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Fission-Track Ages of the Metallogenetic Epoch in Kamaishi Mine, Japan

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Abstract

An attempt to get the fission-track ages of the metallogenetic epoch of ore deposits in Kamaishi Mine was made through the dating of zircon crystals extracted from both Ganidake and Kurihashi granodiorites, which are intruded in the Kamaishi mining area and both intrusion bodies appear to be genetically related to the mineralization of the ore deposits of this mine.

The dating results yield the age of 111 ± 7 my for the Ganidake granodiorite and 95 ± 9 my for the Kurihashi granodiorite. Consequently, the fission-track ages of the metallogenetic epoch of the ore deposits in Kamaishi Mine should also range from 111 ± 7 my to 95 ± 9 my.

I. Introduction

Contact metasomatic deposits of iron and copper, are found at Kamaishi Mine, North Honshu, Japan. These are among the best-known of Japanese deposits.

The ore deposits are formed at the neighbourhood of the contact of Paleozoic limestone and Ganidake igneous complex. The igneous complex, especially the diorite porphyry is intruded along thrusts and faults provided with favourable condition for skarnization and metallic mineralization of the western ore bodies of the Kamaishi deposits. After the intrusion of the Ganidake igneous complex, Kurihashi granodiorite was considered to have emplaced (HAMABE and YANO, 1976).

II. Geological Setting

Kamaishi Mine which is one of the typical contact metasomatic deposits in Japan is located in the northeastern end of the South Kitakami Area, North Honshu, Japan. The mining area is underlain by Carboniferous to Permian eugeosynclinal sedimentary rocks consisting mainly of limestone, slate, sandstone and pyroclastic rocks, followed by Mesozoic pyroclastic and sedimentary rocks. After suffering from earlier folding, faulting and thrusting, these various sedimentary rocks of Paleozoic

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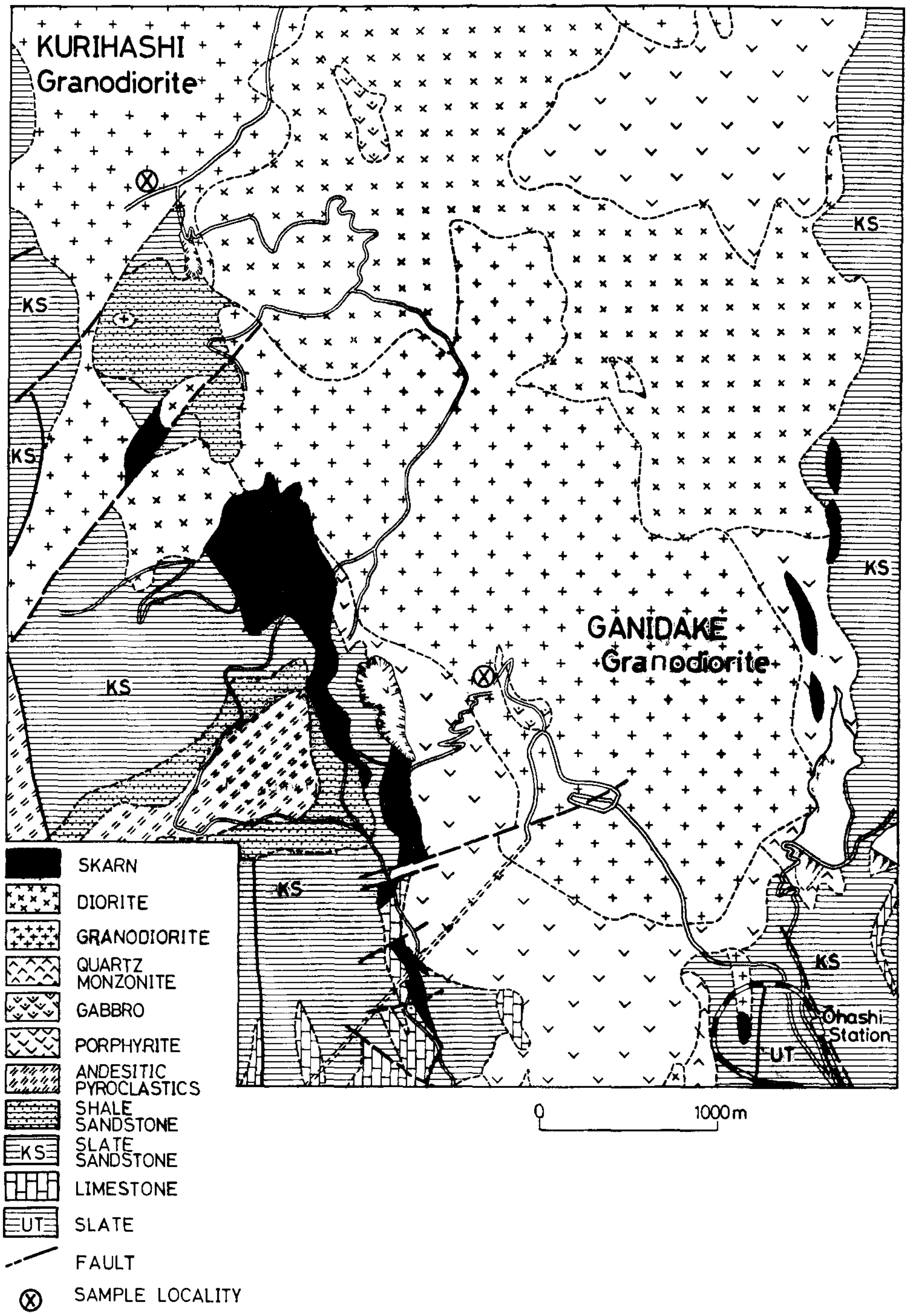

Fig. 1. Geological map of Kamaishi Mine (Nittetsu Mining Co., Ltd., 1973).

and Mesozoic ages were intruded by Ganidake igneous complex, such as granodiorite, diorite, porphyrite and gabbro. Age determination by K-Ar method using biotite shows that Ganidake granodiorite intruded during 110–120 my ago (HAMABE and YANO, 1976).

The ore deposits in Kamaishi Mine are generally formed at the neighbourhood of the contact between Paleozoic limestone and Ganidake igneous complex, the ore deposits occur to be obviously aligned on both eastern and western flanks of Ganidake granodiorite intrusion body, that is, the western ore deposits consisting of Ohmine, Nippo, Shinai and Shinyama ore deposits, and the eastern ore deposits consisting of Takamae, Hosogo and Maeyama ore deposits. The Ganidake igneous complex, especially the diorite porphyry seems to be intruded along thrusts and faults providing favourable conditions for skarnization and metalic mineralization of the western ore deposits.

After the intrusion of Gakidake granodiorite, Kurihashi granodiorite appeared to be also emplaced in this mining area (HAMABE and YANO, 1976). The effect of thermal metamorphism caused by Kurihashi granodiorite intrusion is higher than that of Ganidake granodiorite (Section of Exploration, Kamaishi Mine, 1973).

Field evidences show that both of these intrusion bodies are genetically related to the mineralization of the ore deposits in Kamaishi Mine. Consequently, the ages of these granodiorite intrusion bodies are corresponding to the metallogenetic epoch of ore deposits in Kamaishi Mine. The purpose of the present investigation is to establish the fission-track ages of these granodiorite through the zircon crystals extracted from them.

III. Analytical Procedure

Recent development of fission-track technique in dating both minerals and glasses has indeed offered a new tool for dating purpose (NISHIMURA, 1970; 1977). Granodiorite generally contains an accessory amount of zircon, on which fission-track dating can be properly performed.

Because of its high uranium impurity content, its frequent occurrence in common rocks and its high temperature stability of tracks for thermal fading, zircon is suitable for the application of fission-track dating method (NISHIMURA, 1977). Zircon were separated by the isodynamic separation and by heavy liquid treatments after a sequential processes of crushing, sieving and washing of rock samples.

The method depends on the spontaneous fission of ^{238}U atoms in the mineral, taking place at a constant rate and leaving fission-tracks. The once formed fission-tracks will soon disappear if the mineral is heated above a critical temperature. The fission-track age T yr, can be represented by the following equation (FLEISCHER and PRICE, 1964).

$$T = \frac{1}{\lambda} \ln\left(1 + \frac{\lambda}{\lambda_f} \frac{\rho_s}{\rho_i} \frac{\phi\sigma}{\eta}\right) \cdots\cdots (1)$$

where ρ_s is the fossil track density on crystal surface (cm^{-2}), ρ_i is the induced fission-track density by bombardment with the thermal neutrons (cm^{-2}), λ is the total decay constant for uranium (y^{-1}), λ_f is the fission decay constant for ^{238}U (we used $7.03 \times 10^{-7} y^{-1}$) (FLEISCHER et al., 1975), σ is the thermal neutron cross section for fission ^{235}U (cm^2), ϕ is the thermal neutron dose (cm^{-2}), and η is the isotope ratio $^{235}U/^{238}U$.

If T is younger than 10^9y, the equation can be written as follows:

$$T = 5.96 \times 10^{-8} \phi \frac{\rho_s}{\rho_i} \cdots\cdots (2)$$

Zircon required to be etched for 5–8 hours interval at the temperature of 180°C, in an etchant of 1:1 48% HF and 70% H_2SO_4, by using stainless steel and tepflon capsules.

Table 1. Fission-track ages of zircons in Ganidake granodiorite.

No. of grain	Spontaneous fission-tracks		Induced fission-tracks		Fission-track age (my)
	density (cm^{-2})	counts	density (cm^{-2})	counts	
1	11.0×10^6	289	3.95×10^6	103	116
2	12.5	195	5.01	72	104
3	11.5	278	4.03	97	119
4	8.85	118	3.58	48	103
	$\phi = 0.68 \times 10^{15}$ (cm^{-2})			mean	111 ± 7 (σ)

Table 2. Fission-track ages of zircons in Kurihashi granodiorite.

No. of grain	Spontaneous fission-tracks		Induced fission-tracks		Fission-track age (my)
	density (cm^{-2})	counts	density (cm^{-2})	counts	
1	10.7×10^6	285	5.36×10^6	115	83
2	10.2	198	4.70	95	90
3	7.91	102	3.58	37	92
4	11.5	290	4.15	103	115
5	8.93	118	3.97	52	94
6	10.8	89	4.71	95	95
7	9.02	56	4.02	34	93
	$\phi = 0.68 \times 10^{15}$ (cm^{-2})			mean	95 ± 9 (σ)

IV. Results

The results are listed in both Table 1 and Table 2. The dating results occur to be 111±7 my for the Ganidake granodiorite and 95±9 my for the Kurihashi granodiorite. Consequently, the fission-track ages of the metallogenetic epoch of the ore deposits in Kamaishi Mine should be ranged between these ages.

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