Bulletin of the Geological Survey of Japan, vol.53 (5/6), p.479 - 482, 2002

Re-Os age of molybdenite from the Busetsu two-mica granite, central Japan

Shunso Ishihara[1], Holly J. Stein[2] and Ryoji Tanaka[3]

Shunso Ishihara, Holly J. Stein and Ryoji Tanaka (2002) Re-Os age of molybdenite from the Busetsu two-mica granite, central Japan. *Bull. Geol. Surv. Japan*, vol. 53(5/6), p.479-482, 1 fig, 1 table.

Abstract: Molybdenite discovered in a pegmatitic dikelet in a quarry exposure of the Busetsu Granite in Okazaki City was dated at 76.4±0.3 Ma using the Re-Os method. This age records the final stage of solidification of the Busetsu Granite and agrees well with previously reported CHIME monazite ages.

Keywords: Molybdenite, Re-Os age, late Cretaceous, two-mica granite.

1. Introduction

The Late Cretaceous to Paleogene granitic batholith of the Inner Zone of Southwest Japan has been divided into three metallogenic provinces. From south to north, these are the Barren Province of the Ryoke metamorphic/granitic belt, the W(-Sn) Province of the Sanyo-Naegi volcanic/granitic belt, and the Mo Province of the Sanin-Shirakawa volcanic/granitic belt (Ishihara, 1973). Economic mineralization is absent in the Ryoke belt, which has been generally considered as a deep level exposure of the Ryoke granitoids (Ishihara, 1973), but minor sulfide showings are locally present, especially in active quarries for dimension stone mining.

Molybdenite was discovered in the Nakane granite quarry (Sato and Nakai, 1991) of the Aichi Prefecture of the Chubu District, where the two-mica Busetsu Granite has been quarried. This molybdenite was dated in the AIRIE laboratory at Colorado State University by the Re-Os method using an alkaline fusion dissolution (Markey *et al.*, 1998). Re-Os dating of molybdenite provides a robust chronometer whose accuracy has been recently greatly improved (Stein *et al.*, 1997, 1998). Molybdenite provides a single mineral chronometer for Re-Os in that this mineral contains no common or initial ^{187}Os (Morgan *et al.*, 1968). An overview of Re-Os dating of molybdenite and methodology is found in Stein *et al.* (2001) and references therein. The Re-Os results from the Busetsu granite are reported in this short communication.

2. Previous Studies

The Busetsu two-mica granite was first dated by the K-Ar method at 73 Ma using biotite from Yonegouchi (Kawano and Ueda, 1966; recalculated age is 74.6 Ma using the revised decay constant of Steiger and Jäger, 1977). A Rb-Sr whole-rock isochron age of 82.5±3.9 Ma with a Sr_0 of ratio of 0.7096±0.0002 was subsequently determined (Shibata and Ishihara, 1979).

Suzuki *et al.* (1994) reported CHIME (Chemical Th-U-total Pb isochron method) ages for accessory monazite of 77.6±3.7 to 78.5±2.6 Ma for the northern margin of the main Busetsu body in the Okazaki-Shimoyama area (tentatively called the Okazaki pluton), and 75.0±5.1 to 78.5±5.3 Ma for the granite in the Inabu area (tentatively called the Inabu pluton). They concluded that various phases of the Busetsu granite were solidified in a rather short time span of 75.0±5.1 to 78.9±5.3 Ma.

3. Geological Background and Analyzed Molybdenite

The Busetsu Granite of the Okazaki pluton intrudes the Ryoke metamorphic rocks and hornblende-biotite granodiorite of the Inagawa type in the study area (Fig. 1). It is a two-mica granite with nearly equal amounts of muscovite and biotite, and includes minor biotite tonalite, granodiorite and granite. The two-mica phase contains trace amounts of garnet and monazite. Its SiO_2 and K_2O contents are 73 to 75% and 3.3 to 4.6%, respectively (Ishihara and Terashima, 1977), and its alumina saturation index (ASI) is higher than 1.05 (Sato and Nakai, 1991). Thus, the Busetsu granite has some S-type characteristics among the Ryoke granitoids that are normally hornblende-bearing and I-type in the Chubu District (Ishihara and Terashima, 1977).

[1]Geological Survey of Japan, Central 7, AIST, Higashi 1-1-1, Tsukuba, 305-8567 Japan

[2]AIRIE Program, Department of Earth Resources, Colorado State University, Fort Collins, CO 80523-1482 USA

[3]Institute for Study of the Earth's Interior, Okayama University, Misasa, Tottori, 682-0123 Japan.

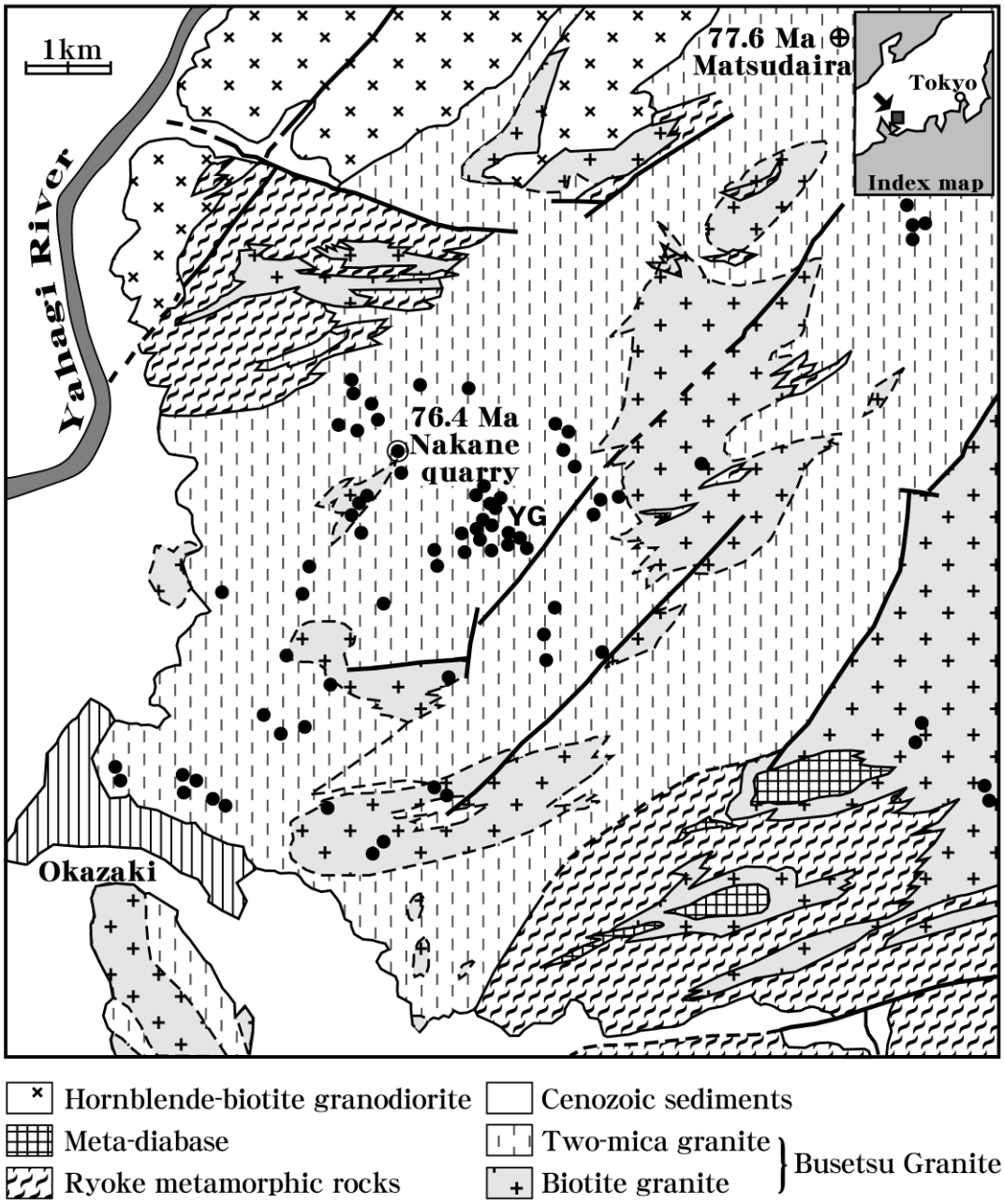

Fig. 1 Geologic map of the Okazaki area with the location of granite quarries (filled circles) and dated molybdenite and monazite samples. Sinplified from Nakai (1985) and Sato and Nakai (1991). YG, Yonegouchi where K-Ar age of 74.6 Ma (Kawano and Ueda, 1966) is reported.

The two-mica Busetsu granite has been quarried for statue and building stones at many places around Okazaki City. This two-mica granite is mostly fine- to medium-grained, but also includes fine- to medium-grained biotite granite, which is known as Ao-ishi, blue granite (Nakai, 1985), especially close to the roof metamorphic rocks (Fig. 1). No metallic ore deposits are known, but Mo-mineralized pegmatitic dikelets are known at one locality in the Okazaki pluton.

The analyzed molybdenite is seen in a pegmatitic dike cutting the two-mica Busetsu granite in the Nakane granite quarry of Taki-machi, Okazaki City (N34°59'18", E137°12'25"). Here the granite is heterogeneous with irregular biotite-rich bands. The pegmatite is composed of quartz, K-feldspar, sodic plagioclase and lesser muscovite and biotite. Molybdenite occurs sporadically in the pegmatite and also along fractures displaying hydrothermal alteration.

4. Results and Interpretation

The age of molybdenite from the Nakano granite quarry was determined to be 76.4±0.3 Ma (Table 1), which we interpret as the age of the hosting pegmatite, representing the crystallization age of the Mo-bearing pegmatite, and probably closely approximating the age of the hosting Busetsu two-mica granite. The Rb-Sr system should be re-examined by detailed sampling in future.

Table 1. Re-Os age for molybdenite from a quarry exposure of the Busetsu granite, Aichi Prefecture, Japan

Quarry (Sample No.)	AIRIE Run	Re (ppm)[1]	^{187}Os (ppb)[1]	Age (Ma)[2,3,4]
Nakane (RY83C)	C-61	2.906 (1)	2.326 (6)	76.4±0.3 Ma

[1]Re and ^{187}Os uncertainties in parentheses are absolute at 2σ for the last digit indicated.

[2]Uncertainty includes error in, (1) ^{185}Re and ^{190}Os spike calibrations, 0.05 and 0.15%, respectively, (2) error magnification with spiking, (3) mass spectrometric measurement of isotopic ratios, and (4) the ^{187}Re decay constant (±0.31%)

[3]Molybdenites rarely require a blank correction with blanks at Re=<20pg, and Os=6 to 8pg with a variable ^{187}Os/^{188}Os ranging from 0.5 to 8.3.

[4]Ages are calculated by $^{187}Os=^{187}Re\ (e^{\lambda\tau}-1)$ where $\lambda=^{187}$Re decay constant and t=age. ^{187}Re decay constant used is 1.666×10^{-11} yr^{-1} with an uncertainty of ±0.31% (Smoliar *et al*., 1996); uncertainties shown for ages are absolute at 2σ.

tic dike. Thus, the Busetsu granite solidified at about 76 Ma. The geographically closest CHIME monazite age obtained by Suzuki *et al*. (1994) is 77.6±3.7 Ma at Matsudaira, which is 7km northeast of our sample locality (Fig. 1). Our Re-Os molybdenite age is in good agreement with this CHIME age for the same pluton, which was interpreted as recording cooling to about 700ºC (Suzuki and Adachi, 1998). This temperature is in agreement with high closure temperature estimates for U-Pb systematics in monazite (e.g., Romer and Rötzler, 2001; Bingen and van Breemen, 1998).

The monazite and molybdenite ages represent the crystallization of granite and the intrusion of late pegmatite dikelets, respectively. U-Pb dating of monazite and Re-Os dating of molybdenite generally provide comparable age results (Stein *et al*., 2001), even in granulite facies terranes(Torrealday *et al*., 2000; Bingen and Stein, 2001). This study is an example of the agreement between U-Pb and Re-Os dating in granite systems with associated molybdenite.

In contrast, the Re-Os age is slightly older than the K-Ar age of 74.6 Ma for a biotite 1.5km away, the result of a lower isotopic closure temperature of 300±50ºC for argon-based systematics (Dodson and McClelland-Brawn, 1995) compared to the magmatic temperatures of the pegmatite (the uncertainty on the K-Ar age was not given in the original paper). The Re-Os age is somewhat younger than a Rb-Sr whole rock isochron age of 82.5±3.9 Ma (Shibata and Ishihara, 1979). We regard the Re-Os and CHIME ages as robust and accu-

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Received February 15, 2002
Accepted April 18, 2002

中部地方，武節両雲母花崗岩中の輝水鉛鉱のRe-Os年代

石原舜三・ホリ- J. シュタイン・田中亮吏

要　旨

岡崎市滝町の中根石材ピットの両雲母花崗岩（岡崎岩体）に貫入するペグマタイト脈中の輝水鉛鉱のRe-Os年代測定をコロラド州立大で行った．結果は76.4±0.3Maであり，その北東方7km，松平のモナズ石CHIME年代である77.6±3.7Maと良い一致を示した．南東1.5km，米河内からは黒雲母K-Ar年代の74.6Ma，岡崎岩体の全岩Rb-Sr年代として82.5±3.9Maがあるが，Re-Os法とU-Pb法の一致性，分析精度を考慮して，岡崎岩体の固結年代は76Ma頃と考えたい．