Bulletin of the Geological Survey of Japan, vol.46 (5), P. 219-224, 1995

Rb-Sr isochron ages and initial Sr isotope ratios of the Ukan granodiorite and Kayo granite, central Okayama prefecture, southwest Japan,

Tetsuichi TAKAGI* and Hiroo KAGAMI**

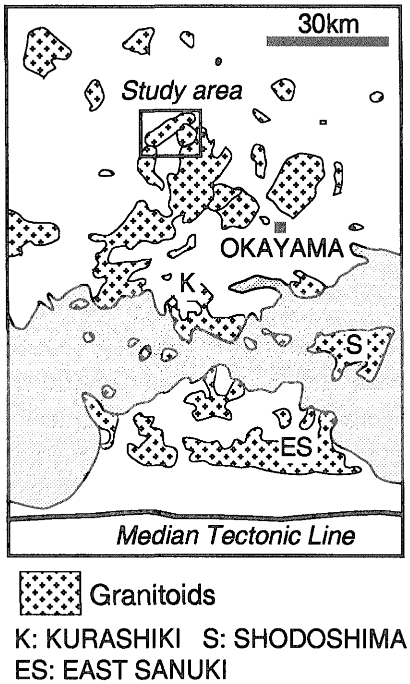
TAKAGI Tetsuichi and KAGAMI Hiroo(1995) Rb-Sr isochron ages and initial Sr isotope ratios of the Ukan granodiorite and Kayo granite, central Okayama prefecture, southwest Japan. *Bull. Geol. Surv. Japan,* vol.46(5), p.219-224, 5figs. 1table.

Abstract : Rb-Sr whole-rock isochron ages and initial Sr isotope ratios (SrI) of the Ukan granodiorite and Kayo granite, central Okayama prefecture, were determined. The main facies of the Ukan granodiorite and Kayo granite show the age of 92.0 ±6.5 Ma with SrI of 0.70696 ±14 and 81.2 ±5.5 Ma with SrI of 0.70684 ±10, respectively.

1. Introduction

In the central Okayama prefecture, granodiorite and granite stocks are widely exposed (Fig. 1). Although these are correlated to late Cretaceous intrusives by their occurrences and rock facies (Geological Survey of Japan, 1992), there are few geochronological and Sr isotopic information on the granitoids. We have determined the Sr isotope ratios and Rb-Sr isochron ages of the Ukan granodiorite and Kayo granite, since they are the representative plutons in this area (Fig. 2).

A petrological study on the plutons has already been presented by Takagi (1992). The Ukan granodiorite is composed of Opx-Cpx-biotite quartz monzodiorite and (Cpx)-hornblende -biotite granodiorite, and the Kayo granite comprises hornblende-biotite granite porphyry and granophyre. The Ukan granodiorite is intruded by the Kayo granite and a late Cretaceous granite



*Hokkaido Branch

**Institute for Study of the Earth's Interior, Okayama University, Misasa, Tottori, 682-01, Japan.

Keywords : Sr isotope ratio, Rb-Sr isochron age, granitoid, Okayama prefecture

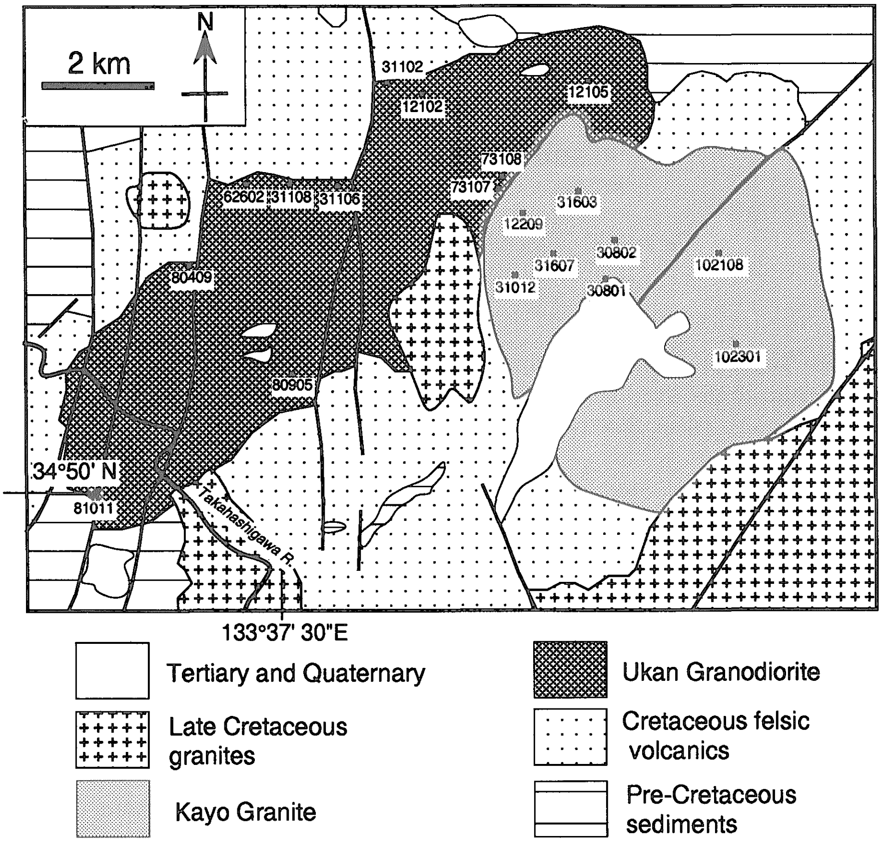


Fig. 2 Simplified geological map of the Ukan and Kayo areas after Takagi (1992) showing the localities of samples for isotopic analyses.

batholith to the south which has a Rb-Sr whole-rock isochron age of 84.0±3.7 Ma (Kagami, *et al.*, 1988), and both plutons intrude into Cretaceous felsic volcanic strata and pre-Cretaceous sediments. The magnetite content in the two granitoids is distinctly different; the Ukan granodiorite shows the contents of ilmenite-series (<0.1 vol. %), while the Kayo granite shows that of the magnetite-series (0.2-0.5 vol. %). Mineralogical data of the granitoids suggest that the difference in magnetite contents of the two granitoids is attributed to different oxidation states at late magmatic to subsolidus stages, and both are presumed to have been of ilmenite-series at their early to middle magmatic stage (Takagi, 1992, 1993).

2. Rb-Sr isotope ratios and whole-rock isochron ages

Eleven whole-rock samples of the Ukan granodiorite and eight whole-rock samples of the Kayo granite were selected for Rb-Sr isotope analysis. Rb and Sr concentrations were determined by the X-ray fluorescence method (with JEOL JSX-60S7 at Shimane University), following the method of Ichikawa, *et al*. (1987). We estimate an error of ±5% for the Rb and Sr concentrations of each sample. Sr isotope ratios were determined using a MAT-261 mass spectrometer at the Institute for Study of the Earth's Interior, Okayama University. Experimental procedures have been described by Kagami, *et al*. (1982, 1987). $^{87}Sr/^{86}Sr$ ratios were normalized to $^{86}Sr/^{88}Sr=0.1194$. The ages and initial ratios were calculated by the least squares regression method (York, 1966), using $\lambda=1.42 \times 10^{-11}/y$ for the decay constant of ^{87}Rb (Steiger and Jäger, 1977). Three replicate analyses of the Sr isotope standard NBS 987 gave the $^{87}Sr/^{86}Sr$ ratios of 0.710260±10 (2σ), 0.710250±10 (2σ), and 0.710261±10 (2σ).

Table 1 Rb and Sr concentrations and Sr isotope ratios of the Ukan granodiorite and Kayo granite. Accuracy of Rb and Sr concentrations are estimated to be±5%.

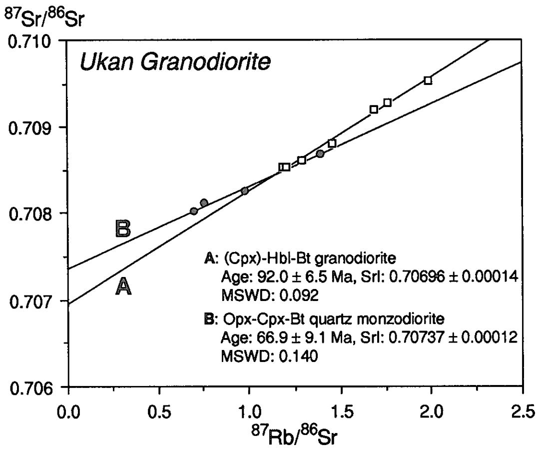
Sample	Type	Rb(ppm)	Sr(ppm)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	2σ
Ukan Granodiorite						
31106	GRD	96	234	1.1871	0.70853	0.00001
12102	GRD	101	243	1.2026	0.70853	0.00002
81011	GRD	108	242	1.2913	0.70862	0.00002
80905	GRD	131	261	1.4523	0.70881	0.00001
73108	GRD	127	218	1.6858	0.70920	0.00001
73107	GRD	127	208	1.7668	0.70928	0.00001
12105	GRD	141	205	1.9904	0.70953	0.00001
80409	QMD	73	300	0.7040	0.70802	0.00002
31108	QMD	70	268	0.7557	0.70812	0.00001
62602	QMD	85	252	0.9760	0.70827	0.00002
31102	QMD	106	220	1.3942	0.70870	0.00001
Kayo Granite						
31012	ECV	54	291	0.5369	0.70741	0.00001
31607	ECV	68	308	0.6388	0.70760	0.00001
30801	ECV	76	301	0.7305	0.70774	0.00001
102301	GPO	99	191	1.4998	0.70856	0.00001
31603	GPH	103	185	1.6110	0.70868	0.00001
30803	GPH	103	168	1.7740	0.70878	0.00001
12209	ECV	135	203	1.9244	0.70917	0.00002
102108	AP	114	144	2.2909	0.70948	0.00002

GRD=granodiorite, QMD= quartz monzodiorite, ECV= enclave, GPO= granite porphyry, GPH= granophyre, AP= aplitic granite

Analytical results are listed in Table 1. The isochrons for the Ukan granodiorite and Kayo granite are shown in Figure 3. In the Ukan granodiorite, two linear trends are recognized. The one linear trend with a gentle slope (B) can be drawn by connecting 4 samples from the Cpx-Opx-biotite quartz monzodiorite, which gives an isochron age of 66.9 ±9.1 Ma with an initial $^{87}Sr/^{86}Sr$ ratio of 0.70737±12 (2σ). The other linear trend with a steep slope (A) can be drawn by connecting 7 samples from the (Cpx)-hornblende-biotite granodiorite, which gives an isochron age of 92.0±6.5 Ma with an initial $^{87}Sr/^{86}Sr$ ratio of 0.70696±14 (2σ). The eight samples from the Kayo granite are aligned on a linear trend giving isochron age of 81.2±5.5 Ma with an initial $^{87}Sr/^{86}Sr$ ratio of 0.70684±10 (2σ).

3. Discussion

The isotope data of the Ukan granodiorite display two independent isochrons (A and B, in Fig. 3). The isochron age of (Cpx)-hornblende-biotite granodiorite (92.0±6.5 Ma), given by the line A, is probably an intrusive age. We interpret



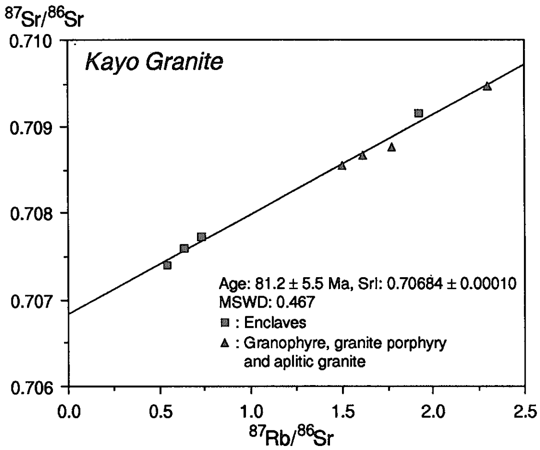


Fig. 3 Whole-rock isochron diagrams for the Ukan granodiorite and Kayo granite. The isochron age given by line A would be an intrusive age of the Ukan granodiorite, and line B is probably a pseudo-isochron. Cpx=clinopyroxene, Opx=orthopyroxene, Hbl=hornblende, Bt=biotite

line B as a pseudo-isochron. Since no intrusive relation between the two rock-facies has been recognized in the field, and transitional facies such as Opx-Cpx-hornblende-biotite granodiorite are observed in places, the trend shows the nearly simultaneous intrusion of the two rock-facies. The Ukan granodiorite is intruded by the 84 Ma granites to the south (Fig. 2) which are older than the age from the line B (66.9±9.1 Ma). Therefore, the age given from line B is not consistent with the geological occurrences. It appears that the line B was formed by a mixing of the granodiorite magma with the quartz monzodiorite magma. Figure 4 shows a plot of the Sr isotope ratios at 92 Ma versus 1/Sr (ppm) ratios of the quartz monzodiorite and the granodiorite samples. The four plots from the quartz monzodiorite samples show a near linear correlation, and the variation can be explained by a mixing of the two magmas. On the other hand, the isotope data of the Kayo granite, including mafic enclaves, form single isochron. This shows that the Kayo granite magma attained equilibrium with respect to Sr isotope ratios at the time of solidification.

The isochron age of the Ukan granodiorite is 5-10 Ma older than those of the batholiths in the southern to eastern Okayama prefecture and Shodoshima areas (Fig. 1, 82-84 Ma, Kagami, *et al.*, 1988), and the age is similar to those of the batholiths in the East Sanuki (93 Ma, Kagami, *et al.*, 1988), Kurashiki, Hiroshima, and Takanawa areas (88-94 Ma, Shibata and Ishihara, 1979; Nakajima, *et al.*, 1990). The Kayo granite shows almost the same age as the batholith in the southern to eastern Okayama prefecture and Shodoshima area.

The difference of initial $^{87}Sr/^{86}Sr$ ratios between the Ukan and Kayo granitoids is small, and therefore it is difficult to distinguish the source rocks for two magmas by the Sr isotope compositions. Based on the Sr and Nd isotope ratios, Kagami, *et al.* (1992) has shown that the granitoids in the Inner zone of southwest Japan can be divided into four zones (North, Transitional, South, and Kyushu, Fig. 5). The Ukan and

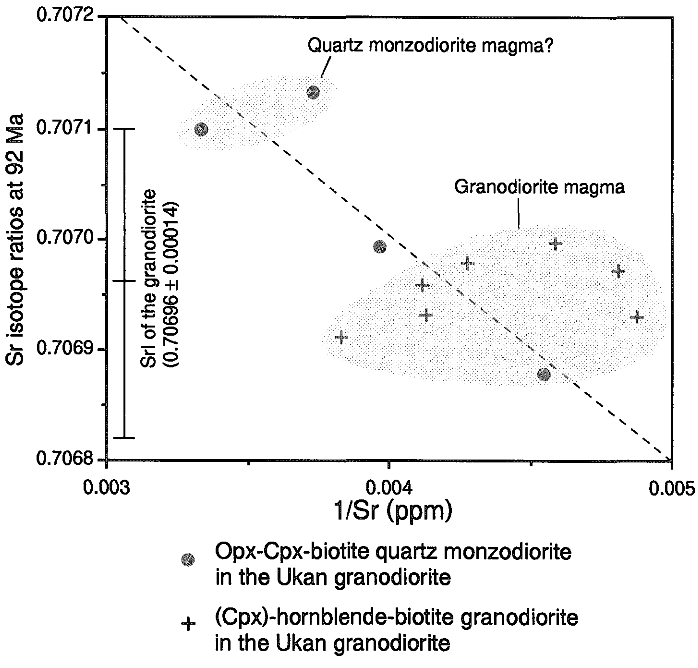


Fig. 4 Sr isotope ratios at 92 Ma versus 1/Sr (ppm) ratios diagram. Dotted line: a regression line for the four plots from the quartz monzodiorite samples.

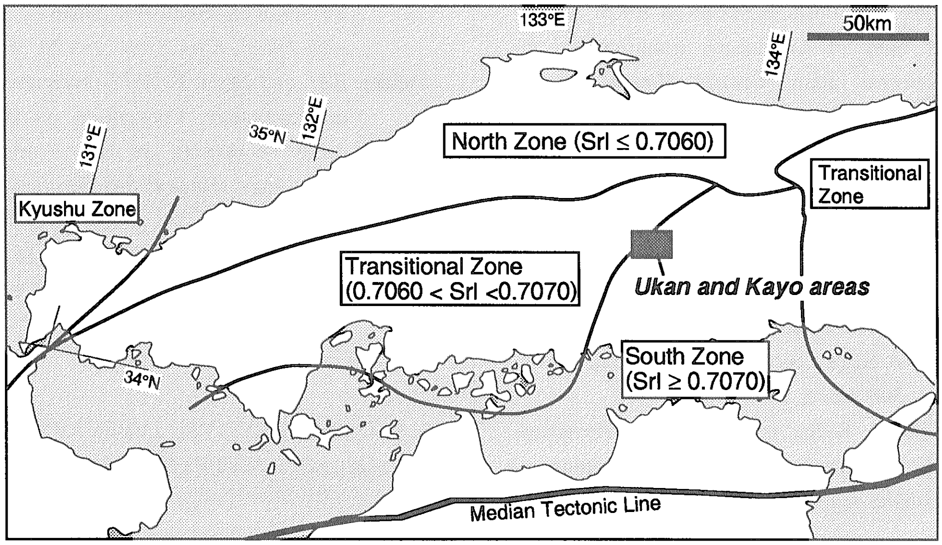


Fig. 5 Regional divisions of the granitoids in the Inner zone of southwest Japan based on the initial Sr isotope ratios after Kagami, *et al*. (1992). The North zone and the Kyushu zone are divided only by the Nd isotopic characteristics. The Rb-Sr isotopic compositions of the Ukan and Kayo granitoids share characteristics of the South and Transitional zones.

Kayo areas are on the boundary of the South and Transitional zones, similarly the initial $^{87}Sr/^{86}Sr$ ratios of the Ukan granodiorite (0.7070) and Kayo granite (0.7068) show intermediate values of the two zones. Thus, the values are consistent with the tendency for Sr isotope variation of the granitoids in the Inner zone of southwest Japan.

Acknowledgments We are grateful to Prof. Terukazu Nureki (Okayama Univ.) for his helpful suggestions and encouragement, and Dr, Jonathan Dehn (Hokkaido Branch) for his improvements of this manuscript.

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* in Japanese with English abstract

MANUSCRIPT RECIVED FEBRUARY 15, 1995
MANUSCRIPT ACCEPTED APRIL 3, 1995

岡山県中部，有漢花崗閃緑岩，賀陽花崗岩の Rb-Sr アイソクロン年代と Sr 同位体初生値

高木哲一，加々美寛雄

要　旨

岡山県中部の花崗岩類は，従来，放射年代値が公表されていなかった．そこで，本地域の代表的岩体である有漢花崗閃緑岩と賀陽花崗岩の Rb-Sr 全岩アイソクロン年代を測定した．有漢花崗閃緑岩の主岩相の年代は 92.0±6.5 Ma，初生値は 0.70696±14 を示す．また賀陽花崗岩の年代は 81.2±5.5 Ma，初生値は 0.70684±10 を示す．これらの値は，西南日本内帯花崗岩類の Sr 同位体比の広域的変化と調和的である．