted characteristic X-ray from the samples is searched, by scanning the detection angle. From the angle (2θ) of the diffraction peak, the wavelength of the X-ray can be calculated and the existence of a certain element can be confirmed. The diffraction spectra are complex, because many characteristic X-ray are emitted by an element many order diffractions are also occurred. To identify a certain peak, other interference peaks are discussed and the minor characteristic X-ray for an element are searched as many as possible. It is very dangerous to confirm the existence with only one characteris-tic

X-ray such as K_α line. The determination of the contration of a sample by X-ray fluorescence method is done by comparing with the calibration curve of the standards. Due to the automatic corrections by computer for the matrix effect, interruption among the elements, overlapping or interference by peaks and background, the concentration can be calculated directly from the intensity of X-rays.

Analyzing conditions and analytical data were presented in Table 1 and 2.

Table 1. Analyzing conditions of quantitative X-ray fluorescence analysis.

X-ray tube	W-target tube	
Accelerating Voltage	40 kv	
Specimen Current	20 mA	
Detector	Gas flow proportional counter	
	scintillation counter	
	attenuation	1
	base line	1
	window	in tergral
Crystal	LiF(200)	$2d=4.028A^{\circ}$

Analysis line

Element	detector	line	2Q
Co	Prop.	Kα 1	52.46
Ni	Prop.	Kα 1	48.61
Fe	Prop.	Kα 1	57.45

4. Geochemical data and discussion

Analytical data on coexisting pyrite-pyrrhotite samples were obtained (Table 2).

Table 2. Analytical data on coexisting pyrite-pyrrhotite from studied area.

Sample No.	Pyrite (wt. %)			Pyrrhotite (wt. %)		
	Fe	Co	Ni	Fe	Co	Ni
C-1	40.30	0.0095	0.0200	58.70	0.0089	0.387
C-2	46.25	0.0080	0.0270	62.30	0.0065	0.395
C-3	47.04	0.0075	0.0360	63.21	0.0070	0.404
C-6	47.31	0.0072	0.0024	63.46	0.0075	0.103
C-8	46.95	0.0100	0.0323	62.59	0.0058	0.560
S-1	46.05	0.0120	0.0285	63.40	0.0064	0.600
S-2	46.35	0.0085	0.0628	63.54	0.0070	0.640
S-3	46.00	0.0065	0.0730	64.02	0.0074	0.690
DH-2	46.28	0.0068	0.0724	63.59	0.0076	0.685
DH-3	47.49	0.0047	0.0630	63.21	0.0110	0.730

The relative concentration of nickel is higher than that of cobalt. This is fairly agreement with Gull Pond, Oliver, Letite, Cameron and South Oliver deposits (Ghosh-Dastidar et. al, 1970).

The relation between temperature of formation of pyrite-pyrrhotite association and partition coefficients is determined by the following equations (Bezmen, 1975);

For nickel

$$\frac{1{,}000}{1.315 + 0.356 \log_{KD} Ni} - 273^{\circ}C$$

For cobalt

$$\frac{1{,}000}{1.907 + 0.538 \log_{KD} Co} - 273^{\circ}C$$

To calculate the formation temperature of coexisting pyrite and pyrrhotite from the studied area, two equations described above have been used.

The values of partition coefficients calculated are given in Table 3 and 4.

Table 3. Analytical data on Partition of Cobalt between pyrite and pyrrhotite

Sample No.	Co, wt. %		(Co, at. %/10^{-3} Fe, at.%)				
	Pyrrh-otite	Pyrite	Pyrrh-otite	Pyrite	K_DCo	$\log_{KD}$ Co	t°C
C-1	0.0089	0.0095	0.0151	0.0235	0.6432	-0.1916	281
C-2	0.0065	0.0080	0.0104	0.01729	0.6015	-0.2207	286
C-3	0.0070	0.0075	0.0110	0.0159	0.6944	-0.1583	275
C-6	0.0075	0.0072	0.0118	0.0152	0.7760	-0.1101	268
C-8	0.0058	0.0100	0.0926	0.0213	0.4352	-0.3613	310
S-1	0.0064	0.0120	0.0110	0.0260	0.4226	-0.3740	286
S-2	0.0070	0.0085	0.0115	0.0183	0.6301	-0.2005	382
S-3	0.0074	0.0065	0.1156	0.0141	0.8181	-0.0872	364
DH-2	0.0076	0.0068	0.0119	0.0146	0.8134	-0.0896	265
DH-3	0.0110	0.0047	0.1740	0.0989	1.7581	0.2450	217

Table 4. Analytical data on partition of nickel between pyrite and pyrrhotite

Sample No.	Ni, wt. %		(Ni, at. % /Fe, at. %) 10^{-3}		K_D^{Ni}	$\log_{K_D} Ni$	t °C
	Pyrrh-otite	Pyrite	Pyrrh-otite	Pyrite			
C-1	0.387	0.0200	0.6592	0.0496	13.29	1.1235	310
C-2	0.395	0.0270	0.6340	0.0583	10.87	1.0362	320
C-3	0.404	0.0360	0.6391	0.0765	8.35	0.9216	335
C-6	0.103	0.0024	0.1623	0.0507	3.2011	0.5052	395
C-8	0.560	0.0323	0.8947	0.0687	13.020	1.1146	311
S-1	0.600	0.0285	0.9463	0.0618	15.310	1.1849	302
S-2	0.640	0.0628	1.0072	0.1354	7.438	0.8714	342
S-3	0.690	0.0730	1.0777	0.1586	6.795	0.8321	347
DH-2	0.685	0.0724	1.0772	0.1564	6.890	0.8382	346
DH-3	0.730	0.0630	1.1548	0.1326	8.708	0.9399	333

4. Conclusions

The partition coefficients of cobalt and nickel are strongly dependent on temperature of the mineral formation (Bezmen, 1975). Increase of temperature causes cobalt and nickel to migrate into the disulfide phase.

These computed temperatures are in fair agreement with homogenization temperatures of fluid inclusions (255-398°C) in associated quartz (Yoo, 1984, Yoo and So, 1986). So these characteristics can be used as a geothermometer.

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