

CHIME monazite ages of the Otagiri and Ichida Granites in the Komagane area, Nagano Prefecture

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ABSTRACT

The Otagiri Granite comprises peraluminous fine-grained two-mica granites to granodiorites, and intrudes into the Ichida Granite within the eastern part of the Ryoke metamorphic belt. Monazites from three samples of the Otagiri Granite and a sample of the Ichida Granite were dated by the Chemical Th-U-total Pb Isochron Method (CHIME). The ages are 77.4 ± 3.1 Ma, 76.3 ± 2.8 Ma and 77.2 ± 3.5 Ma for the Otagiri Granite and 79.4 ± 3.1 Ma for the Ichida Granite. The CHIME monazite ages, interpreted as the time of the emplacement, agree with the intrusive relation. The present dating shows that the 100-90 Ma Rb-Sr whole-rock isochron ages (Yuhara, 1994) for the Otagiri Granite is fortuitous. The CHIME monazite ages support the previous correlation of the Otagiri Granite with the Kadoshima and Busetsu Granites of ca. 77 Ma age (Kagami, 1972; Shibata and Ishihara, 1979; Nakai et al., 1985; Suzuki et al., 1994b).

INTRODUCTION

Peraluminous fine-grained two-mica granites to granodiorites occur in discontinuous plutons over an area of a hundred kilometer long, from Komagane to Mikawa within the eastern Ryoke metamorphic belt (e.g. Ryoke Research Group, 1972). They are named as the Otagiri Granite in the Komagane area, the Kadoshima Granite in the Kadoshima area and the Busetsu Granite in the Mikawa area. Rocks of individual plutons, despite the wide range in spatial distribution, are petrographically quite similar; the fine-grained texture and the presence of muscovite, garnet, monazite, xenotime, sillimanite and/or cordierite are the diagnostic features of the Otagiri, Kadoshima and Busetsu Granites from other granitoids in the eastern Ryoke belt. All plutons of the Otagiri, Kadoshima and Busetsu Granites intrude into the Inagawa Granodiorite which is a continuous pluton extended from Komagane to Mikawa and is regarded as the representative of the Younger Ryoke Granite (i.e. post-tectonic granites, Ryoke Research Group, 1972). The intrusive relations coupled with the petrographic similarity lead many scholars to a conclusion that the Otagiri, Kadoshima and Busetsu Granites formed simultaneously. The Kadoshima Granite has been dated by the Rb-Sr whole-rock isochron method to be 76.1 Ma (Kagami 1973; originally 73.3 Ma, 6 data were recalculated using the currently accepted decay constant of $1.42 \times 10^{-11}/y$). The Busetsu Granite

shows Rb-Sr whole-rock isochron ages of 82.5 ± 3.9 (1σ) Ma (Shibata and Ishihara, 1979) and 75.4 ± 10.4 Ma (Nakai et al., 1985; originally 71.4 ± 1.4 Ma, it was recalculated by discarding data for metabasite and hornblende gabbro) and CHIME monazite ages of 75.0 ± 5.1 - 78.9 ± 5.3 Ma (Suzuki et al., 1994b).

The Otagiri Granite was recently dated by Yuhara (1994) by the Rb-Sr whole-rock isochron method. The ages are 71.6 ± 6.8 , 99.0 ± 10.9 and 92.7 ± 13.8 Ma. These dates, at least 99.0 Ma, are surprisingly older than those for the Kadoshima and Busetsu Granite. If this is true, the previous correlation of the Otagiri Granite with the Kadoshima and Busetsu Granites is invalid. However, the Rb-Sr ages of the Otagiri Granite appear to be inconclusive, since the Rb-Sr isotopic data exhibit a significantly large scatter. To check the existence of the ca. 90-100 Ma plutons by an alternative method, we have determined CHIME (chemical Th-U-total Pb isochron method) monazite ages using an electron microprobe for samples of the Otagiri Granite. Also dated is the Ichida Granite which is intruded by the 92.7 ± 13.8 Ma pluton of the Otagiri Granite. The monazite age can be regarded as representing the time for crystallization of granitic intrusives, since the blocking temperature for Pb in monazite (ca. 700°C ; Parrish, 1990; Smith and Barreiro, 1990; Suzuki et al., 1994a) is close to the temperature for crystallization of granitic magmas (e.g. Merril et al., 1970; Robertson and Wyllie, 1971).

GEOLOGY AND EXPERIMENTS

The Komagane area, situated in the northeastern part of the Ryoke belt, is underlain mainly by the Ryoke metamorphic rocks, a series of granitoids and Quaternary covers (Fig. 1, Murayama and Katada, 1957). The Ryoke metamorphic rocks consists mainly of pelitic and psammitic schists and gneisses. The metamorphic grade increases from the biotite zone in the northwest of the mapped area to the sillimanite-cordierite-orthoclase zone in the southeast (Ono, 1969).

Five granitic intrusives are distinguished in the area, the Inagawa Granodiorite (coarse-grained porphyritic granodiorite to adamellite), the Ichida Granite (medium-grained biotite granodiorite to adamellite), the Otagiri Granite (mainly two-mica adamellite), the Kisokoma Granodiorite (medium-grained hornblende-biotite granodiorite) and the unnamed biotite granodiorite at Miyata. The intrusive sequence of these granitoids (Fig. 2) was synthesized on the basis of field evidence and petrographic correlations by Ryoke Research Group (1972). The relation between the Otagiri Granite and Ichida Granite is not shown in the original context given by Ryoke Research Group, but Yuhara (1994) found that the former intrudes into the latter at Nakatagiri River. Although the geologic relation between the Otagiri Granite and Kisokoma Granodiorite is never detectable, the Kisokoma Granodiorite is considered to intrude after the emplacement of the Otagiri Granite from the mode of occurrence (Tsuchiya, 1966).

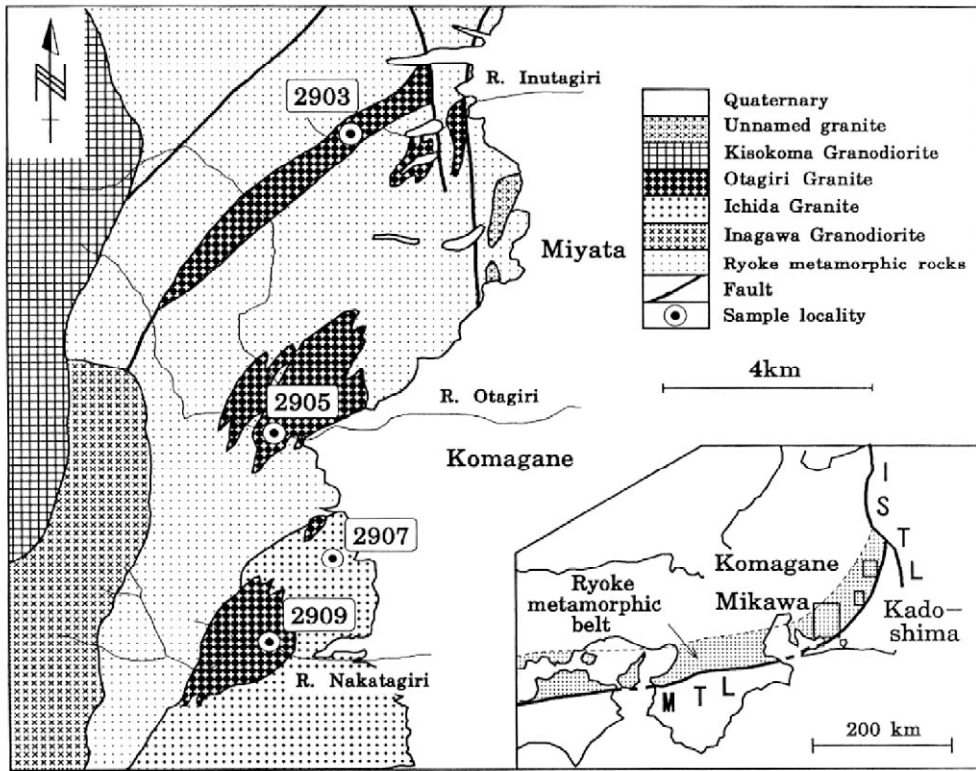


Fig. 1. Geological map of the Komagane area showing sample localities of granitoids (simplified from Murayama and Katada, 1957).

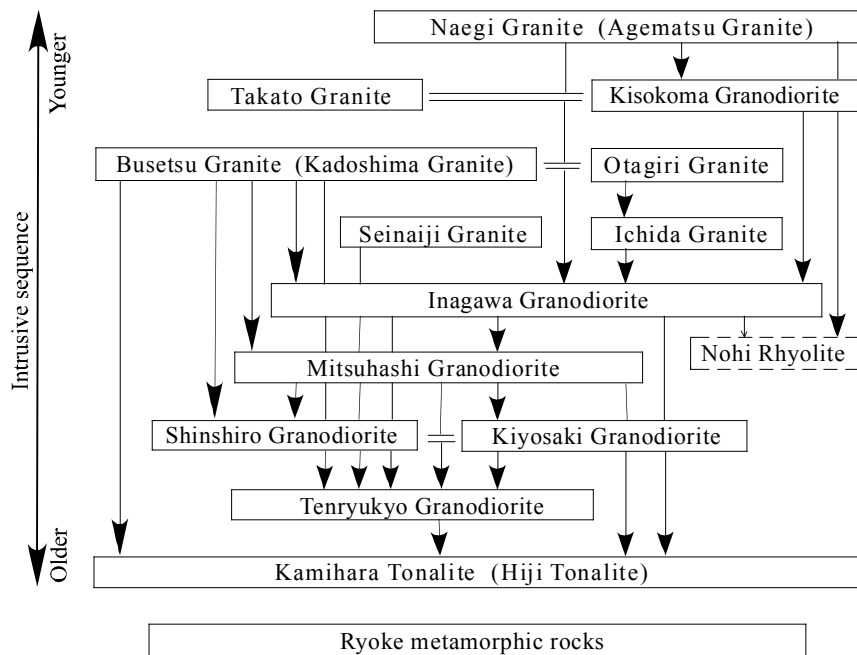


Fig. 2. Intrusive relations of granitoids in the eastern Ryoke metamorphic belt (simplified and modified from Ryoke Research Group, 1972).

Table 1. Microprobe analyses of ThO₂, UO₂ and PbO of monazites from the Otagiri Granite (samples 2903, 2905 and 2909) and the Ichida Granite (sample 2907) in the Komagane area. ThO₂*: sum of the measured ThO₂ and ThO₂ equivalent of the measured UO₂.

Grain No.	ThO ₂ wt.%	UO ₂ wt.%	PbO wt.%	Age Ma	ThO ₂ * wt.%	Grain No.	ThO ₂ wt.%	UO ₂ wt.%	PbO wt.%	Age Ma	ThO ₂ * wt.%
Sample 2903: Otagiri Granite						M15-04	6.23	0.235	0.022	76	6.98
M01-01	10.9	0.287	0.038	77	11.8	M15-05	6.50	0.091	0.023	79	6.79
M01-02	6.86	0.163	0.024	76	7.38	M16-01	7.89	0.215	0.027	74	8.58
M01-03	10.7	0.261	0.038	79	11.5	M16-02	7.49	0.218	0.027	76	8.19
M01-04	10.8	0.338	0.040	80	11.9	M16-03	8.94	0.335	0.035	81	10.0
M02	6.34	0.168	0.023	79	6.88	M16-04	10.1	0.375	0.037	78	11.3
M03-01	6.82	0.227	0.024	76	7.55	M16-05	5.88	0.146	0.020	74	6.35
M03-02	7.47	0.225	0.026	74	8.19	M17-01	8.60	0.283	0.032	79	9.51
M03-03	6.42	0.211	0.023	76	7.09	M17-02	7.20	0.148	0.024	74	7.67
M03-04	7.98	0.221	0.029	78	8.69	M17-03	9.68	0.165	0.032	73	10.2
M04-01	8.61	0.305	0.032	79	9.59	M17-04	11.0	0.345	0.040	78	12.1
M04-02	9.22	0.171	0.031	75	9.77	M17-05	10.4	0.347	0.038	77	11.5
M04-03	9.06	0.247	0.034	81	9.85	M18-01	9.01	0.213	0.031	76	9.69
M05-01	5.51	0.285	0.021	77	6.42	M18-02	8.28	0.197	0.031	81	8.91
M05-02	5.29	0.267	0.020	76	6.15	M18-03	9.00	0.275	0.034	82	9.88
M05-03	6.10	0.396	0.026	83	7.37	M18-04	7.40	0.268	0.026	75	8.26
M06-01	9.16	0.237	0.032	76	9.92	M18-05	7.87	0.182	0.025	71	8.45
M06-02	7.81	0.173	0.026	74	8.36	M19-01	10.7	0.280	0.038	78	11.6
M06-03	8.13	0.331	0.033	84	9.19	M19-02	10.1	0.197	0.034	74	10.7
M07-01	4.62	0.147	0.018	82	5.09	M19-03	8.73	0.199	0.033	82	9.37
M07-02	7.64	0.203	0.028	79	8.29	M19-04	6.93	0.107	0.023	73	7.27
M08	7.90	0.208	0.028	78	8.56	M19-05	7.87	0.208	0.027	75	8.54
M09-01	7.04	0.191	0.026	79	7.65	M19-06	10.9	0.240	0.038	78	11.7
M09-02	7.60	0.169	0.026	76	8.14	M19-07	10.7	0.212	0.036	75	11.4
M10-01	7.07	0.305	0.027	80	8.05	M19-08	10.8	0.299	0.037	74	11.8
M10-02	8.52	0.325	0.030	73	9.56	M19-09	11.3	0.273	0.042	81	12.2
M11-01	5.99	0.129	0.022	80	6.40	M19-10	6.96	0.140	0.024	76	7.41
M11-02	9.38	0.301	0.034	78	10.3	Sample 2905: Otagiri Granite					
M11-03	9.65	0.360	0.036	78	10.8	M01-01	8.09	0.641	0.034	79	10.1
M12-01	5.68	0.225	0.021	79	6.40	M01-02	6.90	0.325	0.024	72	7.94
M12-02	4.34	0.163	0.017	81	4.86	M01-03	9.13	0.213	0.032	78	9.81
M13-01	9.25	0.228	0.033	77	9.98	M01-04	7.69	0.361	0.031	82	8.85
M13-02	6.93	0.229	0.026	80	7.66	M01-05	7.71	0.463	0.027	70	9.19
M14-01	8.31	0.149	0.029	77	8.79	M02-01	10.6	0.223	0.037	77	11.3
M14-02	9.20	0.165	0.033	79	9.73	M02-02	10.3	0.209	0.036	77	11.0
M14-03	8.42	0.082	0.030	80	8.68	M02-03	10.1	0.150	0.034	76	10.6
M14-04	8.08	0.099	0.027	77	8.40	M02-04	9.71	0.138	0.031	73	10.2
M14-05	8.16	0.137	0.029	78	8.60	M02-05	9.97	0.166	0.032	72	10.5
M15-01	4.68	0.207	0.018	80	5.34	M02-06	9.14	0.120	0.030	75	9.53
M15-02	4.70	0.137	0.017	77	5.14	M03-01	4.79	0.050	0.016	77	4.95
M15-03	3.35	0.044	0.012	81	3.49						

Table 1. (continued).

Grain No.	ThO ₂ wt.%	UO ₂ wt.%	PbO wt.%	Age Ma	ThO ₂ * wt.%	Grain No.	ThO ₂ wt.%	UO ₂ wt.%	PbO wt.%	Age Ma	ThO ₂ * wt.%
M03-02	5.74	0.096	0.020	77	6.05	M11-01	5.63	0.113	0.019	75	5.99
M03-03	5.70	0.075	0.019	76	5.94	M11-02	5.62	0.091	0.018	72	5.91
M04-01	4.92	0.092	0.017	75	5.21	M11-03	5.71	0.107	0.020	76	6.05
M04-02	5.40	0.106	0.019	78	5.74	M11-04	5.73	0.154	0.021	78	6.22
M04-03	5.59	0.047	0.019	78	5.74	M11-05	5.35	0.097	0.018	74	5.66
M04-04	5.57	0.045	0.020	83	5.71						
M04-05	5.05	0.029	0.015	69	5.14	Sample 2909: Otagiri Granite					
M05-01	6.62	0.696	0.030	81	8.85	M01-01	3.44	0.918	0.020	74	6.38
M05-02	6.01	0.290	0.023	77	6.94	M01-02	4.98	0.739	0.024	78	7.35
M05-03	4.58	0.371	0.020	82	5.77	M01-03	3.88	1.03	0.024	79	7.18
M05-04	6.28	0.357	0.024	77	7.42	M02-01	5.78	0.195	0.020	75	6.41
M06-01	6.64	0.135	0.023	77	7.07	M02-02	5.90	0.249	0.019	68	6.70
M06-02	5.38	0.084	0.019	81	5.65	M02-03	6.57	0.087	0.023	79	6.85
M06-03	6.31	0.122	0.021	73	6.70	M03-01	4.29	0.057	0.013	71	4.47
M06-04	6.58	0.117	0.023	78	6.96	M03-02	3.71	0.044	0.013	78	3.85
M06-05	10.3	0.282	0.035	74	11.2	M04-01	4.65	0.077	0.018	87	4.90
M07-01	5.26	0.087	0.019	82	5.54	M04-02	4.91	0.111	0.016	72	5.26
M07-02	5.19	0.096	0.018	76	5.50	M04-03	5.00	0.075	0.016	73	5.24
M07-03	4.56	0.098	0.016	76	4.87	M04-04	5.17	0.053	0.018	78	5.34
M07-04	4.80	0.099	0.016	73	5.12	M05-01	6.99	0.121	0.024	77	7.38
M07-05	4.36	0.062	0.015	78	4.56	M05-02	7.69	0.160	0.029	83	8.20
M07-06	4.94	0.091	0.017	75	5.23	M05-03	7.70	0.163	0.026	76	8.22
M08-01	9.21	0.095	0.033	82	9.52	M05-04	7.02	0.169	0.024	75	7.56
M08-02	9.07	0.129	0.030	75	9.48	M05-05	7.26	0.186	0.025	75	7.85
M08-03	9.90	0.087	0.034	78	10.2	M06-01	6.63	0.135	0.024	82	7.06
M08-04	10.1	0.126	0.033	75	10.5	M06-02	6.39	0.124	0.023	81	6.79
M08-05	8.53	0.091	0.029	78	8.82	M06-03	6.13	0.100	0.019	70	6.45
M08-06	6.58	0.121	0.022	74	6.97	M06-04	6.03	0.069	0.022	82	6.25
M08-07	8.63	0.091	0.028	75	8.92	M06-05	5.78	0.086	0.019	75	6.05
M08-08	9.90	0.111	0.032	73	10.3	M07-01	7.74	0.118	0.028	82	8.12
M08-09	9.75	0.112	0.034	79	10.1	M07-02	7.95	0.179	0.028	78	8.52
M09-01	3.59	0.060	0.012	75	3.78	M07-03	8.91	0.165	0.031	78	9.44
M09-02	4.91	0.078	0.017	78	5.16	M07-04	8.69	0.164	0.030	78	9.21
M09-03	5.18	0.094	0.019	83	5.48	M07-05	7.43	0.149	0.026	77	7.91
M09-04	5.04	0.072	0.018	81	5.27	M08-01	5.82	0.141	0.020	76	6.27
M09-05	5.27	0.074	0.017	73	5.51	M08-02	7.21	0.172	0.026	80	7.76
M10-01	7.98	1.75	0.047	82	13.6	M08-03	5.74	0.150	0.020	75	6.22
M10-02	9.18	2.08	0.052	78	15.8	M08-04	6.29	0.142	0.021	72	6.74
M10-03	8.98	2.15	0.051	77	15.9	M09-01	3.03	0.187	0.012	78	3.63
M10-04	8.75	2.04	0.047	73	15.3	M10-01	7.87	0.220	0.027	73	8.57
M10-05	8.74	2.37	0.054	79	16.3	M10-02	7.56	0.225	0.027	77	8.28

Table 1. (continued).

Grain No.	ThO ₂ wt.%	UO ₂ wt.%	PbO wt.%	Age Ma	ThO ₂ * wt.%	Grain No.	ThO ₂ wt.%	UO ₂ wt.%	PbO wt.%	Age Ma	ThO ₂ * wt.%
M10-03	7.73	0.281	0.027	74	8.63	Sample 2907: Ichida Granite					
M10-04	7.56	0.238	0.025	71	8.32	M01-01	6.07	0.122	0.022	79	6.46
M10-05	7.81	0.217	0.030	84	8.50	M01-02	5.48	0.130	0.020	80	5.90
M10-06	7.69	0.234	0.027	75	8.44	M02	4.48	0.124	0.017	80	4.88
M11-01	7.32	0.340	0.026	74	8.41	M03	5.96	0.126	0.022	80	6.36
M11-02	6.73	0.371	0.026	78	7.92	M04	3.41	0.143	0.013	80	3.87
M12-01	6.64	0.115	0.023	76	7.01	M05	5.47	0.143	0.021	84	5.93
M12-02	6.64	0.122	0.022	75	7.03	M06-01	7.80	0.102	0.026	76	8.13
M12-03	5.03	0.048	0.017	75	5.18	M06-02	7.89	0.137	0.028	79	8.33
M13-01	7.56	0.379	0.029	77	8.77	M07-02	6.97	0.129	0.024	78	7.38
M13-02	7.76	0.478	0.031	78	9.29	M07-02	7.54	0.127	0.027	80	7.95
M13-03	7.61	0.430	0.030	79	8.99	M08-01	5.84	0.065	0.020	78	6.05
M13-04	6.42	0.407	0.025	75	7.72	M08-02	6.15	0.093	0.020	74	6.45
M13-05	7.38	0.321	0.027	75	8.41	M09	2.36	0.127	0.010	85	2.77
M13-06	7.77	0.425	0.029	74	9.13	M10	3.74	0.097	0.013	78	4.05
M13-07	7.74	0.491	0.031	78	9.31	M11	3.30	0.032	0.010	69	3.40
M13-08	7.33	0.384	0.030	83	8.56	M11-02	5.08	0.108	0.018	78	5.43
M13-09	7.34	0.430	0.029	79	8.72	M12-01	5.86	0.466	0.025	81	7.35
M14-01	4.22	0.214	0.015	71	4.91	M12-02	6.46	0.194	0.023	76	7.08
M14-02	2.46	0.214	0.010	75	3.14	M13	3.05	0.109	0.011	76	3.40
M14-03	3.10	0.245	0.013	81	3.88	M14	3.66	0.043	0.013	81	3.80
M15-01	10.2	0.215	0.034	75	10.9	M15-01	6.33	0.205	0.022	74	6.99
M15-02	10.2	0.118	0.034	77	10.6	M15-02	7.91	0.205	0.029	79	8.57
M15-03	9.95	0.137	0.032	73	10.4	M15-03	8.01	0.166	0.028	77	8.54
M15-04	9.34	0.164	0.033	78	9.86	M15-04	7.54	0.169	0.027	79	8.08
M15-05	10.4	0.191	0.034	73	11.0	M15-05	8.20	0.361	0.031	79	9.35
M15-06	10.2	0.181	0.035	77	10.8	M16	5.34	0.066	0.020	84	5.55
						M17	4.10	0.070	0.014	75	4.32
						M18-01	5.12	0.062	0.017	74	5.32
						M18-02	6.25	0.147	0.023	79	6.72
						M19-01	4.98	0.089	0.018	81	5.26
						M19-02	4.93	0.076	0.018	83	5.17
						M20-01	3.26	0.050	0.011	73	3.42
						M20-02	3.75	0.059	0.013	78	3.94
						M21-01	4.35	0.072	0.015	75	4.58
						M21-02	3.49	0.061	0.013	85	3.68
						M22	3.97	0.072	0.013	75	4.20
						M23-01	5.17	0.130	0.019	79	5.59
						M23-02	4.44	0.095	0.016	80	4.74
						M24	5.04	0.078	0.017	76	5.29

The Otagiri Granite forms three plutons at Inutagiri, Otagiri and Nakatagiri Rivers (Fig. 1). We temporarily call these plutons as the northern, central and southern plutons, respectively. The northern pluton consists entirely of fine-grained two-mica adamellite. The central body comprises fine-grained gray-colored biotite granodiorite, fine-grained two-mica adamellite and fine- to medium-grained leucocratic two-mica granite. Murayama and Katada (1957) found that fine-grained gray-colored biotite granodiorite is intruded by both two-mica varieties with a sharp boundary, and that fine- to medium-grained leucocratic two-mica granite grades abruptly or intrudes with a sharp boundary into fine-grained two-mica adamellite; the central pluton formed through multiple magmatic events. The southern pluton consists of fine-grained two-mica adamellite and fine-grained to coarse-grained leucocratic two-mica granite. Again this pluton possibly formed through multiple magmatic events.

We collected three samples (sample Nos. 2903, 2905 and 2909) of the Otagiri Granite and a sample (sample No. 2907) of the Ichida Granite (Fig. 1). Monazite was analyzed on an electron microprobe (JCSA-733) by the method described by Suzuki et al. (1991), Suzuki and Adachi (1991) and Adachi and Suzuki (1992). The Th, U and Pb analytical results are listed in Table 1; the detection limit of PbO at 2σ confidence level is 0.01 wt.%, and the relative error in the PbO determination is about 15-25 % for 0.02 wt.% of the concentration. Error in CHIME age is given at 2σ level.

CHIME MONAZITE AGES

Otagiri Granite

Sample 2903 from the northern pluton is weakly foliated fine-grained two-mica adamellite, and consists mainly of quartz, K-feldspar, plagioclase, biotite and muscovite. The partial XRF analysis of this sample is listed in Table 2. The normative composition is 31.8 % quartz, 28.6 % orthoclase, 31.8 % plagioclase, 2.2 % corundum and 4.1 % hypersthene. The molar $\text{Al}_2\text{O}_3/(\text{CaO}+\text{Na}_2\text{O}+\text{K}_2\text{O})$ (A/CNK; hereafter) value is 1.15, and the molar $\text{K}_2\text{O}/(\text{Na}_2\text{O}+\text{K}_2\text{O})$ (K/NK; hereafter) value is 0.52. Plagioclase is zoned with a calcic core and a sodic rim; the calcic core is highly sericitized. Accessories include garnet, apatite, monazite, xenotime, zircon and ilmenite. Titanite is absent, but secondary grains develop in chloritized biotite. Monazite forms euhedral to subhedral crystals and is 0.12 to 0.22 long; exceptionally it attains to 0.30 mm. The length/width ratio is in the range between 1.1 and 2.8 and concentrates around 2.1. Monazite contain 3.34-11.3 wt.% ThO_2 and 0.09-0.38 wt.% UO_2 . A total of 67 analyses on 19 monazite grains are arrayed linearly on the $\text{PbO}-\text{ThO}_2^*$ diagram (Fig 3A), and yield an isochron of 77.4 ± 3.1 Ma (MSWD=0.18).

Sample 2905 from the central pluton is massive fine-grained gray-colored biotite granodiorite, and consists of quartz, plagioclase, K-feldspar and biotite. The A/CNK and K/NK values are 1.14 and 0.41, respectively (Table 2). Compared with other samples from the Otagiri Granite, this is enriched in Zn and Ba but poor in Y and Nb. Primary muscovite is rare, but secondary one

Table 2. Partial XRF analyses of granitoids from the Otagiri and Ichida Granites in the eastern Ryoke Belt.

Sample No.	Otagiri Granite			Ichida Granite
	Northern pluton 2903	Central pluton 2905	Southern pluton 2909	2907
SiO ₂ (%)	72.6	71.1	71.8	72.7
TiO ₂	0.230	0.362	0.259	0.216
Al ₂ O ₃	14.7	15.2	15.1	14.3
FeO*	1.74	2.36	1.91	1.74
MnO	0.044	0.055	0.046	0.040
MgO	0.50	0.67	0.54	0.52
CaO	1.47	2.14	1.65	1.33
Na ₂ O	2.99	3.33	2.93	2.43
K ₂ O	4.84	3.48	5.01	5.53
P ₂ O ₅	0.118	0.177	0.126	0.112
Total	99.232	98.874	99.371	98.918
A/CNK	1.15	1.14	1.14	1.15
K/NK	0.52	0.41	0.53	0.60
Cr (ppm)	5.8	14.6	9.0	5.6
Co	2.5	0.6	1.4	1.1
Ni	5.1	4.6	3.6	5.2
Zn	41.2	70.3	48.6	38.4
Rb	157	88.6	200	128
Sr	174	362	191	252
Y	15.7	11.5	16.8	9.1
Zr	132	150	142	115
Nb	15.5	11.6	16.5	11.4
Ba	625	1080	723	1390

FeO*: total Fe as FeO, A/CNK: molar Al₂O₃/(CaO+Na₂O+K₂O) ratio and K/NK: molar K₂O/(Na₂O+K₂O) ratio

develops in the altered core of plagioclase. Accessories are apatite, monazite, zircon, xenotime and ilmenite. Garnet can not be seen in this sample. Most monazite grains occur in euhedral form of 0.11 to 0.17 mm in length. The length/width ratio rarely attains 1.8. Monazite grains from this sample, unlike those from sample 2903, show high variation in the UO₂ content; the UO₂ content ranges from 0.06 to 2.36%. The ThO₂ content is in the range between 3.59 and 10.6%. Figure 3B shows PbO vs. ThO₂* plots of 58 analyses on 11 grains. All data points are regressed with a single isochron of 76.3 ± 2.8 Ma (MSWD=0.20).

Sample 2909 from the southern pluton is weakly foliated fine-grained two-mica adamellite, consisting mainly of quartz, plagioclase, K-feldspar, biotite

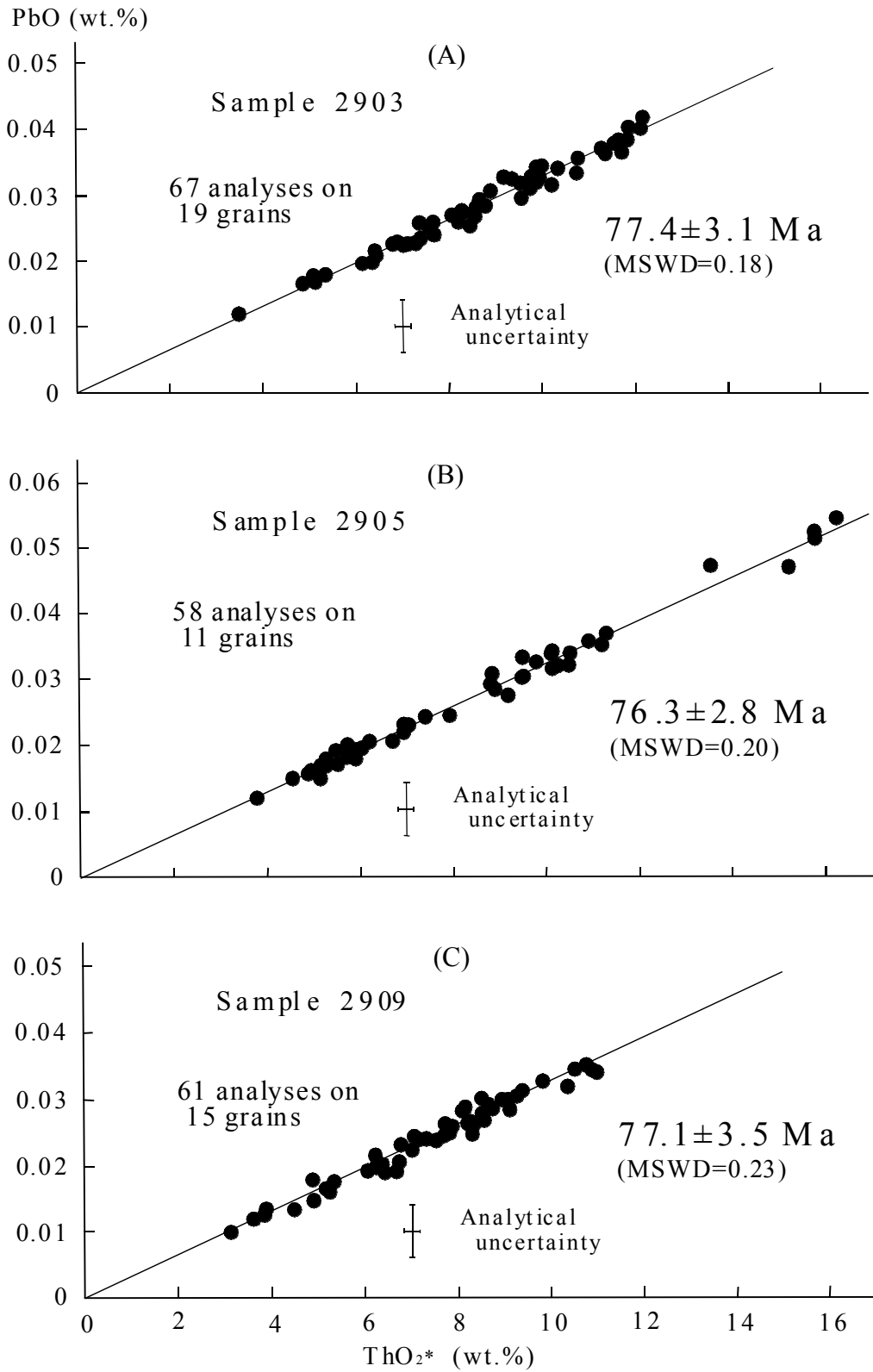


Fig. 3. Plots of PbO vs. ThO₂* of monazites from the northern (A), central (B) and southern plutons of the Otagiri Granite. Error bars in the figure represent 2σ analytical uncertainty, and error given to the age is of 2σ .

and muscovite. The analysis, nearly identical with that of sample 2903, suggests sample 2909 to be peraluminous with the A/CNK value of 1.14 and the K/NK value of 0.53 (Table 2). Accessories are garnet, apatite, monazite, zircon, xenotime and ilmenite. Monazite forms euhedral to subhedral prisms of 0.14 to 0.25 mm in length. The length/width ratio ranges from 1.2 to 1.9. The ThO₂ content ranges from 2.45 to 10.4 % and the UO₂ content from 0.05 to 1.03 %. A total of 61 analyses on 15 grains (Fig. 3C) yields an isochron of 77.2 ± 3.5 Ma (MSWD=0.23).

Ichida Granite

Sample 2907 from the Ichida Granite is medium-grained biotite adamellite, and consists mainly of quartz, plagioclase, K-feldspar and biotite. This sample shows the A/CNK value of 1.15 and the K/NK value of 0.60 (Table 1). Accessories include apatite, zircon, ilmenite, allanite and monazite. Monazite range from 0.13 to 0.28 mm in length, and exceptionally large one is up to 0.35 mm. The ThO₂ content ranges from 2.36 to 7.91 % and the UO₂ content from 0.05 to 0.47 %. The PbO-ThO₂* plots of 39 analyses on 24 grains (Fig. 4) define an isochron of 79.4 ± 3.1 Ma (MSWD=0.13).

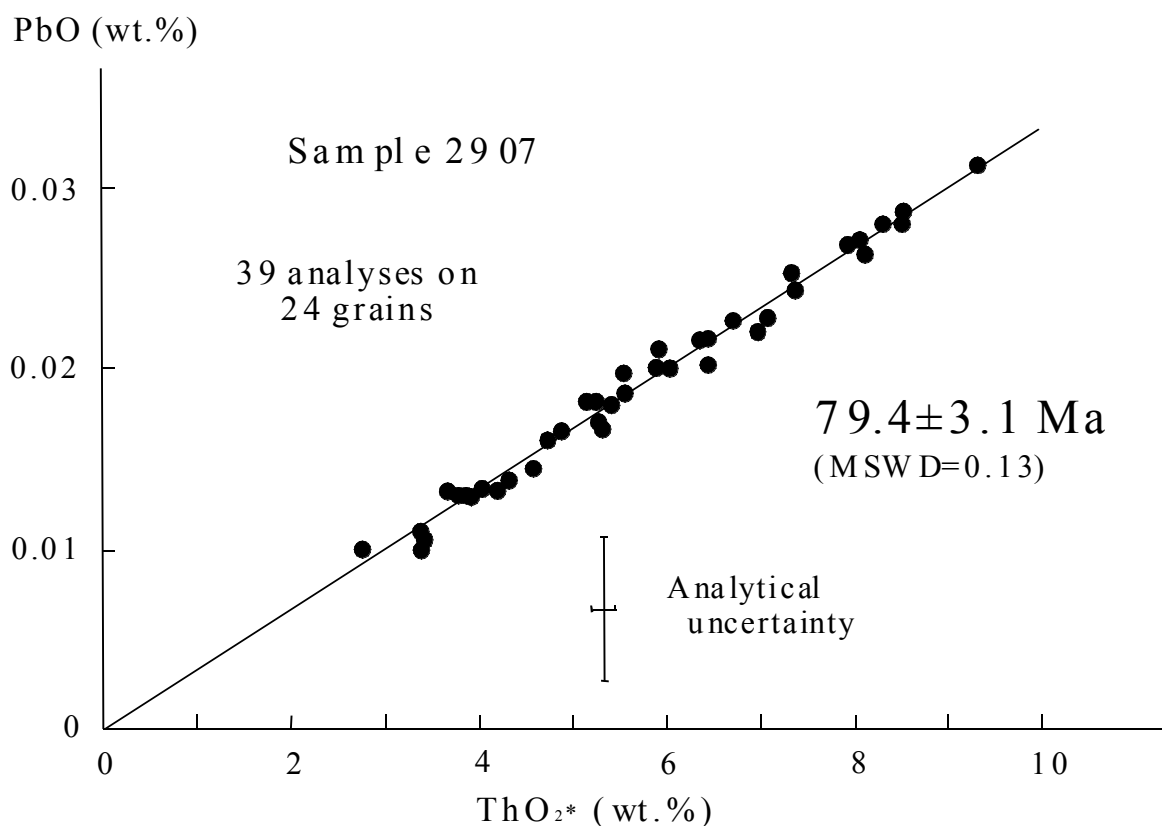


Fig. 4. Plots of PbO vs. ThO₂* of monazites from the Ichida Granite. Explanations for errors are the same as for Fig. 3.

DISCUSSION

The three CHIME monazite ages for the Otagiri Granite are 77.4 ± 3.1 Ma for the northern pluton, 76.3 ± 2.8 Ma for the central pluton and 77.2 ± 3.5 Ma for the southern pluton. The three CHIME dates coincide well each other within the limit of analytical uncertainty. If we regress all analytical data for three plutons, we obtain an isochron of 77.2 ± 1.7 Ma (MSWD=0.20) with an intercept value of 0.00003 ± 0.00057 .

As mentioned earlier, the Otagiri Granite has been dated by Yuhara (1994) by the Rb-Sr whole-rock isochron method. The Rb-Sr ages are 71.6 ± 6.8 , 99.0 ± 10.9 and 92.7 ± 13.8 Ma for the northern, central and southern plutons, respectively (Fig. 5). These Rb-Sr ages, particularly 99.0 ± 10.9 Ma for the central pluton, are inconsistent with the CHIME monazite ages. This inconsistency may not be ascribed to the simple error in both the microprobe and isotopic analyses. Rather, we believe that the 99.0 ± 10.9 Ma Rb-Sr age resulted from isotopic disequilibrium in the Rb-Sr system on the whole-rock scale as documented by Schärer et al. (1984). Inspection of the isochron diagram (Fig. 5) shows a marked scattering of data points for the central pluton (circles). For the age calculation, Yuhara (1994) discarded 6 data (open circles) from 16

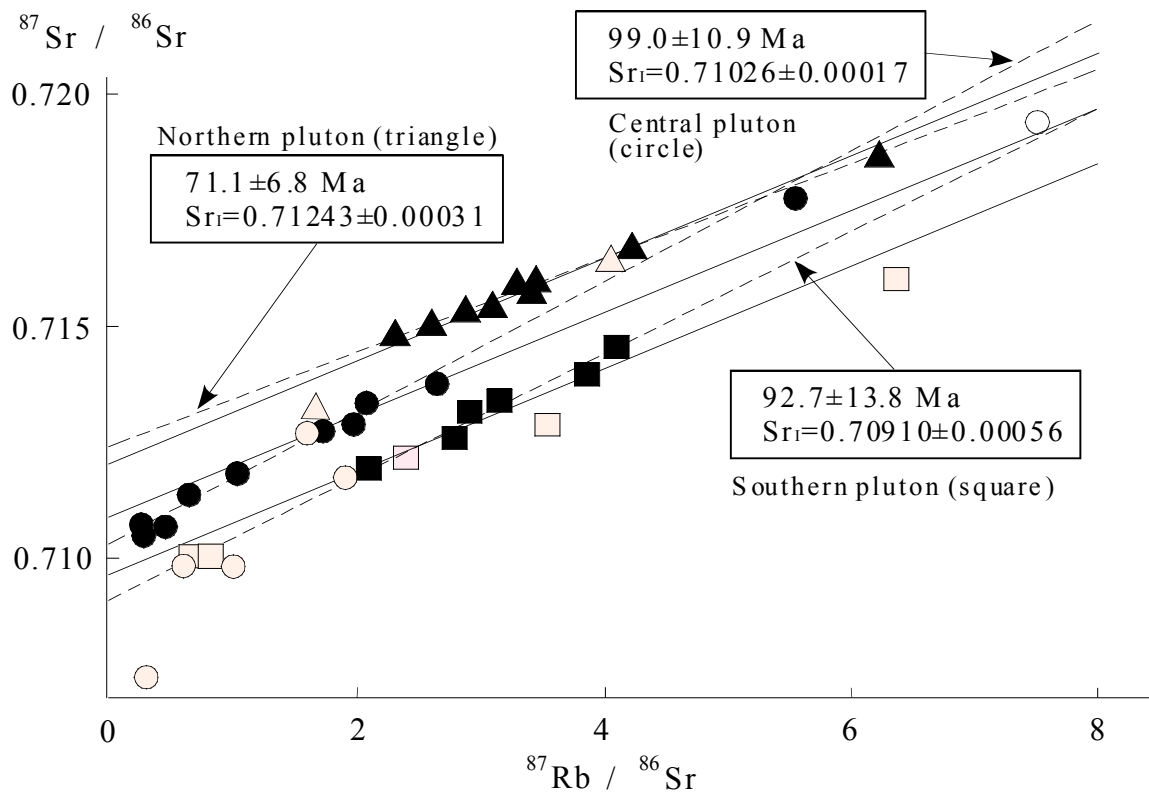


Fig. 5. Rb-Sr isotopic relations in whole-rock samples of the Otagiri Granite (isotopic data from Table 4 of Yuhara, 1994). Solid lines are 77 Ma reference isochrons with different initial $^{87}\text{Sr} / ^{86}\text{Sr}$ ratios, and broken ones represent regression lines of filled data points of individual plutons by Yuhara (1994).

isotopic analyses on the basis of petrographic and chemical criterion. The selected 10 data (solid circles), however, are still not strictly aligned in the isochron diagram; the scatter is beyond analytical uncertainty (mean square of weighted deviated (MSWD)=3.3). This suggests that the Rb-Sr system is not in equilibrium even in the selected 10 samples. In this connection, it is important to note that the central pluton comprises at least three intrusive units with a clear-cut intrusive relation (Murayama and Katada, 1957). These lines of evidence suggest that the Rb-Sr whole-rock isochron ages of 99.0 ± 10.9 Ma might be fortuitous, and not represent the true time of emplacement. This is particularly evident if one examines whole isotopic data of the central pluton with respect to the reference isochron of 77 Ma (solid line); subsets of the data points can be regressed with 77 Ma isochrons of different initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios.

The Rb-Sr data for the southern pluton (squares) also are distinctly not aligned in the isochron diagram (Fig. 5), and subsets of them are regressed with 77 Ma isochrons. Again this is a composite pluton (Murayama and Katada, 1957). We consider that the 92.7 ± 13.8 Ma Rb-Sr whole-rock isochron age is fortuitous. The Rb-Sr isochron plots of data for the northern pluton do not show a major effect of the isotopic disequilibrium, and the age of 71.6 ± 6.8 Ma is essentially identical with the CHIME monazite age of 77.4 ± 3.1 Ma. We

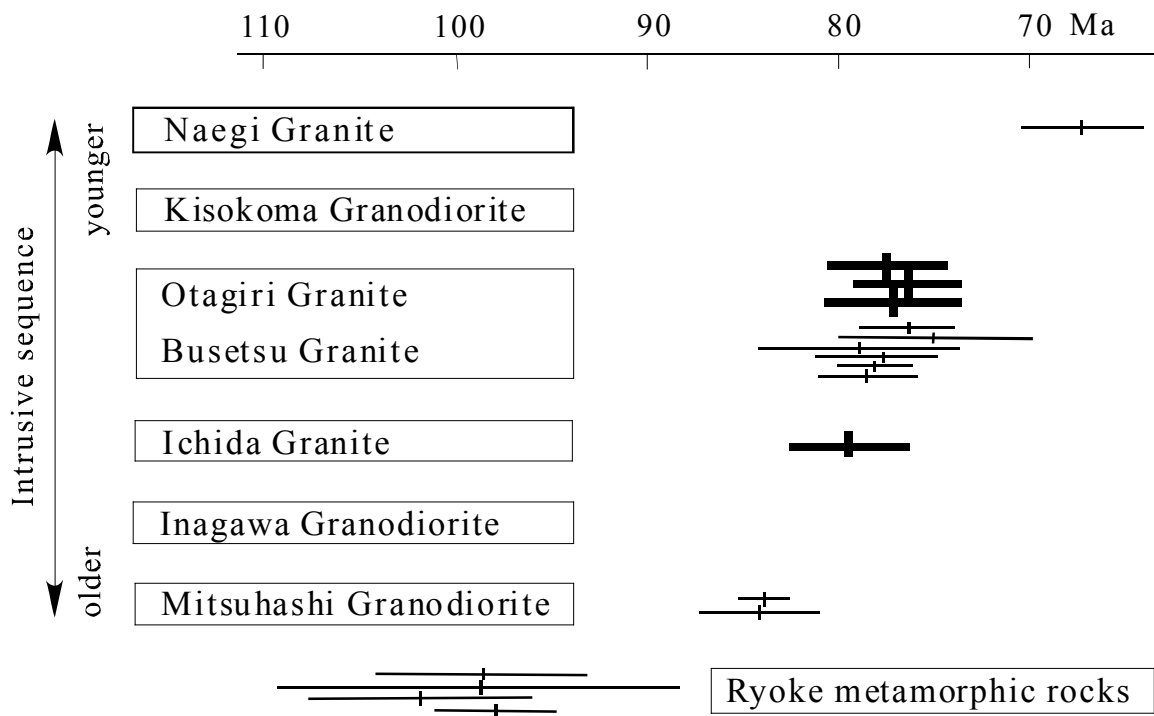


Fig. 6. Diagrammatic presentation of CHIME monazite ages in context of field relations in the Komagane and Mikawa areas. CHIME ages are plotted with error bars (2σ). Bold lines represent age data obtained in this study and other lines represent those reported by Suzuki et al. (1994a,b).

prefer the CHIME monazite ages of ca. 77 Ma (77.4 ± 3.1 , 76.3 ± 2.8 and 77.2 ± 3.5 Ma) as representing the time of intrusion and solidification of the northern, central and southern plutons of the Otagiri Granite.

The present CHIME monazite ages of the Otagiri and Ichida Granites are placed in the context of field evidence in the eastern Ryoke belt (Fig. 6), together with the previously reported CHIME monazite ages for gneisses and granitoids (Suzuki et al., 1994a,b). The ca. 77 Ma CHIME ages of the Otagiri Granite just overlap with those of the Busetsu Granite (75.0 ± 5.1 - 78.9 ± 5.3 Ma, Suzuki et al., 1994b), and appear to be slightly younger than the CHIME monazite age of 79.4 ± 3.1 Ma for the Ichida granite; the ages presented herein are in good harmony with the intrusive relation that the Otagiri Granite intrude into the Ichida Granite. Although we are uncertain whether the Otagiri, Kadoshima and Busetsu Granites are of comagmatic or not, we can state that they were emplaced simultaneously at ca. 77 Ma.

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