

## 黒雲母の閉止温度と熱履歴 Closure temperature of biotite and thermal history

兵藤 博信<sup>1\*</sup>

Hironobu Hyodo<sup>1\*</sup>

<sup>1</sup> 岡山理大・自然研

<sup>1</sup>RINS, Okayama Univ. of Sci

昨年度報告した K-Ar 系の黒雲母の閉止温度は熱履歴について考慮せず冷却速度は深成岩のような 1K/1000 yr という値を用いて 800 °C 以下の <sup>40</sup>Ar/<sup>39</sup>Ar レーザー段階加熱実験から得られる単結晶黒雲母の閉止温度の単純比較を行った。得られた閉止温度は 0 °C 以下から 300 °C 程度に分布し平均値は 250 °C と一般的に知られた値よりやや低めで、活性化エネルギーの平均値は 30 kcal/mol とバルクの実験で報告されている値と大きな違いは見られなかった。この結果はレーザー加熱法から得られる閉止温度でも岩体の熱履歴を考察するのに必要な情報が得られることを示した。

今回、見積もりの精度を改善するため試料数をさらに増やし計算に影響する冷却速度の小さい (1K/1000 yr) 深成岩類 (変成岩を含む) と冷却速度が大きい (1K/1 yr) 火山岩類 (凝灰岩を含む) の閉止温度、活性化エネルギーの比較を行った。その結果異なる熱履歴を経た黒雲母には基本的に活性化エネルギーには大きな差はないが、閉止温度では深成岩の 270 °C に対して火山岩では 330 °C であった。この差は一見閉止温度の計算で冷却速度の違いが反映された結果であるように見える。しかしながらこれらの火山岩に対して深成岩的なゆっくりした冷却速度を適用すると逆に閉止温度は 200 °C を切ってしまう試料が多くなるので見かけの効果ではないと考えている。100 °C を下回るような閉止温度が計算される場合がいくつかあり、その原因は主に黒雲母の変質とくに緑泥石化が強く反映されている。そのような場合は年代スペクトルにも大きく影響している場合が多い。またほとんどの場合、バルク実験で見られる脱水反応後の Arrhenius plot の変化はレーザー加熱実験の結果ではむしろ少ない。バルク実験とレーザー加熱実験の違いからレーザー加熱実験による閉止温度がやや低めに見積もられる理由について考察する。

キーワード: 閉止温度, 単結晶黒雲母, K-Ar 系, <sup>40</sup>Ar/<sup>39</sup>Ar, レーザー段階加熱

Keywords: closure temperature, biotite grain, K-Ar system, <sup>40</sup>Ar/<sup>39</sup>Ar, laser step heating

## K-Ar年代測定における試料サイズと過剰アルゴンの関係 Reduction of extraneous $^{40}\text{Ar}$ contamination for accurate K-Ar age determinations: an experimental study in various sample

山崎 誠子<sup>1\*</sup>, 磯部 翔太郎<sup>2</sup>, 佐藤 洋樹<sup>2</sup>, 田上 高広<sup>2</sup>  
Seiko Yamasaki<sup>1\*</sup>, Shotaro Isobe<sup>2</sup>, Hiroki Sato<sup>2</sup>, Takahiro Tagami<sup>2</sup>

<sup>1</sup> 産業技術総合研究所, <sup>2</sup> 京都大学

<sup>1</sup>Geological Survey of Japan, AIST, <sup>2</sup>Kyoto University

A fundamental assumption of K-Ar dating is that the samples initially contained no radiogenic  $^{40}\text{Ar}$ , but sometimes rocks contain radiogenic  $^{40}\text{Ar}$  called extraneous  $^{40}\text{Ar}$ . Some previous study reported argon isotopes of historical lavas had anomalously high  $^{40}\text{Ar}/^{36}\text{Ar}$  ratios, and show old apparent ages. Since extraneous  $^{40}\text{Ar}$  is likely contained in the phenocrysts and xenoliths, groundmass samples are generally prepared for analysis. Besides, Ozawa et al. (2005) showed fine-grained groundmass samples had less extraneous  $^{40}\text{Ar}$  contamination, and suggested that extraneous  $^{40}\text{Ar}$  is contained in fluid inclusions or vesicles and released during crushing. We measure argon isotopic ratios in various sizes of young lava samples, and investigated the reduction of extraneous  $^{40}\text{Ar}$  contamination. The finer samples roughly showed lower  $^{40}\text{Ar}/^{36}\text{Ar}$  ratios but more difficult to handling of the preparation such as mineral separation and wrapping in foils for isotopic measurements.

キーワード: K-Ar年代測定, 過剰 $^{40}\text{Ar}$ , 粒度

Keywords: K-Ar dating, extraneous  $^{40}\text{Ar}$ , sample size

## ベーリング海におけるパウワーズリッジ ( サイト U1342A&D ) の Ar-Ar 年代 Results of Ar-Ar dating for basaltic rocks from Bowers Ridge, Bering Sea at site U1342A&D

佐藤 佳子<sup>1\*</sup>, 川畑 博<sup>1</sup>, 兵藤 博信<sup>2</sup>, 熊谷 英憲<sup>1</sup>, David W. Scholl<sup>3</sup>, 高橋 孝三<sup>4</sup>, 鈴木 勝彦<sup>1</sup>

Keiko Sato<sup>1\*</sup>, Hiroshi Kawabata<sup>1</sup>, Hironobu Hyodo<sup>2</sup>, Hidenori Kumagai<sup>1</sup>, David W. Scholl<sup>3</sup>, Kozo Takahashi<sup>4</sup>, Katsuhiko Suzuki<sup>1</sup>

<sup>1</sup> 海洋研究開発機構, <sup>2</sup> 岡山理科大学, <sup>3</sup> U.S. Geological Survey, Menlo Park/ University of Alaska, Fairbanks, <sup>4</sup> 北星学園大学  
<sup>1</sup>IFREE, JAMSTEC, <sup>2</sup>Research Institute of Natural Sciences, Okayama University of Science, <sup>3</sup>U.S. Geological Survey, Menlo Park/ University of Alaska, Fairbanks, <sup>4</sup>Hokusei Gakuen University

Basement rocks were drilled down to ca. 42 m into the volcanic sequence directly underneath the sedimentary section at Site U1342 on Bowers Ridge during the IODP Expedition 323 to the Bering Sea. This provided us an opportunity to describe the details of the sequence and to decipher the virtually unknown origin and evolution of the Bowers arc massif. There are two contrasting hypotheses for the origin of the arc, which include formation in the Pacific Basin well to the south of its present location during the Cretaceous and in-situ formation within the Bering Sea in Eocene.

The volcanic sequence recovered from Site U1342D was divided into six major lithological units: Unit 1, vesiculated andesitic lava flow; Unit 2, interbedded volcanic sandstones and polymict volcanic conglomerates; Unit 3, monomict volcanic conglomerates; Unit 4, interbedded volcanic sandstones and polymict volcanic conglomerates; Unit 5, monomict volcanic conglomerates; and Unit 6, polymict volcanic conglomerates. Units 3 and 4 represent hydroclastic volcanoclastics, while units 2, 4, and 6 are epiclastic volcanoclastics (Kawabata et al., 2011). We used the single grain <sup>40</sup>Ar-<sup>39</sup>Ar dating method by step-wise laser fusion for Unit 1 basaltic andesite rocks. We distinguish for the first time two stage (age groups) of activity (34-32Ma and 28-26Ma) from our Ar-Ar data, coupled with those from Wanke et al., (2012).

キーワード: Ar-Ar 年代, ベーリング海, パウワーズリッジ, U1342A&D

Keywords: Ar-Ar dating, Bering Sea, Bowers ridge, U1342A&D

## 本州中部, 高遠地域の苦鉄質岩脈によって焼かれた母岩のフィッション・トラック年代: 中新世ジルコン年代と若いアパタイト年代 Fission track ages for baked country rocks adjacent to the mafic dikes in the Takato area, central Honshu

星 博幸<sup>1\*</sup>, 岩野 英樹<sup>2</sup>, 檀原 徹<sup>2</sup>  
Hiroyuki Hoshi<sup>1\*</sup>, Hideki Iwano<sup>2</sup>, Tohru Danhara<sup>2</sup>

<sup>1</sup> 愛知教育大学, <sup>2</sup> 京都フィッション・トラック  
<sup>1</sup>Aichi University of Education, <sup>2</sup>Kyoto Fission-Track Co. Ltd

We present new fission track (FT) ages for apatites and zircons separated from baked zones of country rock (granite) adjacent to dolerite dikes in the Takato area, Nagano Prefecture. The dolerite dikes form a dike swarm with a dominant NW-SE strike and vertical or subvertical dips, from which a minimum principal stress ( $\sigma_3$ ) axis trending NE-SW is deduced. The country rock is the Takato granite of late Cretaceous age. There are a number of good exposures where the contacts between the dolerite dikes and the granite can readily be recognizable. In order to determine the age of this dike swarm by FT dating, rock samples were collected from three baked zone sites of the granite that are located adjacent to the dolerite dikes. At the baked zone sites, we carefully sampled tiny rock fragments and mineral grains within 8 mm from the contact. We determined FT ages of ca. 17-16 Ma for zircons from all the baked zone sites, compared with the zircon FT ages of ca. 55 Ma determined for granite samples far from dikes. Confined FT length measurements suggest that the zircon FT ages for the contact zones have totally been reset by the heat from dolerite dikes. These FT results indicate that the dolerite dike intrusion took place at ca. 17-16 Ma and that mafic igneous activity occurred in this area in the latest Early Miocene. This finding has an implication that the 17-16 Ma volcanic front probably lay through or close to this area of central Honshu. For apatites, consistent ages of ca. 4 Ma were determined for both the baked zone and distant sites. Such significantly young apatite FT ages can be explained by assuming (i) significant uplift and denudation in and around the Takato area after 4 Ma, or (ii) a local thermal event at that time.

キーワード: フィッション・トラック年代, ドレライト岩脈, 高遠花崗岩, 本州中部, 熱年代学, 中新世火山フロント  
Keywords: fission track age, dolerite dike, Takato granite, central Honshu, thermochronology, Miocene volcanic front

## 鈴鹿山脈から採取したアパタイトのフィッション・トラック年代および(U-Th)/He年代とその地形学的意義 Apatite fission-track and (U-Th)/He ages of the Suzuka Range, southwest Japan, and their geomorphological implications

末岡 茂<sup>1\*</sup>, 山田 国見<sup>1</sup>, 柴田健二<sup>1</sup>, 堤 浩之<sup>2</sup>, 田上 高広<sup>2</sup>, 長谷部 徳子<sup>3</sup>, 田村 明弘<sup>3</sup>, 荒井 章司<sup>3</sup>  
Shigeru Sueoka<sup>1\*</sup>, Kunimi Yamada<sup>1</sup>, Kenji Shibata<sup>1</sup>, Hiroyuki Tsutsumi<sup>2</sup>, Takahiro Tagami<sup>2</sup>, Noriko Hasebe<sup>3</sup>, Akihiro Tamura<sup>3</sup>, Shoji Arai<sup>3</sup>

<sup>1</sup> 日本原子力研究開発機構, <sup>2</sup> 京都大学, <sup>3</sup> 金沢大学

<sup>1</sup>Japan Atomic Energy Agency, <sup>2</sup>Kyoto University, <sup>3</sup>Kanazawa University

鈴鹿山脈は、近畿地方と中部地方の構造境界である伊勢湾 - 敦賀湾構造線に沿って分布する断層地塊山地である。鈴鹿山脈より西の近畿地方は、逆断層の卓越と南北方向の山地と盆地の交互配列で特徴づけられるのに対し（近畿トライアングル；Huzita, 1962, Jour. Geosci. Osaka City Univ.；藤田, 1983「日本の山地形成論」）、東の中部地方は、横ずれ断層の卓越と濃尾平野から日本アルプスにかけての西傾動地塊で特徴づけられる（中部傾動地塊；桑原, 1968, 第四紀研究）。鈴鹿山脈の付近では、フィリピン海プレートが低角に沈み込んで浅い尾根状のスラブを形成しており（伊勢湾 - 湖北スラブ；三好・石橋, 2008, 第四紀研究）、このような特異な深部構造がこの地域に構造境界をもたらす原因となっていると考えられている（三好・石橋, 2008）。しかしながら、上記の深部構造が地形やテクトニクスに作用する具体的なメカニズムについては不明な点が多い。その理由のひとつとして、フィリピン海スラブの沈み込み開始以降の期間に相当する過去数 100 万年間における地殻変動量が把握できていないため、スラブの沈み込み運動と地表の変形との関係を定量的に議論することが困難な点が挙げられる。濃尾平野や近江盆地などの沈降地域では、東海層群や古琵琶湖層群といった鮮新統の分布深度や堆積年代から数 100 万年オーダーの沈降量・沈降速度の推定が可能であるが、両者の間に分布する鈴鹿山脈では、削剥量が不明であるため隆起量が正確に推定できない。

本研究では、数 100 万年以上の長期スケールの削剥速度の推定に有効な熱年代学的手法を用いて、鈴鹿山脈の削剥史の解明を試みている。用いた手法はアパタイトフィッション・トラック法とアパタイト (U-Th)/He 法であるが、これらは熱年代学的手法の中でもっとも閉鎖温度が低いグループに含まれ（それぞれ、90~120 と 55~80 ）、最近の地質時代の削剥イベントを検出するのに適している。花崗岩試料 9 点から得られたアパタイトのフィッション・トラック密度の結果から、鈴鹿山脈内で南北方向に系統的な差は見られなかった。花崗岩体内でウラン濃度がほぼ均一だと仮定すると、鈴鹿山脈内には南北方向に有意な削剥史の違いが見られないことになる。これらのアパタイトフィッション・トラック年代が過去数 100 万年の鈴鹿山脈の隆起・削剥を反映している（年代値が数 Ma まで若返っている場合で、ウラン濃度で 10 数 ppm 以上に相当）とすれば、近江盆地や濃尾平野の沈降場が過去数 100 万年にわたり北進傾向を示すこと（例えば、岡田, 1980, 第四紀研究）と不調和である。すなわち、沈降場を形成している造盆地運動と、山地と盆地を分化させた断層運動は同時進行的に南から北へと進行したのではないことになり、これらの構造運動の原因に関して重要な示唆を与える可能性がある。一方、アパタイトフィッション・トラック年代が鈴鹿山脈隆起開始以前からの過去数 1000 万年の削剥史を反映している（年代値が数 10Ma の古い値の場合で、ウラン濃度で数 ppm 程度に相当）とすれば、削剥史の均質性は広域的な準平原化作用を反映している可能性が考えられ、六甲地域（末岡ほか, 2010, 地学雑誌）、東濃地域（Yuguchi et al., in prep.）、木曽地域（Sueoka et al., 2012, Island Arc）との比較により、中部～近畿地方における準平原化時代の削剥史の検討が期待できる。発表では、アパタイトフィッション・トラック年代とアパタイト (U-Th)/He 年代から、本地域の隆起・削剥史とその地形学的な解釈についてより詳細な議論をおこなう予定である。

キーワード: フィッション・トラック法, (U-Th)/He 法, 鈴鹿山脈, 削剥

Keywords: fission-track thermochronology, (U-Th)/He thermochronology, Suzuka Range, denudation

## 重晶石中のSO<sub>3</sub>-ラジカルの線による生成効率：ESR年代測定への応用 The alpha effectiveness for formation of SO<sub>3</sub>- in barite : an application to ESR dating

磯野 祐輔<sup>1\*</sup>, 豊田 新<sup>1</sup>, 西戸 裕嗣<sup>2</sup>, 鹿山 雅裕<sup>3</sup>

YUSUKE ISONO<sup>1\*</sup>, Shin Toyoda<sup>1</sup>, Hirotsugu Nishido<sup>2</sup>, Masahiro KAYAMA<sup>3</sup>

<sup>1</sup> 岡山理科大学理学部応用物理学科, <sup>2</sup> 岡山理科大学生物地球学部, <sup>3</sup> 広島大学大学院理学研究科地球惑星システム学専攻  
<sup>1</sup>Department of Applied Physics, Faculty of Science, Okayama University of Science, <sup>2</sup>Department of Biosphere-Geosphere Science, Okayama University of Science, <sup>3</sup>Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University

While Kasuya et al. (1991) first pointed out that ESR (electron spin resonance) dating of barite (BaSO<sub>4</sub>) is possible, the method was first practically applied by Okumura et al. (2010) to a sample formed by the submarine hydrothermal activity. A subsequent study by Sato et al. (2011) studied the thermal stability of the signal and concluded that the dating signal due to SO<sub>3</sub><sup>-</sup> is stable so that dating method is applicable up to at least several thousand years.

Barite crystals formed by submarine hydrothermal activities contains large amount of Ra which replaces Ba in the crystal lattice where all dose rate is due to radiation from Ra. Okumura et al. (2010) reported a concentration of 7.7 Bq/g of Ra in a hydrothermal sulfide including barite where the internal alpha dose rate in barite contributes 40 to 60 % of total dose rate. Determination of alpha effectiveness is thus the one of the essential factors for improving the precision of dating of barite by ESR.

Toyoda et al. (2012) investigated the alpha effectiveness for the ESR signal due to SO<sub>3</sub><sup>-</sup> in barite by comparing the dose responses of the signal for gamma irradiation and for He ion implantation with an energy of 4 MeV. A value 0.043 was obtained for a sample from Morocco.

However, the dose response was far from good, where the number of points is not sufficient. The experiments of He ion implantation was repeated in the present study for several samples to determine the precise alpha effectiveness.

As results, a value of 0.0012 was obtained from a sample from Morocco, and 0.00045 from one from Funaoka mine. The results of further repeated analysis will be presented.

キーワード: 重晶石, 電子スピン共鳴

Keywords: barite, electron spin resonance



## 海底熱水域の熱水性鉱石中の重晶石のESR年代測定 ESR dating of barite in sea-floor hydrothermal sulfide deposits

藤原 泰誠<sup>1\*</sup>, 豊田 新<sup>2</sup>, 石橋 純一郎<sup>4</sup>, 中井 俊一<sup>5</sup>, 内田 乃<sup>2</sup>, 賞雅 朝子<sup>6</sup>

Taisei Fujiwara<sup>1\*</sup>, Shin Toyoda<sup>2</sup>, Jun-ichiro Ishibashi<sup>4</sup>, Shun'ichi Nakai<sup>5</sup>, Ai Uchida<sup>2</sup>, Asako Takamasa<sup>6</sup>

<sup>1</sup> 岡山理科大学大学院理学研究科, <sup>2</sup> 岡山理科大学理学部応用物理学科, <sup>3</sup> 岡山理科大学大学院理学研究科, <sup>4</sup> 九州大学大学院理学研究院地球惑星科学部門, <sup>5</sup> 東京大学地震研究所, <sup>6</sup> 放射線医学総合研究所

<sup>1</sup>Okayama University of Science, <sup>2</sup>Department of Applied Physics, Faculty of Science, Okayama University of Science, <sup>3</sup>Department of Applied Physics Okayama University of Science, Japan, <sup>4</sup>Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, <sup>5</sup>Earthquake Research Institute, University of Tokyo, <sup>6</sup>National Institute of Radiological Sciences

The temporal change of submarine hydrothermal activities has been an important issue in the aspect of the evolution of hydrothermal systems which is related with ore formation (Urabe, 1995) and biological systems sustained by the chemical species arising from hydrothermal activities (Macdonald et al., 1980). Dating methods using disequilibrium between radioisotopes such as U-Th method (e.g. You and Bickle, 1998), <sup>226</sup>Ra-<sup>210</sup>Pb and <sup>228</sup>Ra-<sup>228</sup>Th method (e.g. Noguchi et al., 2011) have been employed for such studies.

Okumura et al., (2010) made the first practical application of ESR (electron spin resonance) dating technique to a sample of submarine hydrothermal barite to obtain preliminary ages, while Kasuya et al. (1991) first pointed out that barite can be used for ESR dating. Toyoda et al. (2011) determined the optimum ESR condition while Sato et al. (2011) confirmed that the signal is thermally stable enough for an age range of several thousand years. Takamasa et al. (in press) obtained U-Th and ESR ages which are roughly consistent with each other.

The samples were taken by NT11-20 and NT12-06 research cruises operated by JAMSTEC. Barite (BaSO<sub>4</sub>) was extracted from hydrothermal chimney samples (HPD#1331G01, HPD#1331G03, and HPD#1333G06) taken from two sites at Okinawa Trough. Blocks of sulfide deposits were cut into pieces, and about 2.0g was crushed. The samples were soaked in 12M hydrochloric acid, left for approximately 24 hours. Then, 13M nitric acid was added. Finally, after rinsing in distilled water, the sample was filtered and dried. Impurities were removed by handpicking. An X-ray diffraction study was made to confirm that the grains are pure barite. After gamma-ray irradiation at Takasaki Advanced Radiation Research Institute, Japan Atomic Energy Agency, they were measured at room temperature with an ESR spectrometer (JES-PX2300) with a microwave power of 1mW, and the magnetic field modulation amplitude of 0.1mT. The bulk Ra concentration was measured by the low background pure Ge gamma ray spectrometer. Assuming that Ra is populated only in barite, the dose rate was calculated with the alpha effectiveness of 0.043 (Toyoda et al., 2012), where the decay of Ra (a half life of 1600 years) was also taken into account.

The ages of the pieces of HPD#1331G01 (Hatoma Knoll) were obtained to be 2600 to 4000 years, where outer pieces tend to be older. The ages of HPD#1331G03 are older to a direction, from 2.2 ka to 10 ka (Hatoma Knoll). HPD#1331G06 (Yoron Knoll) showed much younger ages around 100 years where they are older to a direction.

The results, the ages of the Hatoma Knoll is older than the Hatoma Knoll, are consistent with the landscape observation from the submarine vehicle, which gave such impression such as by number of dead chimneys and amount of sediments on the sulfide deposits, and with the diversity of the creatures inhabiting in the area.

キーワード: 重晶石, 海底熱水活動, 電子スピン共鳴, 年代測定

Keywords: barite, hydrothermal activities, electron spin resonance, dating

## 石英中の不純物中心を用いた DoseRecoveryTest と ESR 年代測定 ESR dating of tephra with dose recovery test for impurity centers in quartz

浅越 光矢<sup>1\*</sup>, 豊田 新<sup>1</sup>  
mitsuya Asagoe<sup>1\*</sup>, Shin Toyoda<sup>1</sup>

<sup>1</sup> 岡山理科大学

<sup>1</sup> Okayama University of Science

Determining the age of tephra is an important issue for reconstructing the history of environmental change during the Quaternary epoch. To this end, we consider dating of quartz using the electron spin resonance (ESR) method. Quartz was first found to be useful for ESR dating of fault gouge while the mineral was also used for dating of tephra, heated flints, and sediments.

The first investigation pertaining to ESR dating of tephra using quartz was published using the Al center (a hole trapped at Al site replacing Si). Subsequently, several other successful results on tephra have been reported (e.g. Imai and Shimokawa, et al., 1988, Imai et al., 1992, Toyoda et al., 1995, and Yokoyama et al., 2004). Buhay et al. (1992) reported that the ESR age (45-49 ka) of a tephra from New Zealand is consistent with the <sup>14</sup>C age (42-44) within statistical errors.

However, in other studies, systematic discrepancies were observed between the ages obtained using the Al center and Ti-Li center (an electron trapped at a Ti atom replacing Si, accompanying a Li ion as a charge compensator). Toyoda et al. (2006) systematically investigated the ESR and RTL (red thermoluminescence) ages of tephra with a known age range of 30 to 900 ka, and found that ESR dating has problems in obtaining the equivalent doses. Using the same dose rate, the RTL ages were consistent with the expected ages while the ESR based results were inconsistent and involved large scatter in data. The scatter in ESR ages was found to increase with age. Toyoda et al. (2009) proposed a new protocol, the multiple-aliquot regenerative-additive dose method, which provides equivalent doses estimates with smaller errors than the traditional additive dose method.

In the present paper, we have analyzed the same Nm-Sb tephra and A-Fm tephra and Ikezuki tuff to check the reproducibility of dating results and to test if known doses can be recovered using the multiple-aliquot regenerative-additive dose procedure.

キーワード: ESR 年代測定, 石英, テフラ

Keywords: ESR dating, quartz, tephra



## TLとESRを用いた黒部川流域における河川堆積物の起源の推定 Estimate of the origin of the river sediment in the Kurobe River basin using TL and the ESR

吉田 真徳<sup>1\*</sup>, 豊田 新<sup>1</sup>, 蜷川 清隆<sup>1</sup>, 高田 将志<sup>2</sup>, 島田 愛子<sup>3</sup>  
Msanori Yoshida<sup>1\*</sup>, Shin Toyoda<sup>1</sup>, Kiyotaka Ninagawa<sup>1</sup>, Masashi Takada<sup>2</sup>, Aiko Shimada<sup>3</sup>

<sup>1</sup> 岡山理科大学理学部応用物理学科, <sup>2</sup> 奈良女子大学文学部人文社会学科, <sup>3</sup> JEOL RESONANCE

<sup>1</sup> Department of Applied Physics, Faculty of Science, Okayama University of Science, <sup>2</sup> Department of History, Sociology and Geography, Faculty of Letters, Nara Women's University, <sup>3</sup> JEOL RESONANCE, Inc

While the ESR signals of the E1' center in quartz was used to investigate the origin of the loess in MIS 1 and 2 (Toyoda and Naruse, 2002) and these sediments in the Sea of Japan (Nagashima et al., 2007), Shimada (2008) showed that TL (thermoluminescence color image) may be useful for similar qualitative study on river sediments. In the present study, the wavelength-temperature two dimensional thermoluminescence measurement was employed, together with the ESR measurements, to investigate the origin of the river sediments quantitatively.

Sediment samples were collected from the 23 locations at the prefectural border of Nagano and Toyama and the Kurobe River basin. Eight samples of these were sieved to obtain four grain size fractions of 2-1mm, 1-0.5mm, 0.5-0.25mm, 0.25-0.125mm. Quartz grains were extracted using chemicals, heavy liquid, and an isodynamic separator. The obtained quartz grains were heated at 300 degree celsius for 1 hour to erase the inherited signals. Each sample was then separated into 9 subsample aliquots for gamma ray irradiation up to 2640 Gy, which are for ESR measurements. Another separate aliquot for TL measurement was given a dose of 857 Gy where the sample glass tube was wrapped by Al foil to prevent from giving any light.

TL measurements were performed the two dimensional TL apparatus which measures the TL emission spectra during heating up to 450 degree celsius. Red emission (538 to 658 nm) was observed between 90 and 390 and Blue emission (379 to 538 nm) was between 70 and 370. The integrated counts were taken as the intensities of the red and blue emissions. The intensities of the blue emission are roughly constant for all samples of river sediments and river terrace samples while red emission tends to increase with age, i.e., lower in higher terraces and higher in lower terraces and present river sediments. The results of ESR measurements will be given in the presentation together with the TL results.

キーワード: 電子スピン共鳴, 熱ルミネッセンス, 石英, 河床堆積物  
Keywords: ESR, TL(thermoluminescence), Quartz, river sediment

## 複数の年代測定法を用いた神鍋スコリア丘の噴火活動年代決定 Eruption age determination of Kannabe scoria cone using multi-dating method

下岡 順直<sup>1\*</sup>, 齋藤 武士<sup>2</sup>, 早田 勉<sup>3</sup>, 三好 雅也<sup>4</sup>, 石橋 秀巳<sup>5</sup>, 山本 順司<sup>6</sup>

Yorinao Shitaoka<sup>1\*</sup>, Takeshi Saito<sup>2</sup>, Tsutomu Soda<sup>3</sup>, Masaya Miyoshi<sup>4</sup>, Hidemi Ishibashi<sup>5</sup>, Junji Yamamoto<sup>6</sup>

<sup>1</sup> 京都大学地球熱学研究施設, <sup>2</sup> 信州大学, <sup>3</sup> (株) 火山灰考古学研究所, <sup>4</sup> 福井大学, <sup>5</sup> 静岡大学, <sup>6</sup> 北海道大学総合博物館

<sup>1</sup>Institute for Geothermal Sciences, Kyoto University, <sup>2</sup>Shinshu University, <sup>3</sup>Institute of Tephrochronology for Nature and History Co., Ltd., <sup>4</sup>University of Fukui, <sup>5</sup>Shizuoka University, <sup>6</sup>The Hokkaido University Museum

兵庫県豊岡市に位置する神鍋単成火山群は、中国地方に分布する第四紀火山の中で最も活動時期の新しい火山の一つである(古山, 1973)。その中でも神鍋スコリア丘(神鍋山)とスコリア丘から流出した神鍋溶岩流は、神鍋単成火山群の中でも最新の活動によるものとされ(古山ほか, 1993)、広域火山灰(テフラ)との層位関係(川本, 1990)およびカリウム・アルゴン(K-Ar)年代測定やレスの堆積速度による推定(古山ほか, 1993)によって噴火活動年代が報告されてきた。しかし、これら年代値は必ずしも一致をみておらず、活動年代は決着していない。近年、神鍋単成火山群を含む山陰海岸国立公園地域周辺が山陰海岸ジオパークとして世界ジオパークに認定されたこともあり、神鍋単成火山群の火山活動を再検討することは火山学的観点のみならず、防災や観光の観点からも求められている。今回、古地磁気測定、光ルミネッセンス(OSL)年代測定およびテフラ編年学を用いて検討した神鍋スコリア丘の噴火活動年代について報告する。

古地磁気測定については、神鍋溶岩流の6地点から計23個の定方位サンプルを採取し、3つのパイロットサンプルについては段階交流消磁実験を、20個のサンプルについては段階熱消磁実験を行い、残留磁化方位を検討した。すべての試料から高消磁段階で原点に向かう安定な自然残留磁化成分が認められた。平均方向は偏角=7.5度、伏角=65.9度(95=2.7度、k=126.5度、N=23)となり、良く集中した結果が得られた。神鍋溶岩流の噴出年代と予想される年代を含み、地理的にも近い、琵琶湖堆積物コアの永年変化曲線(Hayashida *et al.*, 2007)と比較することで年代の検討を行った。琵琶湖堆積物コアからは60度を超える深い伏角が報告されていないが、50度を超えて深い値を示すピークが約21.5および25kaに認められる。偏角は、約21.5kaではほぼ0度で比較的一定した値を示し、約25kaでは約7-29度と大きく変動している。古地磁気方位では、約25kaが偏角、伏角ともに誤差の範囲で一致するため、可能性が高いと考えられる。

OSL年代測定は、地点bの露頭(図1)において、神鍋スコリア層の上位にある黄褐色-褐色土を採取して行った。採取した試料から約4-10 μmの石英を抽出し、Single aliquot regenerative-dose(SAR)法(Murray and Wintle, 2000)を用いてOSL測定を行った。その結果、 $21 \pm 1.7$ kaであった。

テフラ分析は、スコリア丘周辺2地点(地点b, c)の露頭(図1)で試料を採取して実施した。地点cでは、神鍋スコリア層のすぐ下位にある細粒テフラ層が認められ、層相や含まれる火山ガラスの特徴などから始良Tnテフラ(AT, 町田・新井, 1976; 2003)に同定された。地点bでは、神鍋スコリア層上位の黒ボク層(OSL測定した黄褐色-褐色土層より上位)の最下部で、無色透明や有色のバブル型ガラスが急増することが明らかになった。この試料に含まれる火山ガラスの多くは、南九州の鬼界カルデラから噴出した鬼界アカホヤテフラ(K-Ah, 町田・新井, 1978; 2003)起源と考えられる。

OSL年代測定とテフラ分析から、噴火活動年代は20kaよりも古く、ATの年代よりも新しいとなり、これは古地磁気方位の結果と整合する。以上より、複数の年代測定法を用いて検討した結果、神鍋スコリア丘の噴火活動年代を約25kaと見積もることができた。

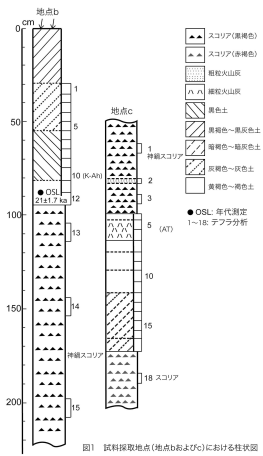
キーワード: 神鍋スコリア丘, 噴火活動年代, 古地磁気測定, OSL年代測定, 火山灰編年学

Keywords: Kannabe scoria cone, eruption age, paleomagnetic dating, OSL dating, tephrochronology

SGL40-P10

会場:コンベンションホール

時間:5月19日 18:15-19:30



## 酸 - アルカリ - 酸洗浄法におけるアルカリ洗浄段階の有無による 14C 年代値への影響評価 An assessment for alkaline treatment in ABA method to charcoal sample for 14C dating (AMS)

渥美 晋<sup>1\*</sup>  
Shin Atsumi<sup>1\*</sup>

<sup>1</sup> 東京理科大学応用化学科

<sup>1</sup>Department of applied chemistry, Tokyo University of Sciences

酸塩基酸 (Acid-Base-Acid: ABA) 処理法は 14C 年代測定法における木炭試料の処理法の一つである。ABA 法の処理条件に関して化学的指標に基づく研究例は少ない。試料処理段階の木炭自体に対するラマンスペクトルを用いたアセスメント法が試みられているが、試料中のフミン酸の有無を確認できる可能性を示唆したのみで、14C 年代値の検討は行われていない。そこで本研究では、14C 年代測定法の問題点として、従来、詳細は未解明であった前処理起源の誤差の発生の有無を明らかにすることを目的とする。その結果、NaOH 溶液にて洗浄した試料の年代値群の中央値において、最大値と最小値の差として 57 14Cyr が得られた。一方、NaOH 溶液による洗浄を行っていない試料の年代値群のそれぞれの中央値の最大値と最小値の差は 216 14Cyr であった。この 2 つの年代値群を 2 検定によって検定すると、NaOH 洗浄済みの試料の年代値群は、 $T=0.45$  (自由度 3; 5% 危険率:  $T > 12.59$ ) と高い収束性を示すのに対して、NaOH 未洗浄試料の年代値は  $T=10.74$  (自由度 4; 5% 危険率:  $T > 9.49$ ) と発散が大きく、NaOH 未洗浄試料 5 試料の中で有意の差が現れた。また、NaOH 未洗浄試料の年代値は、NaOH 洗浄済み試料の年代値の平均値  $3701 \pm 43$  BP に対して、 $3589 \pm 41$  BP という若い年代値を示す場合と  $3805 \pm 40$  BP という古い年代値を示す場合が見られた。このことから試料の汚染には若い年代値を示すものと古い年代値を示すものがあることが判る。以上の結果から ABA 処理法の有効性が部分的に証明された。

キーワード: 放射性炭素年代測定法, 木炭, 考古試料, 酸アルカリ酸洗浄法  
Keywords: radiocarbon dating, charcoal, archaeological sample, ABA method

同位体地球科学を生痕化石研究に応用する：生痕化石 *Phymatoderma* の炭素同位体  
比分析に基づく古生態復元  
Application of isotope-geology to ichnology: paleoecology of the *Phymatoderma*-producer  
based on carbon-isotope analysis

泉 賢太郎<sup>1\*</sup>

Kentaro Izumi<sup>1\*</sup>

<sup>1</sup> 東大地惑

<sup>1</sup>Dept. Earth and Planetary Science, Univ. Tokyo

The present study shows a case study that applies isotopic analysis to ichnology. The ichnogenus *Phymatoderma* is a subhorizontal branching burrow system consisting of radiating tunnels filled with fecal pellets. This ichnogenus has been interpreted as a product of a deposit-feeding organism, but the question of whether the *Phymatoderma*-producer was a subsurface deposit feeder or a surface deposit feeder is still a topic of controversy. Here I present evidence for the surface deposit-feeder hypothesis, based on carbon-isotope analyses, for the trace fossil *Phymatoderma granulata* from the lower Toarcian black shale in southern Germany. Carbon-isotope ratios of organic carbon in the pelletal infill of *P. granulata*, the surrounding black shale, and the overlying gray mudstone are -26.64 permil, -28.49 permil, and -26.27 permil, respectively. The difference between the pelletal infill and overlying mudstone in terms of C-isotope ratio is much smaller than that between the fillings and black shale; therefore, these data clearly indicate that the *Phymatoderma*-producer ingested the surface sediments and subsequently excreted fecal pellets into the subsurface sediments. Such a surface deposit-feeding style would be an effective way of absorbing nutrients, because surface sediments contain much fresh organic material, whereas organic matter in subsurface deposits consists mostly of refractory material that is poorly utilized by most marine benthos.

## U-Th-Pb 系年代測定法における放射非平衡の補正 Correction of initial-disequilibrium on U-Th-Pb system for Accurate Zircon Dating

坂田 周平<sup>1\*</sup>, 平川晋輔<sup>1</sup>, 岩野英樹<sup>2</sup>, 檀原徹<sup>2</sup>, 平田岳史<sup>2</sup>

Shuhei Sakata<sup>1\*</sup>, Hirakawa, Shinsuke<sup>1</sup>, Iwano, Hideki<sup>2</sup>, Danhara, Tohru<sup>2</sup>, Hirata, Takahumi<sup>2</sup>

<sup>1</sup> 京都大学大学院理学研究科地球惑星科学専攻, <sup>2</sup> 株式会社京都フィッション・トラック

<sup>1</sup>Department of Earth and Planetary Sciences, Kyoto University, <sup>2</sup>Kyoto Fission Track Co. Ltd.

During recent years, the improvement of analysing technique provides a more precision in case of dating Quaternary zircons. Major analytical problems associated with age determination of the young zircons are (1) the analytical difficulty to measure extremely low Pb/U and Pb/Th ratios (e.g.,  $^{206}\text{Pb}/^{238}\text{U} < 0.0001$ ), and (2) initial-disequilibrium in the U-Th-Pb decay systems through the crystallization of zircon in source magma. The ability to measure isotope ratios with high-dynamic ranges could be improved by the suppressor device for ion counting systems in the ICPMS instrument, in which the gain of the ion counting could be changed during the fast mass scanning, and the resulting precision and accuracy for the Pb/U and Pb/Th ratio measurements was dramatically improved. However, correction of the initial-disequilibrium is highly desired to obtain reliable age data for young (<1Ma) zircons. Because of the different distribution coefficient ( $D_{\text{zircon/magma}}$ ) between U and Th, isotope equilibrium was disturbed at the crystallization of zircons in source magma. Among the uranium series decay products, the initial disequilibrium of  $^{230}\text{Th}$  can become a major source of systematic error in the resulting ages. To evaluate and correct the contribution of the initial disequilibrium on  $^{230}\text{Th}$ , the ratio of the distribution coefficient for Th and U ( $f_{\text{Th/U}} = D^{\text{Th}}/D^{\text{U}}$ ) must be defined [2]. To achieve this, we have determined both the  $^{238}\text{U}$ - $^{206}\text{Pb}$  and  $^{232}\text{Th}$ - $^{208}\text{Pb}$  ages were obtained for three tephra zircon samples collected from Kirigamine rhyolite, Bishop tuff and Toga pumice ( $^{40}\text{Ar}$ - $^{39}\text{Ar}$  ages are  $0.945 \pm 0.005$  Ma,  $0.7589 \pm 0.0036$  Ma, and  $0.42 \pm 0.01$  Ma reported by [3], [4], and [5], respectively) using a LA-ICPMS. The resulting  $^{232}\text{Th}$ - $^{208}\text{Pb}$  ages were  $0.938 \pm 0.026$  Ma (Kirigamine),  $0.757 \pm 0.008$  Ma (Bishop), and  $0.428 \pm 0.004$  Ma (Toga), respectively, demonstrating that the resulting ages were consistent with the previously reported values. The  $f_{\text{Th/U}}$  values could be calculated based on the measured  $^{206}\text{Pb}/^{238}\text{U}$  ratio and the resulting  $^{232}\text{Th}$ - $^{208}\text{Pb}$  ages, and the calculated  $f_{\text{Th/U}}$  values were  $0.50 \pm 0.26$  for Kirigamine,  $0.51 \pm 0.10$  for Bishop, and  $0.55 \pm 0.07$  for Toga zircons. The resulting three  $f_{\text{Th/U}}$  values agreed well within the analytical uncertainties. The disequilibrium-corrected  $^{238}\text{U}$ - $^{206}\text{Pb}$  age can be calculated under the assumption that the  $f_{\text{Th/U}}$  value did not vary significantly among the zircons. To evaluate this, we have measured the  $^{238}\text{U}$ - $^{206}\text{Pb}$  and  $^{232}\text{Th}$ - $^{208}\text{Pb}$  ages for zircons from Sanbekisuki tephra [6]. The  $f_{\text{Th/U}}$  values used for the correction was based on the weighted mean of three  $f_{\text{Th/U}}$  values obtained here ( $f_{\text{Th/U}} = 0.53 \pm 0.05$ ). The corrected  $^{238}\text{U}$ - $^{206}\text{Pb}$  age was  $86.2 \pm 2.1$  ka, which agreed with the  $^{232}\text{Th}$ - $^{208}\text{Pb}$  age ( $90.1 \pm 2.6$  ka) within the analytical uncertainties. It should be noted that the  $^{238}\text{U}$ - $^{206}\text{Pb}$  dating after the correction of the initial disequilibrium can provide accurate and precise chronological information. To evaluate the reliability of the present correction technique for the U-Pb dating, we have developed a pseudo concordia diagram (plot of  $^{206}\text{Pb}/^{238}\text{U}$  ratio against the  $^{208}\text{Pb}/^{232}\text{Th}$  ratio). In this diagram, most of the U-Th-Pb isotope data fall close to a concordia curve, suggesting that the Sanbekisuki zircon did not suffer from significant Pb-loss. In conclusion, we can construct more accurate and effective dating tool based on the U-Th-Pb decay systems based on the  $f_{\text{Th/U}}$  value defined in this study, especially, for the young zircons.

[1] Y. Sano, Y. Tsutsumi, K. Terada, and I. Kaneoka, J. volcano. geotherm. res, 2002, 117, 285-296.

[2] U. Scharer, Earth and Planetary Science Letters, 1984, 67, 191-204.

[3] K. Wadatsumi, N. Kitada, and A. Deino, Fission Track News Letters, 1994, 7, 7-8.

[4] A.M. Sarna-Wojcicki, J. Geophys. Res., 2000, 105, 21,431-21,443.

[5] K. Uto, K. Kano, and O. Ishizuka, Volcano, 2010, 55, 201-206.

[6] H. Machida and H. Arai, Atlas of Tephra in and around Japan, 2003.

キーワード: ジルコンウラン - 鉛年代測定法, 放射非平衡, 第四紀ジルコン, 高精度同位体分析, レーザーアブレーション, 誘導結合プラズマ質量分析計

Keywords: zircon U-Pb dating, disequilibrium, Quaternary zircon, precise isotopic analysis, laser ablation, ICPMS



## 富山県和田川地域における飛騨片麻岩の SHRIMP 年代 SHRIMP geochronology of the Hida gneiss in the Wada-gawa area, Toyama Prefecture

竹原 真美<sup>1\*</sup>, 堀江 憲路<sup>3</sup>, 外田 智千<sup>3</sup>, 清川 昌一<sup>2</sup>  
Mami Takehara<sup>1\*</sup>, Kenji Horie<sup>3</sup>, Tomokazu Hokada<sup>3</sup>, Shoichi Kiyokawa<sup>2</sup>

<sup>1</sup>九州大学 大学院理学府 地球惑星科学専攻, <sup>2</sup>国立極地研究所, <sup>3</sup>九州大学 大学院理学研究院 地球惑星科学部門  
<sup>1</sup>Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, <sup>2</sup>National Institute of Polar Research, <sup>3</sup>Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University

The Hida belt, situated at the northern part of southwestern Japan, consists of low P/T metamorphic rocks such as paragneisses, orthogneisses, amphibolite and marble with multiple episodes of metamorphism evident, and Permo-Triassic granitoids. Previous works suggested that an earlier metamorphism occurred at ca. 350Ma under the granulite-facies conditions, and was overprinted by the amphibolite-facies metamorphism at 240-220 Ma (e. g., Arakawa et al., 2000) but these data were probably distributed by the Funatsu-type granites intrusion at about 180 Ma.

In regard to protolith, Sano et al. (2000) reported U-Pb zircon ages peaked at about 3420 Ma, 2560 Ma, 1840 Ma, 1130 Ma, 580 Ma, 400 Ma, 360 Ma, 285 Ma, and 250 Ma from the Hida gneiss at Amo area. Asano et al. (1990) also reported protolith ages of 415 +/- 189 Ma (Sm-Nd whole rock isochron) and 413 +/- 60 Ma (Sm-Nd mineral isochron) from basic metamorphic rocks and amphibolite at the Wada-gawa area, respectively. However, there is no precise geochronological data for protolith and the timing of the metamorphism. In this study, the Hida gneisses collected from the Wada-gawa area were analyzed by SHRIMP (Sensitive High-Resolution Ion Microprobe) to discuss about the protolith and the timing of the metamorphism of the Hida belt.

The Hida gneiss sample, WD090810-3, is composed of biotite, orthopyroxene, plagioclase, quartz and other minor mineral, such as prehnite, titanite, zircon, apatite and opaque minerals. Some biotite is chloritized. Most of plagioclase is also altered and fresh ones were partly observed. Zircon grains of the sample are rounded to well-rounded morphologies. Cathodoluminescence images reveal existence of overgrowth rim.

U-Pb dating of the zircon core yielded five age peaks centered at about 2526 Ma, 1864 Ma, 760 Ma, 553 Ma and 316 Ma, which indicates that the protolith is probably a sedimentary rock. Some age peaks are consistent with those reported by Sano et al. (2000). The youngest age peak suggests that the protolith was formed after 316 Ma. The overgrowth rim yielded weighted mean of <sup>206</sup>Pb-<sup>238</sup>U ages of 247.7 +/- 0.5 Ma (MSWD = 1.18), which indicates the timing of metamorphism in the Hida belt. This age is first report of precise age of the Hida metamorphism and we will discuss about thermal history of the Hida belt with U-Pb titanite ages of the Hida gneiss.

## NanoSIMS を用いた太古代ジルコンの U-Pb 年代測定 U-Pb dating of Eoarchaeon zircon using a NanoSIMS

石田 章純<sup>1\*</sup>, 高畑 直人<sup>1</sup>, Daniele Pinti<sup>2</sup>, Jean David<sup>2</sup>, 佐野 有司<sup>1</sup>  
Akizumi Ishida<sup>1\*</sup>, Naoto Takahata<sup>1</sup>, Daniele Pinti<sup>2</sup>, Jean David<sup>2</sup>, Yuji Sano<sup>1</sup>

<sup>1</sup> 東京大学大気海洋研究所, <sup>2</sup> ケベック大学

<sup>1</sup>AORI, the University of Tokyo, <sup>2</sup>Universite du Quebec a Montreal

太古代火成岩中の水素や硫黄などの揮発性成分の挙動を明らかにすることは、初期地球内部の進化を知る上で非常に重要である。ジルコン中のアパタイトやガラスの包有物はこうした揮発性成分を含み、かつ初生的な情報を保持していると期待されるが、そうした包有物はしばしばマイクロからサブマイクロのスケールで存在しており、分析には高感度かつ高分解能な手法が求められる。NanoSIMS はジルコンの年代測定を高精度で行いつつ、ジルコン中のマイクロスケールの包有物の揮発性成分を測定可能な装置である。

太古代のトーナル岩から分離したジルコンについて、NanoSIMS50 を用いて  $^{238}\text{U}$ - $^{206}\text{Pb}$  及び、 $^{207}\text{Pb}$ - $^{206}\text{Pb}$  年代測定を行った。測定手法は [1]Takahata et al.(2008) に準じた。測定にはスポット径 15 マイクロメートル (以下  $\mu\text{m}$ )、強度 5nA の酸素一次イオンを用いた。 $^{238}\text{U}$ - $^{206}\text{Pb}$  の年代測定では、 $^{30}\text{Si}^+$ ,  $^{90}\text{Zr}_2^{16}\text{O}^+$ ,  $^{204}\text{Pb}^+$ ,  $^{206}\text{Pb}^+$ ,  $^{238}\text{U}^{16}\text{O}^+$ ,  $^{238}\text{U}^{16}\text{O}_2^+$  の正イオンを多重検出器で同時に測定し、 $^{207}\text{Pb}$ - $^{204}\text{Pb}$  の年代測定では  $^{204}\text{Pb}^+$ ,  $^{206}\text{Pb}^+$ ,  $^{207}\text{Pb}^+$  を一つの検出器の磁場を変化させながら測定した。測定においてはまず U-Pb 分析を行い、同じスポットに対して Pb-Pb 分析を行った。標準試料には年代既知のジルコンである QGNG (Quartz- Gabbro- Norite- Gneiss, South Africa; 1842Ma) を用いた [2]。

測定は、カナダ Nuvvuagittuq supracrustal belt のトーナル岩から分離されたジルコンを対象に行った。過去の研究で報告されているこのトーナル岩の年代は、LA-MC-ICP-MS を用いた U-Pb 年代測定法で  $3661 \pm 4 \text{Ma}$  である [3]。測定に用いたジルコンには自形から半自形のものを選択した。結晶の長軸方向の長さは 50 から 200 $\mu\text{m}$  であった。いくつかのジルコンには直径 10 $\mu\text{m}$  前後のアパタイトやガラスの包有物がみられ、年代測定はこれら包有物を避けて行われた。また累帯構造をもつジルコンもいくつか見られたため、そのようなジルコンに対しては累帯構造の層ごとにスポット分析を行った。

その結果、 $^{206}\text{Pb}/^{238}\text{U}$  比は  $4.932\text{E}^{-1}$  から  $7.644\text{E}^{-1}$  の値をとることが分かった。これらの比は累帯構造の中心から外側に向かって減少することが分かった。 $^{207}\text{Pb}/^{206}\text{Pb}$  比は  $3.052\text{E}^{-1}$  から  $3.407\text{E}^{-1}$  の値をとることが分かった。コモン鉛の補正後、 $^{238}\text{U}/^{206}\text{Pb}^*$  と  $^{207}\text{Pb}^*/^{206}\text{Pb}^*$  を Terra-Wasserburg コンコーディア図にプロットすると、ディスコーディアがみられ、このジルコン形成後に Pb が失われるイベントがあったことが示唆された。コンコーディアとディスコーディアの交点は  $3633 \pm 35 \text{Ma}$  の年代を示し、先行研究の報告値と良く一致した。今後、ジルコン中包有物の揮発性元素の分析を進め、初期地球進化史の解明にアプローチしていく。

### References

[1] Takahata et al., *Gondwana Res.*, 14, 587-596, 2008.

[2] Sano et al., *Geochem. J.*, 34, 135-153, 2000.

[3] David et al., *GSA Bulletin*, 121, 150-163, 2008.

キーワード: ナノシムス, ジルコン, ウラン鉛年代測定法

Keywords: NanoSIMS, zircon, U-Pb age, Pb-Pb age

## 東南極セールロンダーネ山地に産出する変成炭酸塩岩における化学層序学的堆積年代とジルコン年代を用いた堆積年代 Chemically estimated depositional and zircon ages from metacarbonate rocks in the Sor Rondane Mountains, East Antarctica

大辻 奈穂<sup>1\*</sup>, Madhusoodhan Satish-Kumar<sup>1</sup>, 外田 智千<sup>2</sup>, 堀江 憲路<sup>2</sup>, 亀井 淳志<sup>3</sup>, G.H. Grantham<sup>4</sup>, 土屋 範芳<sup>5</sup>, 河上 哲生<sup>6</sup>, 石川 正弘<sup>7</sup>

Naho Otsuji<sup>1\*</sup>, Satish-Kumar Madhusoodhan<sup>1</sup>, Tomokazu Hokada<sup>2</sup>, Kenji Horie<sup>2</sup>, Atsushi Kamei<sup>3</sup>, G.H. Grantham<sup>4</sup>, Noriyoshi Tsuchiya<sup>5</sup>, Tetsuo Kawakami<sup>6</sup>, Masahiro Ishikawa<sup>7</sup>

<sup>1</sup>新潟大学, <sup>2</sup>国立極地研究所, <sup>3</sup>島根大学, <sup>4</sup>Council for Geoscience, South Africa, <sup>5</sup>東北大学, <sup>6</sup>京都大学, <sup>7</sup>横浜国立大学  
<sup>1</sup>Niigata University, <sup>2</sup>National Institute of Polar Research, <sup>3</sup>Shimane University, <sup>4</sup>Council for Geoscience, South Africa, <sup>5</sup>Tohoku University, <sup>6</sup>Kyoto University, <sup>7</sup>Yokohama National University

Estimation of timing of carbonate deposition implies the presence of platform environment for the accumulation of sediments from surrounding continents. As a consequence the determination of deposition ages in metasedimentary sequences is important in understanding the tectonic history of continental collisions and closure of oceans to form supercontinents. In general, radiometric dating, such as U-Th-Pb, of key horizons or the interval between youngest protolith age and metamorphic age in zircon from metasedimentary rocks helps us to determine the sedimentation age. However, zircons in metasedimentary rocks will provide information of provenance of source rocks in a wide interval between opening and closure of ocean. For this reason, other methods have to be employed for estimating exact depositional ages. In this study we have selected a typical continental collision zone of the Sor Rondane Mountains, located in the African-Antarctic orogenic belt formed during the Neoproterozoic to Cambrian time. This region is composed of medium- to high-grade metasedimentary, metaigneous and intrusive rocks of diverse composition. Shiraishi et al. (2008) and other studies reported wide range of depositional ages that were estimated by detrital and metamorphic ages of zircon from ortho- and paragneiss. Recently, Otsuji et al. (2013), estimated the depositional ages of 880-850 Ma and 820-790 Ma (late-Tonian and early-Cryogenian age) for the metacarbonate rocks by using strontium and carbon isotope chemostratigraphy. The metacarbonate rocks are considered to have deposited chemically in the so-called the "Mozambique Ocean" that separated the continental blocks of Gondwana and possibly record geochemical signatures of contemporaneous seawater. However, according to the results by Otsuji et al. (2013), there are regional differences in their depositional timing. The determination of sedimentation ages may not be straight forward, and it has to be confirmed by the correlation with material derived from continental blocks. Here we present age information from zircon grains in impure metacarbonate rocks.

Petrographic observations of impure metacarbonate rocks, that contain relatively higher modal abundance of calc-silicate minerals, have shown that zircon is present in impure carbonate rocks from the Sor Rondane Mountains. Therefore it is possible that the zircons in impure metacarbonate rocks might be of detrital origin and record information about the provenance of pelitic components within the carbonate sediments. In contrast to the expected detrital ages, we obtained well-defined tight concordia U-Pb zircon ages of 545 +/- 1, 546 +/- 2 and 549 +/- 2 Ma, from three different layers in the Balchen region of the Sor Rondane Mountains. This age represent the latest phase of metamorphic age for this region, as reported in many recent studies. The zircons in metacarbonate rocks show hydrothermal re-equilibration texture on cathodoluminescence observations. Most of them have rounded shape, characterized by the absence of oscillatory growth texture, and shows dissolution-reprecipitation structures. Metacarbonate rocks are usually depleted in zirconium, however those in the Balchen region have abundant zircons. In general, zircon shows enriched heavy-REE pattern, whereas zircon in metacarbonate rocks from Balchen has flat REE pattern and low HREE concentrations, consistent with the rare earth pattern of zircons formed by hydrothermal activity. In addition to the high Cl-rich fluid activity around 600 Ma, our result shows that another important fluid activity was present in Balchen at around 545 Ma. Similar zircon age is reported from the matrix zircon in pelitic gneiss from Balchen (Higashino et al. 2013), implying that pelitic lithology also experienced the same fluid activity at around 545 Ma.

References; Shiraishi et al. 2008. *GSL special publications*, 308, 21-67; Otsuji et al. 2013. *PR* (in press); Higashino et al., 2013. *JpGU abstract*.

Keywords: depositional age, metacarbonate rocks, the Sor Rondane Mountains, zircon