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Precambrian detrital monazites and zircons from Jurassic turbidite sandstones in the Nomugi area, Mino terrane

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ABSTRACT

CHIME (Chemical Th-U-total Pb Isochron Method) ages were determined for monazite and zircon grains from Jurassic sandstones in the Nomugi area, central Japan. Many of the monazite grains yield middle Precambrian ages ranging from 1650 to 1450 Ma, but some yield much younger ages of ca. 250 Ma and ca. 180 Ma. The youngest age of ca. 180 Ma constrains that the turbidite sandstone was deposited after the early Jurassic igneous or metamorphic event. This is consistent with the middle Jurassic radiolarian fossils contained in shales below the sandstones. Zircon grains retaining nearly euhedral shape yield middle Ordovician ages of ca. 460 Ma, while rounded purple zircon grains yield middle Precambrian ages of ca. 2000 Ma. The CHIME monazite and zircon ages as well as mineral compositions of the sandstones indicate that the clastic materials were derived from a provenance having Precambrian granitoids and metamorphics, and Paleozoic-Mesozoic granitoids and metamorphics.

INTRODUCTION

The Mino terrane, a Mesozoic melange terrane in central Japan, is a collage of several different units of sedimentary complex formed during Jurassic to Cretaceous time (e.g. Wakita, 1988; Mizutani and Yao, 1992; Adachi et al., 1992). The sedimentary complex of the Nomugi area in the northern Mino terrane (Fig.1) consists essentially of Triassic bedded chert and Jurassic turbidite sandstone, and is correlatable with the Kamiaso unit of Wakita (1988) and the Sawando complex of Otsuka (1989). Both the bedded chert and turbidite sandstone, although repeated by thrusts, retain original stratigraphic successions. Paleocurrent analysis on turbidites has shown that clastic materials in the Nomugi area were derived mainly from a provenance in the north (Adachi and Mizutani, 1971).

On the basis of CHIME geochronology (e.g. Suzuki and Adachi, 1991a), we have shown that some sandstones in the Nomugi area contain detrital monazites of middle Precambrian age (Suzuki et al., 1991). However, no CHIME ages of detrital zircons that are associated with monazites have come to hand. Furthermore, no chronological data other than radiolarian fossils that indicate the sedimentation age of sandstones have hitherto been obtained. In order to clarify the provenance nature and the sedimentation process, we

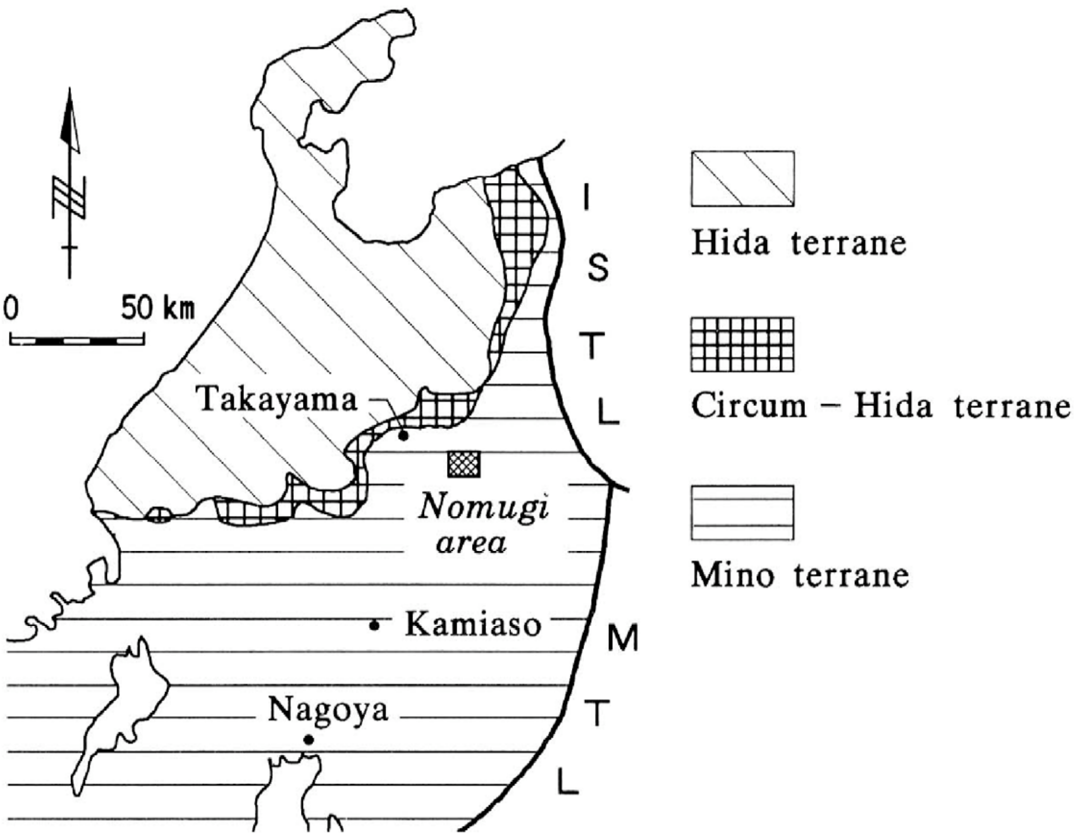

Fig. 1. Index map showing the locality of the Nomugi area in the Mino terrane. ISTL = Itoigawa-SHizuoka Tectonic Line. MTL = Median Tectonic Line.

have made CHIME age determinations on detrital monazite and zircon grains in sandstones. Although our CHIME geochronological research on the Nomugi sandstone is in progress, we here present the dating results and discuss their meaning.

GEOLOGICAL OUTLINE OF THE NOMUGI AREA

The Nomugi area covers an area of the upper reaches of the Hida River in northeastern Gifu Prefecture, situated between two active volcanoes, Mt. Norikuradake (3026m) in the north and Mt. Ontakesan (3063m) in the south; the Nomugi pass (1651m) lies in the east end of the study area (Fig.2). The Mesozoic sedimentary complex in the Nomugi area consists mainly of sandstone, shale and chert, with minor amounts of greenstone, conglomerate and chert breccia. Sandstones exhibit various primary sedimentary structures: graded bedding, parallel lamination, convolute lamination, groove cast, flute cast, bounce cast and load cast. Sole markings are more or less destroyed or completely obscured by bedding slip during folding. The Nomugi sandstone is characterized by having, although rare, detrital chloritoid grains and rock fragments of chloritoid phyllite and sillimanite gneiss (Adachi, 1977). The sandstone in places passes into conglomerate that contains subangular to well-rounded clasts of sedimentary, igneous and metamorphic rocks. From the lithological similarity, the conglomerate of the Nomugi area can be correlated with the Sawando conglomerate (e.g. Kano, 1962) and the Bandokoro conglomerate (Otsuka, 1985) that occur some 10km northeast of the Nomugi pass.

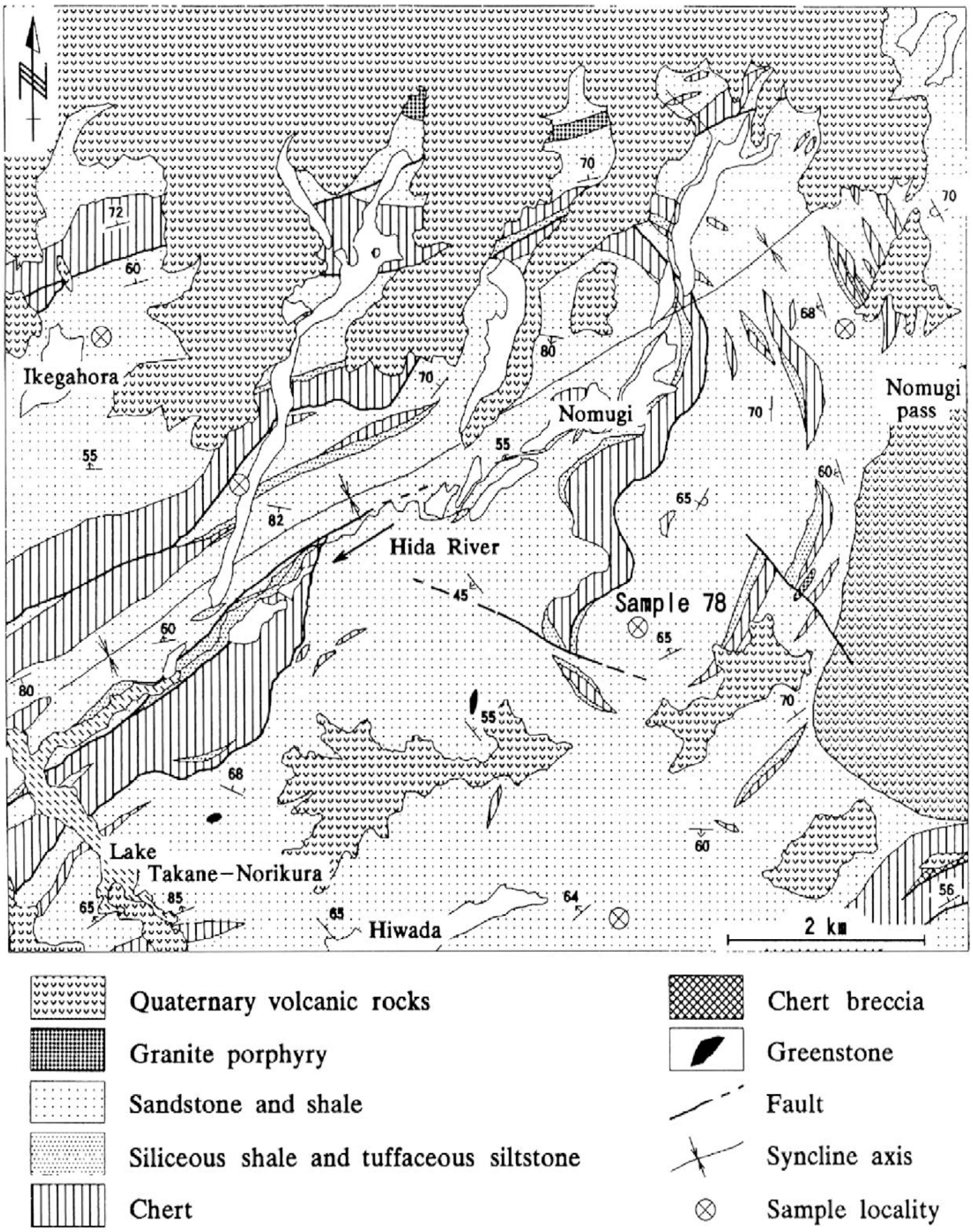

Fig. 2. Geologic map of the Nomugi area, with localities of sandstone samples.

Bedded chert showing gray, greenish gray, chocolate brown or dark bluish green in color, yields Triassic radiolarians and/or conodonts. Some of the chert is alternated with light gray micritic limestone. Siliceous shale and tuffaceous siltstone, commonly greenish gray to dark gray, contain well-preserved middle Jurassic radiolarians (Mizutani et al., 1981; Adachi, unpublished) of the Tricolocapsa conexa zone of Matsuoka and Yao (1986). Some dark gray siliceous shale contains manganese nodules that consist largely of black manganese oxides originated from manganese carbonates. These lines of lithological features as well as middle Jurassic radiolarians show that the siliceous shale in the Nomugi area is the same as that in the Takayama area (Adachi and Kojima, 1983; Kojima, 1984; Yamada et al., 1985) to the west and that of the Azusagawa area (Otsuka, 1989) to the east.

The successive sequence from Triassic chert to Jurassic turbidite through siliceous shale (chert-clastics sequence of Otsuka, 1989) is in places observed. The Triassic-Jurassic sequence is typical of the sediments of the Kamiaso unit of the Mino terrane. Although the sedimentary complex of the Nomugi area appears to be regionally folded like that in the Kamiaso area (Mizutani, 1964; Mizutani and Koido, 1992), detailed fold structures except a westerly-plunging syncline (Fig.2) are still unclear.

SAMPLE DESCRIPTION AND EXPERIMENTAL

Sandstones examined for the CHIME geochronology are poorly- to moderately-sorted feldspathic wacke or arenite rich in quartz, K-feldspar and plagioclase, with varying amounts of rock fragments, heavy minerals and clayey matrix. Heavy minerals include opaques, biotite, garnet, zircon, tourmaline, muscovite, apatite, monazite, with small amounts of sillimanite, sphene, epidote, chrome spinel and chloritoid (Adachi, 1977).

Monazite grains, transparent yellow to pale yellow, range in size from about 0.08 to 0.25mm; some monazite grains are well-rounded. Zircon grains, 0.05 to 0.35mm in size, are colorless, pale brown, pale pink or purple, and are of various morphologies. Some zircon grains are rounded, showing various degrees of abrasion, and some others form euhedral prisms with well-preserved crystal faces.

Monazite and zircon grains, separated from sandstone samples by panning, were analyzed on a JXA-5A electron microprobe. For details of the analytical procedures and CHIME age calculations, the readers are requested to refer to our previous papers (e.g. Suzuki et al., 1991, 1992; Suzuki and Adachi, 1991a,b, 1994; Adachi and Suzuki, 1992). Microprobe analyses of ThO_2, UO_2 and PbO are given in Table 1, together with $ThO_2{}^*$ for monazite and $UO_2{}^*$ for zircon. The detection limits of PbO at 2σ– confidence level are 0.005-0.008wt.%. and the relative error is about 10-15% for 0.02wt.% of the PbO concentration.

Table 1. ThO_2, UO_2 and PbO analyses of detrital monazite (M) and zircon (Z) grains from a sandstone sample (Nomugi-78) in the Nomugi area, Gifu Prefecture. RO_2* : ThO_2* (sum of the measured ThO_2 and ThO_2 equivalent of the measured UO_2 for monazite) and UO_2* (sum of the measured UO_2 and UO_2 equivalent of the measured ThO_2 for zircon).

Grain No.	ThO_2 (wt.%)	UO_2 (wt.%)	PbO (wt.%)	Age (Ma)	RO_2* (wt.%)
M01-01	6.19	0.126	0.436	1517	6.64
M01-02	6.25	0.127	0.444	1531	6.71
M01-03	6.93	0.145	0.479	1487	7.45
M01-04	6.90	0.163	0.483	1494	7.49
M01-05	6.87	0.138	0.479	1504	7.37
M02-01	8.09	0.510	0.568	1333	9.90
M02-02	7.58	0.508	0.495	1231	9.37
M03-01	7.75	0.198	0.552	1509	8.47
M03-02	7.32	0.194	0.512	1479	8.02
M03-03	7.78	0.191	0.529	1447	8.46
M03-04	7.92	0.227	0.547	1452	8.74
M04-01	14.7	0.290	1.01	1480	15.7
M04-02	14.7	0.274	1.01	1496	15.7
M04-03	10.9	0.551	0.833	1500	12.9
M04-04	14.9	0.286	1.01	1479	15.9
M05-01	5.31	0.266	0.478	1748	6.29
M05-02	6.31	0.256	0.487	1557	7.24
M05-03	7.06	0.283	0.542	1548	8.09
M06-01	6.07	0.391	0.504	1555	7.49
M06-02	5.92	0.420	0.505	1568	7.45
M06-03	6.07	0.417	0.510	1555	7.58
M06-04	6.24	0.386	0.472	1437	7.63
M07-01	9.40	0.569	0.088	186	11.2
M07-02	8.77	0.571	0.080	179	10.6
M07-03	9.28	0.587	0.083	177	11.2
M07-04	10.3	0.551	0.095	188	12.1
M07-05	12.9	0.466	0.108	178	14.4
M07-06	12.4	0.507	0.110	187	14.0
M07-07	8.16	0.589	0.077	183	10.1
M08-01	6.34	0.096	0.461	1591	6.69
M08-02	5.85	0.068	0.420	1591	6.10
M08-03	5.99	0.080	0.430	1582	6.28
M08-04	6.02	0.098	0.432	1564	6.38
M09-01	8.05	0.249	0.586	1513	8.95
M09-02	7.83	0.256	0.561	1486	8.75
M09-03	7.63	0.258	0.605	1630	8.57

Grain No.	ThO_2 (wt.%)	UO_2 (wt.%)	PbO (wt.%)	Age (Ma)	RO_2* (wt.%)
M10-01	8.96	0.476	0.760	1639	10.7
M10-02	10.8	0.519	0.898	1631	12.7
M10-03	7.68	0.487	0.660	1611	9.46
M10-04	6.16	0.500	0.563	1626	7.99
M10-05	9.31	0.481	0.780	1625	11.1
M10-06	11.0	0.480	0.897	1627	12.8
M10-07	8.77	0.450	0.728	1614	10.4
M11-01	5.49	0.071	0.407	1635	5.75
M11-02	5.79	0.080	0.427	1617	6.08
M11-03	6.05	0.095	0.443	1601	6.40
M11-04	6.10	0.082	0.445	1607	6.40
M12-01	1.77	0.216	0.026	252	2.47
M12-02	3.55	0.299	0.048	254	4.52
M12-03	4.00	0.336	0.054	254	5.09
M12-04	8.09	0.221	0.093	253	8.81
M12-05	6.83	0.248	0.082	257	7.63
Z01 (rounded purple grain)					
-01	0.046	0.037	0.017	2034	0.049
-02	0.074	0.029	0.016	1991	0.048
-03	0.025	0.050	0.020	2092	0.056
-04	0.258	0.021	0.030	2029	0.088
-05	0.067	0.015	0.011	2039	0.032
-06	0.027	0.025	0.011	2038	0.032
-07	0.058	0.017	0.010	1971	0.032
Z02 (euhedral brown gain)					
-01	0.076	0.733	0.048	456	0.756
-02	0.056	0.571	0.037	454	0.588
-03	0.071	0.408	0.027	450	0.430
-04	0.072	0.469	0.032	464	0.490
-05	0.074	0.586	0.039	464	0.608
Z03 (rounded purple grain)					
-01	0.037	0.053	0.031	2662	0.062
-02	0.065	0.047	0.032	2752	0.062
Z04 (euhedral brown gain)					
-01	0.152	0.429	0.030	450	0.475
-02	0.108	0.355	0.024	440	0.387
-03	0.140	0.397	0.026	434	0.439
-04	0.160	0.383	0.025	420	0.432
-05	0.125	0.367	0.025	449	0.405

RESULTS

Monazite

Monazite contains 1.77-14.9% ThO_2, 0.068-0.589% UO_2 and 0.026-0.898% PbO (Table 1). The ThO_2 and UO_2 contents are variable even within a single monazite grain. Many monazite grains show CHIME ages ranging from 1640 to 1450 Ma. The PbO vs. ThO_2* plot of seven microprobe analyses for monazite grain M10 from Sample 78 is shown in Fig.3, together with other analyses. Seven data points (large solid circle) give an isochron of 1629±50 Ma. Some monazite grains yield much younger isochrons of 254±4 Ma of late Permian age and of 182±29 Ma of early Jurassic age.

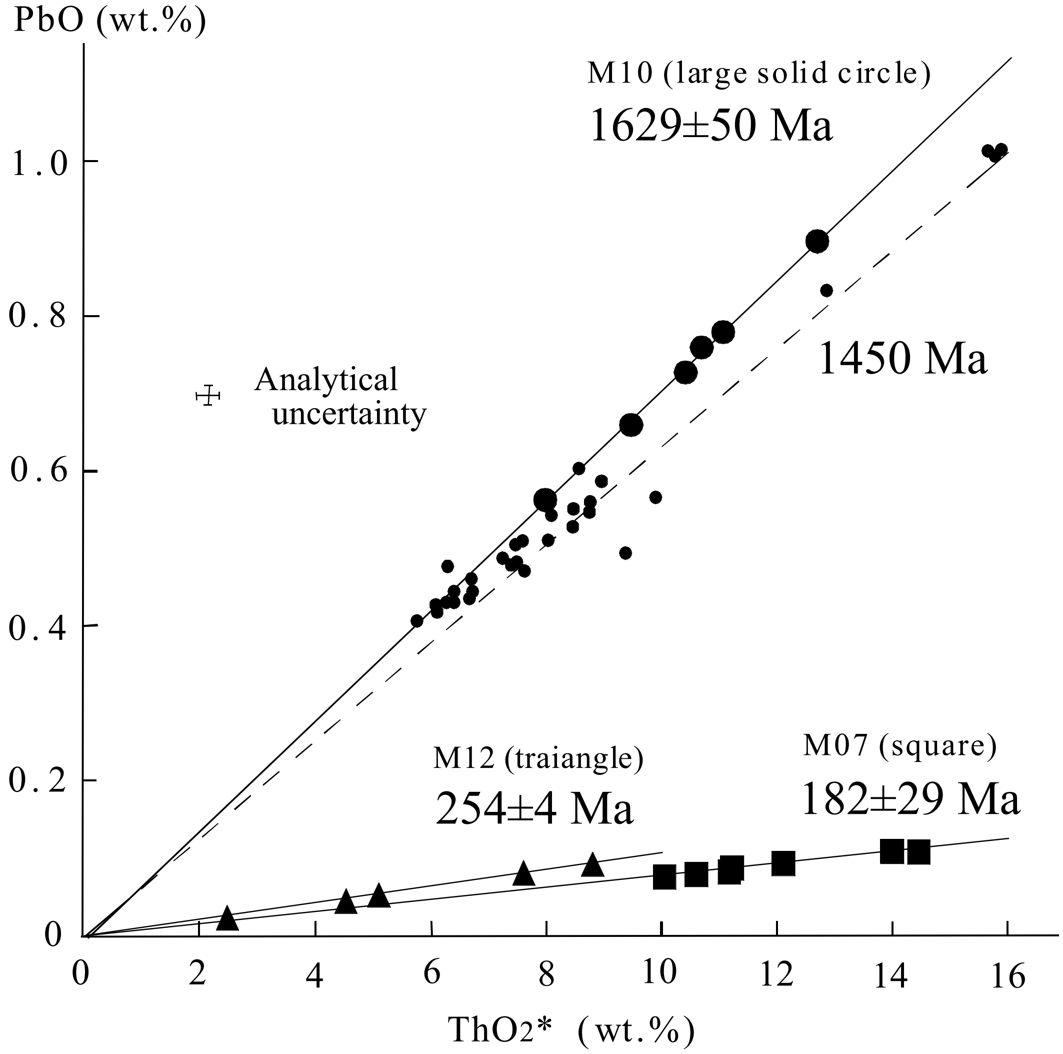

Fig. 3. Plots of PbO vs. ThO_2* of detrital monazite grains. M10, M12 and M07 monazite grains from Sample 78 give isochrons of 1629± 50, 254± 4 and 182± 29 Ma, respectively. Although data points for the 1629±50 Ma isochron look six, they are actually seven (see Table 1).

Zircon

Since many of zircon grains have very low concentrations of PbO, only limited number of zircon grains were suitable for CHIME dating. Analyzed zircon contains 0.027-0.258% ThO_2, 0.015-0.733% UO_2 and 0.010-0.048% PbO (Table 1). Nearly euhedral pale brown zircon grains yield isochrons of 466±34 Ma and 458±183 Ma of middle Ordovician age, while a rounded purple zircon yields an isochron of 2059±78 Ma (Fig.4). If we combine all data points for grains Z02 and Z04, we obtain a CHIME age of 491±41 Ma. Another rounded purple zircon gives an apparent age of ca. 2700 Ma (cross in Fig.4).

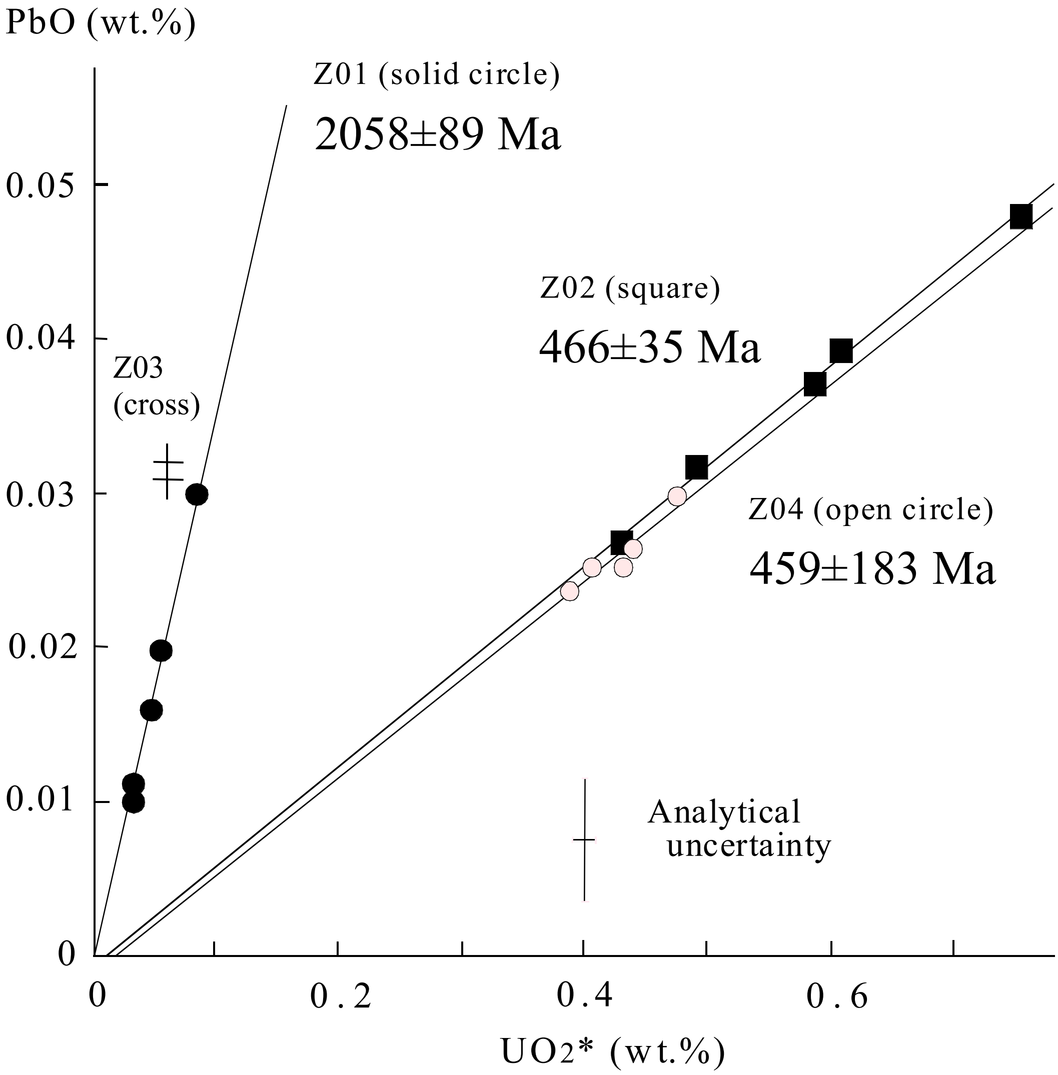

Fig. 4. Plots of PbO vs. UO_2* of detrital zircon grains. Z01, Z02 and Z04 zircon grains from Sample 78 give isochrons of 2058±89, 466±35 and 459±183 Ma, respectively.

DISCUSSION AND CONCLUDING REMARKS

The CHIME ages obtained from this study are generally very similar to those reported for detrital monazites in Jurassic sandstones in the Mino terrane (Suzuki et al., 1991) and for monazites in gneiss clasts in the Kamiaso conglomerate (Adachi et al., 1992). The majority of monazite ages range from 1640 to 1450 Ma, with minor concentrations of ca. 250 and 180 Ma. Of these, the youngest age of 182 Ma is worthy of note, because this age has constraints on the sedimentation of monazite-bearing sandstones in the Nomugi area. The 182 Ma points to the Toarcian stage of the early Jurassic according to Harland et al.(1989). The CHIME age and shape of this monazite grain suggest that it was abraded, transported and deposited after its formation in early Jurassic time. The post-182 Ma deposition of sandstones is in agreement with the middle Jurassic radiolarian age for siliceous shales associated with the monazite-bearing sandstones. Although the ca. 180 Ma age apparently corresponds to the emplacement age of the Funatsu granitic rocks in the Hida terrane, age data are not sufficient for further discussion.

The 254 Ma CHIME monazite age reminds us of the 254 Ma K-Ar hornblende age from metagabbro intruding the Arakigawa Formation in the circum-Hida terrane (Adachi and Shibata, 1991) and of the 250-230 Ma Gray Granite (Suzuki and Adachi, 1991b) and the ca. 250-220 Ma metamorphism (e.g. Shibata et al., 1970) in the Hida terrane. Since the ca. 250 Ma detrital monazite grains occur not only in the Nomugi area but in many other parts of the Mino terrane (Suzuki et al., 1991), metamorphic and igneous rocks having ca. 250 Ma monazite and/or zircon grains were probably widespread in the provenance of clastic rocks in the Mino terrane. As already pointed out by us (Adachi and Shibata, 1991; Adachi and Suzuki, 1992; Suzuki and Adachi, 1993), the ca. 250 Ma events including the emplacement of granitoids were extensive in and around the Japanese Islands.

Aside from the ca. 180 and 250 Ma monazite ages, the ca. 460 Ma Ordovician zircon ages are also important. The ca. 460 (500-400) Ma zircons have been reported from the Hida gneiss on the Oki-Dogo Island (Suzuki and Adachi, 1994), the Okuhinotsuchi Granite in the Kitakami Mountains (Adachi et al., 1994), and so on. Ordovician detrital monazite grains are common in the Upper Triassic Nabae Group in the Maizuru terrane (Adachi and Suzuki, 1992) and in the "Silurian" arkosic sandstone in the Kitakami Mountains (Suzuki et al., 1992). These suggest that the ca. 460 Ma rocks were also common in the provenance of the Japanese Paleozoic-Mesozoic clastic rocks.

As stated earlier, lenticular bodies of intraformational conglomerates in the Nomugi area can be correlated with the Sawando conglomerate that contains well-rounded clasts of sillimanite-biotite gneiss (Adachi, 1976, 1979) and garnet-biotite gneiss (Otsuka, 1989), together with various granitoid clasts. On the basis of mode of occurrence, clast variety and petrological features of matrix sandstone of the conglomerate, Adachi (1979) has correlated the Sawando conglomerate with the Kamiaso conglomerate (Adachi, 1971, 1973).

Our CHIME dating results confirm this view and have shown the ubiquitous occurrence of detrital monazite and zircon grains of middle Precambrian age. The ca. 2000 Ma CHIME zircon age coincides well with the ca. 2000 Ma Rb-Sr whole-rock isochron age for orthogneiss clasts in the Kamiaso conglomerate (Shibata and Adachi, 1974).

The present Nomugi area is separated from the Kamiaso area by the Cretaceous Nohi Rhyolites. However, the CHIME age data together with the petrological characteristics of clastic rocks, same Jurassic radiolarians and chert-clastics sequence strongly suggest a more intimate relationship of the two areas than was thought. Taking into the left-lateral dislocation of the Atera fault, the sedimentary complex of the Nomugi area can be regarded as the northeastern extension of that of the Kamiaso area.

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