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FISSION TRACK DATING OF SOME COPPER ORE FORMATIONS IN INDIA

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Abstract - The fission track (f.t.) age determinations of garnet occurring in copper ore deposits of Khetri copper belt, Rajasthan and Singhbhum copper belt, Bihar reveal the metamorphism of copper ore formations of these areas. The f.t. age of garnet from Khetri copper belt varies from 831 to 897 m.y. suggesting the occurrence of last metamorphism in the belt corresponding to Delhi system. The f.t. age of garnet from Bihar copper belt is found to be 1014 m.y. which corresponds to the Satpura cycle. The maximum enrichment of uranium is observed in copper ore formations of Bihar.

1. INTRODUCTION

Garnet because of its property to retain fission tracks even at high temperatures[1,2] is preffered in geochronology for fission track dating. Though a large data is available on dating natural minerals and rocks[3,4,5] a very little work[6,7,8] has so far been reported on the use of garnet in dating metal ore formations. In the present investigations an attempt has been made to reveal the metamorphism of the copper ore formations from Khetri copper belt, Rajasthan and Bihar copper belt, Bihar, India. Uranium content in copper ore formations is determined using the overlay technique with lexan as the track detector. The aim of this work was to observe the level of uranium for exploration purposes.

Khetri copper belt extends for about 80 Km from Singhana (Jhunjhunu district) to Raghunathgarh (Sikar district) and comprises three highly mineralized sections-Madhan, Kolihan and Akhwali. Mineralization has taken place in phyllites, schists and slates of Delhi system. The ore localization in this belt is thought to be primarily controlled by structural features (Shear zones and fractures). The ore bodies occur as enechelon ore-shoots, stringers and also as disseminations. In this belt the host rocks around Dhanota are the phyllites, phyllitic quartzites and quartz schists. The country rocks around Dariba are phyllites and quartzite rocks are embeded with small quantity of minerals like garnet, apatite, quartz etc.

The copper belt thrust of Bihar extends for about 150 Km and separate the low grade metamorphic rocks from south to high grade metamorphic rocks from north. The copper bearing rocks persist along a zone of overthrust in the Dharwar schists and intrusive granites.

2. EXPERIMENTAL TECHNIQUE

The experimental technique for age determination is the same as reported earlier[7]. Garnet samples were separated in the form of small grains from the host rock. After grinding and polishing, the samples were etched in the boiling 25N NaOH for 4 hrs to reveal tracks. The fossil track density, ρ_s, was determined with the help of a binocular Carl Zeiss microscope at a magnification of 1500X. A few samples were heated at 700°C for 2 hrs to remove fossil tracks. These were then irradiated with a thermal neutron dose of 10^{17}(nvt) from CIRUS Reactor at BARC, Trombay. These samples were etched under identical conditions as for fossil tracks for induced track density measurements. The f.t. age was calculated by using the simplified version of the formula[3,7].

$$T = 6.01 \times 10^{-8} \times \frac{\rho_s}{\rho_i} \phi \qquad (1)$$

where ϕ is the total thermal neutron dose and is determined by using a calibrated glass dosimeter (SRM 614) using the relation[9].

$$\phi = k \times \rho d$$

where k is calibration constant and ρd is the track density.

For uranium estimation, different ore samples were powdered upto 120 mesh size. A homogeneous mixture containing 100 mg. of methyl cellulose powder and 50 mg.of ore powder was pressed in a hand processing machine to form thin pellets. A similar pellet of glass dosimeter containing 20 ppm of uranium was also prepared. These pellets covered from both sides with the lexan detector discs of the same size as that of pellet were irradiated with a thermal neutron dose of 10^{15}(nvt) in IC-1 position of CIRUS Reactor. The induced track density in the lexan detectors due to ore and glass dosimeter pellets was separately determined. The uranium concentration was calculated by using the relation[4,10].

$$Cx(U) = Cs(U) \frac{\rho_x}{\rho_s}$$

where Cx(U) and Cs(U) are uranium concentration in the unknown and standard samples respectively. ρ_x and ρ_s are the induced track densities in the lexan detector due to unknown and standard samples respectively.

3. RESULTS AND DISCUSSION

Three orogenic cycles namely Banded gneissic complex, Aravalli cycle and Delhi cycle are found to affect most of the rocks of the Rajasthan state according to radiometric data collected by various authors[11-13]. The garnet samples from Khetri copper belt have yielded a mean f.t. age of 877±158 m.y. (Table 1) suggesting the occurrence of last major metamorphism of copper ore

Table 1. Fission track age of copper ore formations.
Total thermal neutron dose = 1.40×10^{17}(nvt)

Sample location	Lab symbol	ρ_s	ρ_i	F.T. age T(m.y.)
Garnet, Khetri Khetri copper belt, Rajasthan.	GK-1	5714* (60)	54560 (250)	881±126**
	GK-2	6025 (65)	55450 (260)	914±126
	GK-3	5862 (62)	55040 (280)	896±125
				Mean = 897±125
Garnet, Kho Dariba, Khetri copper belt, Rajasthan.	GKD-1	2360 (35)	39900 (225)	880±160
	GKD-2	2500 (40)	40000 (240)	896±153
	GKD-3	2405 (37)	41450 (245)	913±161
				Mean = 897±158
Garnet, Gardih Distt. Bihar copper belt, Bihar.	GB-1	7215 (105)	60050 (280)	1010±115
	GB-2	7300 (110)	60560 (295)	1014±113
	GB-3	7420 (120)	61180 (306)	1020±109
				Mean= 1014±112

*N = Number of tracks counted **$1\sigma = \sqrt{\sigma s^2 + \sigma i^2 + \sigma d^2}$

$\sigma s = \frac{100}{\sqrt{N_s}}$, $\sigma i = \frac{100}{\sqrt{N_i}}$, $\sigma d = \frac{100}{\sqrt{N_d}}$

formation in the region corresponsing to Delhi system. Aravalli and Banded gneissic group cycle have not left any residual record of their occurrence in the form of fossil fission tracks. The fission track age of garnet in copper ore of Gardih district, Bihar is found to be 1014±112 m.y. This age corresponds to the Satpura cycle, the range for which has already been reported[11].

The uranium content in the copper ore formations from Khetri copper belt is found to vary from 10.10±0.70 to 14.25±1.00 ppm. While from Bihar copper belt, it varies from 19.00±1.30 to 61.70±4.30 ppm (Table 2).

Table 2. Uranium concentration in copper ore formations.
U concentration in glass dosimeter = 20 ppm.
Thermal neutron dose = 1.05×10^{15} (nvt).

Sample location	Lab symbol	U. conc.(ppm)	Mean U.conc. (ppm)
Copper ore, Khetri copper belt, Rajasthan.	CK-1	13.50±0.91	
	CK-2	14.17±0.78	13.99±0.96
	CK-3	14.25±1.00	
Copper ore, Kho Dariba, Khetri copper belt Rajasthan.	CKH-1	12.95±0.84	
	CKH-2	12.30±0.84	12.96±0.86
	CKH-3	13.65±0.84	
Copper ore, Kolihan, Khetri copper belt, Rajasthan.	CKL-1	11.00±0.77	
	CKL-2	10.10±0.70	10.66±0.72
	CKL-3	10.92±0.70	
Copper ore, Gardih, Bihar copper belt, Bihar.	CG-1	16.00±1.13	
	CG-2	17.35±1.20	17.25±1.20
	CG-3	18.42±1.27	
Copper ore, Jaduguda, Singhbum Thrust, Bihar.	CJ-1	58.07±4.10	
	CJ-2	60.70±4.24	59.94±4.20
	CJ-3	61.70±4.30	
Copper ore, Rakha, Singhbhum Thrust, Bihar.	CR-1	38.20±2.68	
	CR-2	39.62±2.70	39.57±2.57
	CR-3	40.90±2.82	
Copper ore, Mosabani, Singhbhum Thrust, Bihar.	CM-1	32.77±2.26	
	CM-2	28.05±1.90	30.41±2.09
	CM-3	30.42±2.12	
Copper ore, Dhobani, Singhbhum Thrust, Bihar.	CD-1	19.00±1.30	
	CD-2	21.14±1.48	20.89±1.44
	CD-3	22.54±1.55	

$$1\sigma = \frac{100}{\sqrt{N}}$$

The maximum enrichment of uranium is observed in copper ore formations of Jaduguda mine (Bihar). The errors shown in the results are 1σ statistical counting errors. As the tracks in garnet are stable even at high temperature range[1,2] annealing correction in fission track age due to geothermal variations in the orogenies may be ignored.

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