Radiolarian research by the Geological Survey of Japan, AIST, with bibliographic lists from 1950 to 2019

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**Abstract:** The Geological Survey of Japan (GSJ), established in 1882, marked its 135th anniversary in 2017 and has issued numerous publications, such as geologic maps, research articles and newsletters, during its history. This article compiles previous GSJ publications related to radiolarian research for future reference. In the GSJ publications from 1950 to 2019, the term of RADIOLARIA in Japanese appears in 252 Geological Maps of the Quadrangle Series (1:50,000), in 21 Geological Maps of the Quadrangle Series (1:200,000), in 75 articles of the Bulletin of the Geological Survey of Japan, in 14 items in Chishitsu News, in 21 items in GSJ Chishitsu News and in seven articles in the Cruise Report. The GSJ publications related to radiolarian research increased during the 1980s, which is consistent with the commonly called Radiolarian Revolution.

**Keywords:** radiolaria, bibliography, compilation, Paleozoic, Mesozoic, Cenozoic, Japan

1. Introduction

The Geological Survey of Japan (GSJ), a Japanese public organization for geological survey, was established in 1882 under the Ministry of Agriculture and Commerce. In 2001, the National Institute of Advanced Industrial Science and Technology (AIST) was extensively restructured as an independent administrative agency to integrate 15 research institutes, including GSJ.

Since its establishment, GSJ has aimed to make geological maps of Japan and has published many geological maps on several scales (Fig. 1) (Kato et al., 2011). In 1890, GSJ published a geological map of the Japanese Islands (1:3,000,000) for the first time (Fig. 2A). Geologic maps of the Japanese Islands have been often renewed. The most recently published geological map of the Japanese Islands (1:1,000,000) was published in 1992 as the 3rd Edition (Fig. 2B). Twenty quadrangular areas (1:500,000) cover the Japanese Islands (Fig. 3).

GSJ began publishing Geological Maps of the Quadrangle Series (1:50,000) in the 1950s and continued the publication thereafter (e.g. Saito, 2009; Miyazaki, 2018). Radiolarians are important index fossils used to make the geologic maps of the series, some of which contain descriptions of radiolarians. In addition to the geological maps, GSJ has issued various publications, such as the Bulletin of the Geological Survey of Japan and GSJ Chishitsu News. Some of these publications also contain radiolarian information.

GSJ has also conducted marine surveys since the 1970s (e.g. Arai et al., 2013). Some of their survey results have been presented via GSJ publications, such as in the Cruise Report. Description of radiolarians are included in many of these publications because they are marine protozoa that are generally included in ocean deposits around the Japanese Islands.

Geological Maps of the Quadrangle Series (1:50,000), the Bulletin of the Geological Survey of Japan, GSJ Chishitsu News and Chishitsu News can be downloaded as portable document format (PDF) files from the website of GSJ (Appendix). All documents are OCRRed; thus, we searched the documents for the term RADIOLARIA in Japanese (=“放射虫”). The Cruise Report was also downloaded as a PDF file from the website; however, the files are not OCRRed.

Here, we present a brief history of radiolarian research by GSJ via the compilation of previous publications. This paper aims to provide bibliographic lists related to radiolarians for future reference.

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Fig. 1  History of the creation of geological maps by GSJ (modified from Kato et al., 2011).

Fig. 2  Geological maps of GSJ. A: First published geological map of the Japanese Islands (1:3,000,000) by GSJ in 1890, as drawn by T. Harada (reprints from Kato et al., 2011); B: Most recently published geological map of the Japanese Islands (1:1,000,000, 3rd Edition) by GSJ in 1992.
2. Notable descriptions of radiolarian research in GSJ publications

2.1 Geological Maps of the Quadrangle Series (1:50,000)

The Geological Maps of the Quadrangle Series (1:50,000) have been published since the 1950s (Fig. 1). Between 1951 and 2019, over 700 geological maps in the series have been published. Among them, 252 geological maps contain descriptions of radiolaria (Table 1).

Until the early 1970s, radiolaria were not an important index fossil because they could not be extracted from hard rocks. Pessagno and Newport (1972) discovered a radiolarian extraction method by using hydrofluoric acid (HF). Since their discovery, radiolarian studies have rapidly progressed (e.g. Ichikawa, 1982; Yao et al., 2001; O’Dogherty et al., 2009; Danelian et al., 2017). High-resolution biochronology based on microfossils (radiolaria and conodont) prompted the overturn of previously believed scenarios for geologic history of the Japanese Islands (e.g. Sakai et al., 1982; Nakaseko et al., 1983; Ichikawa et al., 1985; Ichikawa, 1990; Isozaki and Maruyama, 1991; Yao and Mizutani, 1993; Isozaki et al., 2010; Agematsu-Watanabe and Kamata, 2018). This research progress and the revision of the geologic history are commonly referred to as the Radiolarian Revolution (e.g. Ishigaki and Yao, 1982; Nakaseko, 1984; Sato, 1989; Suzuki and Aita, 2011; Matsuoka and Ito, 2017). Likewise, the GSJ Publications related to radiolarian research also increased in the early 1980s (Fig. 4). Among the geological maps from 1981 to 2019 that include radiolarian descriptions, approximately half present an occurrence list and/or an image of radiolarians in addition to the text.

Meanwhile, even before the 1970s, radiolarian had been described in some geologic maps. In the 1950s, S. Igi had shown an occurrence species list of radiolarians (identified by K. Ichikawa) from chert of the Hidaka Group in the...
Table 1 Bibliographic list from the Geological Maps of the Quadrangle Series (1:50,000) that include radiolarian descriptions.
+ Appearance from its district. -: Appearance from adjacent district(s).

| No. | District | English | Japanese | Author(s) | Year | Illustrations | Radiolarian age |
|-----|----------|---------|----------|-----------|------|---------------|-----------------|
|     |          |         |          |           |      | SEM           | Thin section    |
|     |          |         |          |           |      | Etched surface| Silurian        |
|     |          |         |          |           |      | Devonian      | Carboniferous   |
|     |          |         |          |           |      | Permian       | Triassic        |
|     |          |         |          |           |      | Jurassic       | Cretaceous      |
|     |          |         |          |           |      | Paleogene     | Neogene         |
|     |          |         |          |           |      | Quaternary    |                 |
| 1   | Abashiri | 網走      | 網走      | Hasegawa K. et al. | 1969 | +             |                 |
| 9   | Kamiokoppe | 上興部    | 上興部    | Hasegawa K. and Uozumi | 1975 | +             |                 |
| 10  | Okoppe   | 興部      | 興部      | Matsunami | 2002 | + +           |                 |
| 15  | Kamishokotsu | 上渚滑    | 上渚滑    | Matsunami et al. | 2002 | - -           | + + +           |
| 23  | Maruseppu-Hokubu | 丸瀬布北部 | 丸瀬布北部 | Yahata et al. | 1988 | + +           |                 |
| 24  | Enganu   | 遠軽      | 遠軽      | Tajika and Yahata | 1991 | +             | + + +           |
| 26, 27 | Abashiri | 網走      | 網走      | Kawakami G. et al. | 2018 | -             | - -             |
| 47  | Kitami   | 北見      | 北見      | Ishida and Sawamura | 1968 | +             |                 |
| 58  | Honki   | 本岐      | 本岐      | Yamaguchi and Sawamura | 1965 | +             |                 |
| 2   | Kushiro  | 釧路      | 釧路      | Sakō and Hasegawa | 1957 | +             |                 |
| 5   | Rikubetsu | 陸別     | 陸別     | Mitani et al. | 1960 | +             |                 |
| 19  | Ashobuto | 足寄太    | 足寄太    | Mitani et al. | 1958 | +             |                 |
| 32  | Honbetsu | 本別      | 本別      | Mitani et al. | 1959 | +             |                 |
| 33  | Kamicharo | 上茶路    | 上茶路    | Sato S. et al. | 1961 | +             |                 |
| 53  | Nukanai | 糠内      | 糠内      | Yamaguchi and Satoh | 1989 | +             |                 |
| 56  | Idomappudake | イドンナップ岳 | イドンナップ岳 | Suzuki M. et al. | 1961a | +             |                 |
| 59  | Chūrui  | 忍顕      | 忍顕      | Yamaguchi et al. | 2003 | +             |                 |
| 65  | Mitsuishi | 三石      | 三石      | Wada et al. | 1992 | -             |                 |
| 66  | Nishicha | 西舎      | 西舎      | Sakai and Kanie | 1986 | + +           |                 |
| 69  | Urakawa | 浦河      | 浦河      | Kanie and Sakai | 2002 | +             |                 |
| 72  | Erimo-Misaki | 襲雲岬    | 襲雲岬    | Igi and Kakimi | 1956 | + +           |                 |
| 3   | Asahikawa | 旭川      | 旭川      | Tanaka K. | 1960 | +             |                 |
| 16  | Kamisarufutsu | 上猿払    | 上猿払    | Tanaka K. | 1960 | +             |                 |
| 20  | Pinmeshiri | 敏音知    | 敏音知    | Igi | 1959 | +             |                 |
| 25  | Hatsuura | 初浦      | 初浦      | Hata | 1961 | +             |                 |

Bibliographic list from the Geological Maps of the Quadrangle Series (1:50,000) that include radiolarian descriptions.
| No. | District                  | Author(s)               | Year | Occurrence list | SEM | Etched surface | Thin section | Silurian | Devonian | Carboniferous | Permian | Triassic | Jurassic | Cretaceous | Paleogene | Neogene | Quaternary |
|-----|--------------------------|-------------------------|------|-----------------|-----|----------------|--------------|-----------|----------|--------------|---------|----------|----------|------------|-----------|----------|------------|
| 35  | Soeushinai               | Hashimoto *et al.*     | 1965 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 39  | Horokanai                | Igi *et al.*            | 1958 | + +             |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 40  | Kenbuchi                 | Matsushita *et al.*    | 1977 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 41  | Rumoii                   | Tsushima and Yamaguchi | 1954 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 42  | Ebishima                 | Watanabe and Yaoshida  | 1995 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 44  | Pippu                    | Suzuki J.              | 1957 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 48  | Fukagawa                 | Suzuki J.              | 1953 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 49  | Asahikawa                | Suzuki J.              | 1955 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 54  | Biei                    | Suzuki M. *et al.*     | 1961 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |

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| No. | District                  | Author(s)               | Year | Occurrence list | SEM | Etched surface | Thin section | Silurian | Devonian | Carboniferous | Permian | Triassic | Jurassic | Cretaceous | Paleogene | Neogene | Quaternary |
|-----|--------------------------|-------------------------|------|-----------------|-----|----------------|--------------|-----------|----------|--------------|---------|----------|----------|------------|-----------|----------|------------|
| 7   | Shimofurano              | Hashimoto               | 1955 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 15  | Ikushimbetsu-Dake        | Yoshida T. and Kambe   | 1955 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 16  | Yamabe                   | Hashimoto               | 1953 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 23  | Yūbari                   | Sasa *et al.*           | 1964 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 24  | Ōyubari                  | Nagao *et al.*          | 1954 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 25  | Ishikarikanayama         | Osanai *et al.*         | 1958 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 32  | Oriwake                  | Matsumoto and Hata     | 1960 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 33  | Momijiyama               | Takahashi Koh. *et al.*| 2002 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 34  | Hidaka                   | Takahashi Koh. and Suzuki | 1986 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 35, 46 | Harauta and Karibayama | Yamagishi and Kurosawa | 1987 | -               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 41  | Tarumaizan               | Doi                     | 1957 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 45  | Iwachishi                | Takahashi Koh. and Suzuki | 1978 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 47  | Ohbirayama               | Kurosawa *et al.*       | 1993 | + +             |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 52  | Shiraoi                  | Doi                     | 1953 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 55  | Tomikawa                 | Imai and Sumi           | 1957 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| 56  | Biu                      | Yoshida T. *et al.*     | 1959 | +               |     |                |              |           |          |              |         |          |          |            |           |          |            |
| No. | District | English | Japanese | Author(s) | Year | Text | SEM | Etched surface | Thin section | Silurian | Devonian | Carboniferous | Permian | Triassic | Jurassic | Cretaceous | Palaeogene | Neogene | Quaternary |
|-----|----------|---------|----------|-----------|------|------|-----|---------------|-------------|----------|----------|-------------|---------|---------|---------|------------|------------|--------|-----------|
| 64, 65, 71, 72 | Okushiritō Hokubu and Nambu | 奥尻島北部及び南部 | Hata et al. | 1982 | + | | | | | | | | | | |
| 73 | Kumaishi | 熊石 | Hata | 1975 | + | | | | | | | | | | |
| 87 | Esan | 忠山 | Fujiwara and Kônoya | 1969 | + | | | | | | | | | | |
| 92 | Matsumae | 松前 | Hata et al. | 1990 | + | | | | | | | | | | |
| 5 | Aomori | 青森 | | | | | | | | | | | | | |
| 4 | Shiriyazaki | 兀屋崎 | Tsushima and Takizawa | 1977 | + | | | | | | | | | | |
| 5 | Ichinohe | 一戸 | Tuzino et al. | 2018 | + | | | | | | | | | | |
| 10 | Kodomari | 小泊 | Tsushima and Uemura | 1959 | + | | | | | | | | | | |
| 11 | Kanita | 蟹田 | Uemura et al. | 1959 | + | | | | | | | | | | |
| 20 | Aji-gasawa | 鰤ヶ沢 | Hirayama J. and Uemura | 1985 | + | | | | | | | | | | |
| 22 | Aomori-Setibu | 青森西部 | Nagamori et al. | 2013 | + | | | | | | | | | | |
| 26 | Fukaura | 深浦 | Moritani | 1968 | + | | | | | | | | | | |
| 35 | Nakahama | 中浜 | Ōzawa et al. | 1983 | + | | | | | | | | | | |
| 38 | Towada ko | 十和田湖 | Kudo et al. | 2019 | + | | | | | | | | | | |
| 43 | Noshiro | 能代 | Ōzawa et al. | 1984 | + | | | | | | | | | | |
| 49 | Rikuchū-Ōno | 隠ヶ大野 | Yoshida T. et al. | 1987 | + | | | | | | | | | | |
| 51 | Ugo-Hamada | 羽後浜田 | Ōzawa et al. | 1985 | + | | | | | | | | | | |
| 52 | Moritake | 森岳 | Ōzawa et al. | 1985 | + | | | | | | | | | | |
| 6 | Akita | 秋田 | | | | | | | | | | | | | |
| 1, 2 | Toga and Funakawa | 戸賀及び船川 | Kano K. et al. | 2011 | + | | | | | | | | | | |
| 3 | Gojōme | 五城目 | Hase and Hirayama | 1970 | + | | | | | | | | | | |
| 4 | Aniai, 2nd Edition | 阿仁合(第2版) | Kano K. et al. | 2012 | + | | | | | | | | | | |
| 11 | Akita | 秋田 | Huzioka et al. | 1977 | + | | | | | | | | | | |
| 12 | Taiheizan | 大平山 | Ōzawa et al. | 1981 | + | | | | | | | | | | |
| 19 | Ugo-Wada | 羽後和田 | Huzioka et al. | 1976 | + | | | | | | | | | | |
| 20 | Kariwano | 剰和野 | Tsuchiya and Yoshikawa | 1994 | + | | | | | | | | | | |
## Table 1 Continued.

| No. | English       | Japanese       | Author(s)             | Year | Text | Occurrence list | SEM | Etched surface | Thin section | Silurian | Devonian | Carboniferous | Permian | Triassic | Jurassic | Cretaceous | Paleogene | Neogene | Quaternary |
|-----|---------------|----------------|------------------------|------|------|----------------|-----|----------------|--------------|----------|----------|---------------|---------|----------|----------|------------|------------|----------|------------|
| 24  | Hayachine San | 早池峰山       | Kawamura *et al.*      | 2013 | +    | +             |     | +              | +            | +        | -        | +             | +       | +        | +        | +          | +          | +        |            |
| 26  | Miyako        | 宮古            | Yoshida T. and Katada  | 1984 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 28  | Honjō         | 本荘            | Ōzawa *et al.*         | 1977 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 35, 36 | Otsuchi and Karodake | 大槌・霞露岳 | Yoshida T. and Katada  | 1964 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 37  | Kisakata      | 象潟            | Ōzawa *et al.*         | 1982 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 38  | Yashima       | 矢島            | Ōzawa *et al.*         | 1988 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 39  | Asamai        | 浅舞            | Ōzawa *et al.*         | 1979a| +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 46, 47 | Chōkaisan and Fukura | 烏海山及び吹浦 | Nakano and Tsuchiya   | 1992 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 48  | Yuzawa        | 湯沢            | Ōzawa *et al.*         | 1979b| +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 55  | Sakata        | 酒田            | Ikebe *et al.*         | 1979 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 56  | Ōsawa         | 大沢            | Tsuchiya              | 1989 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 64  | Tsunokura     | 鶴岡            | Tsuchiya *et al.*      | 1984 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 65  | Kiyokawa      | 清川            | Tsuchiya *et al.*      | 1986 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 79  | Toyama        | 登米            | Takizawa *et al.*      | 1990 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 98  | Sendai        | 仙台            | Kitamura *et al.*      | 1986 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 7   | Niigata       | 新潟            | Takahashi Yut. *et al.*| 1996 | -    |               |     |                |              | -        |          | -             | -       | -        | -        | -          | -          | -        |            |
| 11  | Iidesan       | 飯豊山         | Takahashi Yut. *et al.*| 1996 | -    |               |     |                |              | -        |          | -             | -       | -        | -        | -          | -          | -        |            |
| 12  | Tamaniwa      | 玉庭          | Yanagisawa and Yamamoto| 1998 | -    |               |     |                |              | -        |          | -             | -       | -        | -        | -          | -          | -        |            |
| 16  | Kakuda        | 角田          | Fujita *et al.*        | 1988 | -    |               |     |                |              | -        |          | -             | -       | -        | -        | -          | -          | -        |            |
| 25  | Sōmanakamura  | 相馬中村        | Yanagisawa *et al.*    | 1996 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 26  | Izumoizaki    | 出雲崎        | Kobayashi *et al.*     | 1993 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 27  | Sanjō         | 三条           | Kobayashi *et al.*     | 2002 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 27  | Kamo          | 加茂           | Kudo *et al.*          | 2011 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 31  | Kitakata      | 喜多方         | Yamamoto *et al.*      | 2005 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 35, 36 | Haramachi and Ōmika | 原町及び大甕     | Kubo *et al.*          | 1990 | +    |               |     |                |              | -        |          | -             | -       | -        | -        | -          | -          | -        |            |
| 37  | Kashiwazaki   | 柏崎           | Kobayashi *et al.*     | 1995 | +    |               |     |                |              | +        |          | +             | +       | +        | +        | +          | +          | +        |            |
| 38  | Nagaoaka      | 長岡          | Kobayashi *et al.*     | 1991 | -    |               |     |                |              | -        |          | -             | -       | -        | -        | -          | -          | -        |            |
Table 1 Continued.

| No. | District | English | Japanese | Author(s) | Year | Illustrations | Radiolarian age |
|-----|----------|---------|----------|-----------|------|---------------|----------------|
|     |          |         |          |           |      | SEM           | Text           |
|     |          |         |          |           |      | Etched surface| Occurrence list |
|     |          |         |          |           |      | Thin section  |                |
|     |          |         |          |           |      | Silurian      |                |
|     |          |         |          |           |      | Devonian      |                |
|     |          |         |          |           |      | Permian       |                |
|     |          |         |          |           |      | Triassic      |                |
|     |          |         |          |           |      | Jurassic      |                |
|     |          |         |          |           |      | Cretaceous    |                |
|     |          |         |          |           |      | Paleogene     |                |
|     |          |         |          |           |      | Neogene       |                |
|     |          |         |          |           |      | Quaternary    |                |
| 41  | Miyashita| 宮下     | Yamamoto and Komazawa | 2004 | + |                  | + |
| 42  | Wakamatsu| 若松     | Yamamoto and Yoshioka  | 1992 | + |                  | + + |
| 46  | Namie and Iwaki-Tomioka | 浪江及び磐城富岡 | Kubo et al. | 1994 | + |                  | + |
| 50  | Oiwa     | 小千谷  | Yanagisawa et al.     | 1986 | - |                  | - |
| 51  | Suhara   | 須原   | Takahashi Yut. et al.  | 2004 | + + |                  | + + + |
| 54  | Tajima   | 田島   | Yamamoto             | 1999 | + |                  | + |
| 58, 59 | Kawamae and Ide | 川前及び井出 | Kubo et al. | 2002 | + |                  | + |
| 63  | Tōkamachi | 十日町 | Yanagisawa et al.     | 1985 | + |                  | + |
| 64  | Hakkaisan | 八海山 | Chihara and Komatsu   | 1992 | - |                  | - |
| 70  | Takanuki | 竹貫   | Kano H. et al.        | 1973 | + |                  | + |
| 71, 58, 59 | Taira and Kawamae (incl. Ide) | 平・川前(付井出) | Iwao and Matsui | 1961 | + |                  | + |
| 103 | Utsunomiya | 宇都宮 | Yoshikawa et al.     | 2010 | - |                  | - |
| 8   | Tōkyō | 東京   | Fujimoto | 1961 | + |                  | + |
| 11  | Nakaminato | 那珂湊 | Sakamoto et al.      | 1972 | + |                  | + |
| 27  | Yorii  | 寄居   | Makimoto and Takeuchi | 1992 | + + |                  | + + + |
| 34  | Takatō | 高遠   | Makimoto et al.       | 1996 | + |                  | - - + |
| 37  | Misumine | 三峰  | Hara et al.          | 2010 | + + |                  | + + + |
| 45  | Ichinose | 市野瀬 | Kawachi et al.       | 1983 | - |                  | - |
| 49  | Itsukaichi | 五日市 | Sakai                | 1987 | + + |                  | + + + + + + |
| 50  | Ōme    | 青梅   | Ueki and Sakai       | 2007 | + |                  | + + + + + + |
| 59  | Kofu   | 甲府   | Katada              | 1956 | + |                  | + |
| 62  | Hachiōji | 八王子 | Ueki et al.       | 2013 | + |                  | + + |
| 69  | Minobu | 身延   | Ozaki and Sugiyama   | 2018 | + + |                  | - - - - - |
| 79  | Nanbu | 南部   | Sugiyama Y. and Matauda | 2014 | + + |                  | + + |

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Table 1 Continued.

| No. | District | English | Japanese | Author(s) | Year | Occurrence list | SEM | Etched surface | Thin section | Silurian | Devonian | Carboniferous | Permian | Triassic | Jurassic | Cretaceous | Paleogene | Neogene | Quaternary |
|-----|----------|---------|----------|-----------|------|----------------|-----|----------------|-------------|----------|----------|--------------|---------|---------|----------|-----------|----------|---------|------------|
| 84  | Yokosuka | 横須賀   | Eto et al. | 1998     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 85  | Futsu    | 富津     | Nakajima and Watanabe | 2005     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 87  | Kazusa-Obara | 上総大原 | Utsunomiya and Ooi | 2019     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 89  | Shimizu  | 清水     | Sugiyama Y. and Shimokawa | 1990     | +    |                |     |                |             | +        |          |              |         |         |          |           |          |         |            |
| 94  | Nago     | 那古     | Suzuki Y. et al. | 1990     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 95  | Kamogawa | 鴨川     | Nakajima et al. | 1981     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 98  | Shizuoka | 静岡     | Sugiyama Y. et al. | 1982     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 102 | Tateyama | 館山     | Kawakami S. and Shishikura | 2006     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 10  | Kanazawa | 金沢     |                      |          |      |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 3, 4, 6, 7 | Suzumisaki, Noto-iida and HoRYUzan | 珠洲岬, 能登飯田及び宝立山 | Yoshikawa et al. | 2002 | + |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 14  | Itoigawa | 系魚川 | Nagamori et al. | 2018     | -    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 15, 16 | Ōchigata and Abugashima | 良知浦・虻ガ島 | Imai and Sakamoto | 1966     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 18  | Tomari   | 宿利     | Takeuchi M. et al. | 2017     | -    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 19  | Kotaki   | 小滝     | Nagamori et al. | 2010     | +    |                |     |                |             | +        |          |              |         |         |          |           |          |         |            |
| 23  | Uozu     | 魚津     | Sunii and Nozawa | 1973     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 25  | Shiroumadake | 白馬岳 | Nakano et al. | 2002     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 28  | Yatsuo  | 八尾     | Sakamoto and Nozawa | 1960     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 31  | Ōmachi  | 大町     | Kato et al. | 1989     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 37  | Yaigatake | 槿ヶ岳 | Harayama et al. | 1991     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 45  | Kamikōchi | 上高地 | Harayama | 1990     | +    |                |     |                |             | +        |          |              |         |         |          |           |          |         |            |
| 47  | Fukui   | 福井     | Kano K. et al. | 2007     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 52  | Takayama | 高山     | Yamada et al. | 1985     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
| 53  | Norikuradake | 乗鞍岳 | Nakano et al. | 1995     | +    |                |     |                |             | +        |          |              |         |         |          |           |          |         |            |
| 58  | Arashimadake | 荒島岳 | Kawai et al. | 1957     | +    |                |     |                |             |          |          |              |         |         |          |           |          |         |            |
Table 1  Continued.

| No. | District          | English  | Japanese   | Author(s)       | Year | Text | Occurrence list | Illustrations | Radiolarian age |
|-----|-------------------|----------|------------|-----------------|------|------|----------------|---------------|-----------------|
| 60  | Hagiwara         | 萩原     | Kawada et al. | 1988          | +    | +    | SEM            | -             | -               |
| 61  | Ontakesan        | 吉國山   | Yamada and Kobaishi | 1988 | +    | -    | Etched surface | -             | -               |
| 62  | Kiso-Fukushima   | 木曽福島 | Takeuchi M. et al. | 1998 | +    | -    | Thin section   | -             | -               |
| 63  | Ina               | 伊那     | Katada and Isomi | 1962          | +    |       | Silurian       | -             | -               |
| 64  | Imajō and Takenami | 今庄及び竹波 | Nakae et al. | 2013 | +    | +    | Devonian       | +             | +               |
| 65  | Kiso-Fukushima   | 木曽福島 | Takeuchi M. et al. | 1998 | +    | -    | Carboniferous  | -             | -               |
| 66  | Gero             | 下呂     | Wakita and Koido | 1994          | +    | +    | Permian        | +             | +               |
| 67  | Tangoyura        | 丹後由良 | Hirokawa and Kuroda | 1958 | +    |       | Triassic       | +             | +               |
| 68  | Kanmuri Yama     | 冠山     | Nakae et al. | 2015 | +    | +    | Jurassic       | +             | +               |
| 69  | Neo               | 根尾     | Kawai | 1964 | -    |       | Cretaceous     | -             | -               |
| 70  | Hachiman         | 八幡     | Wakita | 1984 | +    | +    | Paleogene      | +             | +               |
| 71  | Gero             | 下呂     | Wakita and Koido | 1994 | +    | +    | Neogene        | -             | -               |
| 72  | Nishizuka        | 西津     | Nakae et al. | 2002 | +    | +    | Quaternary     | +             | +               |
| 73  | Tsuruga          | 敦賀     | Kurimoto et al. | 1999 | +    | +    | No.            | +             | +               |
| 74  | Yokoyama         | 横山     | Saito and Sawada | 2000 | +    | +    | District       | +             | +               |
| 75  | Tanigumi         | 谷汲     | Wakita | 1991 | +    | +    | Author(s)      | +             | +               |
| 76  | Mino             | 美濃     | Wakita | 1995 | +    | -    | Year           | +             | -               |
| 77  | Kanayama         | 金山     | Mizutani and Koido | 1992 | +    |       | Text           | +             | +               |

**Kyōto**

| No. | District     | English  | Japanese  | Author(s)       | Year | Text | Occurrence list | Illustrations | Radiolarian age |
|-----|--------------|----------|-----------|-----------------|------|------|----------------|---------------|-----------------|
| 2   | Maizuru      | 舞鶴     | Igi et al. | 1961 | +    |       | SEM            | -             | -               |
| 3   | Obama        | 小浜     | Hirokawa et al. | 1957 | +    |       | Etched surface | -             | -               |
| 4   | Kumagawa     | 熊川     | Nakae and Yoshioka | 1998 | +    | +    | Thin section   | +             | +               |
| 5   | Chikubu Shima | 竹生島   | Nakae et al. | 2001 | +    | +    | Silurian       | -             | -               |
| 8   | Gifu         | 岐阜     | Yoshida F. and Wakita | 1999 | +    | +    | Devonian       | +             | +               |
| 13  | Fukuchiyama  | 福知山   | Kurimoto and Makimoto | 1990 | +    | +    | Carboniferous  | +             | +               |
| 14  | Ayabe        | 鶴ヶ丘   | Kimura et al. | 1989 | +    |       | Permian        | +             | +               |
| 15  | Yotsuya      | 四ツ谷   | Kimura et al. | 1994 | +    | +    | Triassic       | +             | +               |
| 16  | Kitakomatsu  | 北小松   | Kimura et al. | 2001 | +    | +    | Jurassic       | -             | +               |
| 19  | Nagoya-Hokoku | 名古屋北部 | Sakamoto et al. | 1984 | +    |       | Cretaceous     | +             | +               |
| No. | District       | English          | Japanese     | Author(s)      | Year  | Illustrated  | Radiolarian age |
|-----|----------------|------------------|--------------|---------------|-------|-------------|-----------------|
|     |                |                  |              |               |       | SEM         | Etched surface | Thin section | Silurian | Devonian | Carboniferous | Permian | Triassic | Jurassic | Cretaceous | Paleogene | Neogene | Quaternary |
| 25  | Sasayama       | 篠山             | Kurimoto et al. | 1993         | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 26  | Sonobe         | 阪部             | Imoto et al.  | 1991         | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 27  | Kyōto-Seihokubu| 京都西部         | Imoto et al.  | 1989         | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 28  | Kyōto-Tōhokubu | 京都東北部      | Kimura et al. | 1998         | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 29  | Ōmi-hachiman   | 近江八幡         | Yoshida F. et al. | 2003     | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 30  | Gozaishoyama   | 御在所山         | Harayama et al. | 1989     | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 31  | Kuwana         | 桑名             | Yoshida F. et al. | 1991     | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 38  | Hirone         | 広根             | Matsuura et al. | 1995     | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 39  | Kyōto-Seinambu | 京都西南部       | Miyachi et al. | 2005     | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 40  | Kyōto-Tōnambu  | 京都東南部      | Wakita et al. | 2013     | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 41  | Minakuchi      | 水口             | Nakano et al. | 2003     | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 49  | Köbe           | 神戸             | Huzita and Kasama | 1983     | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 50  | Osaka-Seihokubu| 大阪西部         | Huzita and Kasama | 1982     | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 54  | Tsu-Seibu      | 津西部           | Yoshida F. et al. | 1995     | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 58, 70 | Toyohashi and Tahara | 豊橋及び旧原 | Nakashima et al. | 2008 | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 59  | Hamamatatsu    | 浜松             | Isomi and Inoue | 1972     | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 60, 71 | Mitsuke and Kakezuka | 見付・掛塚 | Makida and Sakamoto | 1957 | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 62  | Osaka-Seinambu | 大阪西南部       | Huzita and Maeda | 1985 | -     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 69  | Inagomisaki    | 伊良湖岬         | Nakashima et al. | 2010 | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 73  | Kishiwada      | 岸和田           | Itihara et al. | 1986     | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 79  | Toba           | 鳥羽             | Uchino et al. | 2017     | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 81  | Kokawa         | 粉河             | Makimoto et al. | 2004 | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 82  | Koyasan        | 高野山           | Hirayama K. and Kambe | 1959 | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 83  | Sanjōgatake    | 山上ヶ岳         | Shida et al.  | 1989     | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 88  | Kainan         | 海南             | Hirayama K. and Tanaka | 1956a | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 89  | Todorogi       | 動木             | Hirayama K. and Tanaka | 1956b | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| 96  | Ryūjin         | 龍神             | Tokuoka et al. | 1981 | +     | +           | +               | -            |          |          |             |         |          |          |            |           |         |            |
| No. | District | English | Author(s) | Year | Occurrence list | Illustrations | Etched surface | SEM | Table 1 Continued. | Corrected Proof |
|-----|----------|----------|-----------|------|----------------|---------------|---------------|-----|-------------------|----------------|
| 106 | Esami | 1979 | Tsuta et al. | + | + | + | + | + | + | + | + | + | + | + |
| 12  | Okayama | 2000 | Tsuta et al. | 1963 | + | + | + | + | + | + | + | + | + | + |
| 11, 21 | Tottorihokubu and Tottorinambu | 1998 | Kano K. et al. | 1998 | + | + | + | + | + | + | + | + | + | + |
| 20  | Motomachi | 1966 | Kano K. et al. | 1966 | + | + | + | + | + | + | + | + | + | + |
| 16  | Hata | 2001 | Kanno et al. | 2002 | + | + | + | + | + | + | + | + | + | + |
| 17  | Matsuura | 2005 | Yamamoto et al. | 2000 | + | + | + | + | + | + | + | + | + | + |
| 32  | Chizui | 1990 | Murayama et al. | 1963 | + | + | + | + | + | + | + | + | + | + |
| 25, 26 | Iwami-Ōda and Ōura | 1998 | Kano K. et al. | 1998 | + | + | + | + | + | + | + | + | + | + |
| 36, 37 | Yunotsu and Gōtsu | 1999 | Yamada et al. | 1999 | + | + | + | + | + | + | + | + | + | + |
| 46  | Yamasaki | 2002 | Yamamoto et al. | 2000 | + | + | + | + | + | + | + | + | + | + |
| 47  | Ikuno | 2005 | Yamamoto et al. | 2000 | + | + | + | + | + | + | + | + | + | + |
| 50  | Akana | 2007 | Yamamoto et al. | 2000 | + | + | + | + | + | + | + | + | + | + |
| 58  | Tatsuno | 1995 | Yamamoto et al. | 1995 | + | + | + | + | + | + | + | + | + | + |
| 59  | Hōjō | 2013 | Yamamoto et al. | 2000 | + | + | + | + | + | + | + | + | + | + |
| 2  | Hiroshima | 1991 | Takahashi Yuh. et al. | 1991 | + | + | + | + | + | + | + | + | + | + |
| 3  | Kaitaichi | 1999 | Takahashi Yut. et al. | 1999 | + | + | + | + | + | + | + | + | + | + |
| 11  | Sumoto | 1992 | Takashima et al. | 1992 | + | + | + | + | + | + | + | + | + | + |
| 12  | Ono | 1986 | Takashima et al. | 1986 | + | + | + | + | + | + | + | + | + | + |
| 24  | Wakahama | 1993 | Takashima et al. | 1993 | + | + | + | + | + | + | + | + | + | + |
| 25, 26 | Kurasaki Jima and Tatsuno Jima | 2007 | Takahashi et al. | 2001 | + | + | + | + | + | + | + | + | + | + |
| 30  | Kan-onji | 2017 | Takahashi et al. | 2017 | + | + | + | + | + | + | + | + | + | + |
| 40  | Niihama | 2013 | Noda et al. | 2013 | + | + | + | + | + | + | + | + | + | + |
### Table 1  Continued.

| No. | District | Author(s) | Year | Occurrence list | SEM | Etched surface | Thin section | Silurian | Devonian | Carboniferous | Permian | Triassic | Jurassic | Cretaceous | Paleogene | Neogene | Quaternary |
|-----|----------|-----------|------|----------------|-----|----------------|-------------|----------|----------|--------------|---------|----------|----------|------------|-----------|---------|------------|
| 52  | Hibihara | Aoya and Yokoyama | 2009 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 53  | Motoyama | Endo and Yokoyama | 2019 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 55  | Kitagawa | Hara et al. | 2014 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 59  | Ōzu      | Banno et al. | 2010 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 77  | Uwajima  | Teraoka et al. | 1986 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 87  | Tsurumisaki | Okumura and Teraoka | 1988 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 88  | Iyokashima and Sukumo | Tanaka K. | 1980 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 14  | Fukuoka  |                        |      |            |    |                |             |          |          |              |         |          |          |            |           |         |            |
| 34  | Kokura   | Nakae et al. | 1998 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 68  | Sasebo   | Matsui et al. | 1989 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 77  | Saganoseki | Miyazaki and Yoshioka | 1994 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 87  | Inukai   | Teraoka et al. | 1992 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 88  | Usuki    | Kambe and Teraoka | 1968 | -         |    |                |             |          |          |              |         |          |          |            |           |         | -          |
| 15  | Kagoshima |                        |      |            |    |                |             |          |          |              |         |          |          |            |           |         |            |
| 24  | Miemachi | Sakai et al. | 1993 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 25  | Saiki    | Teraoka et al. | 1990 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 34  | Kumata  | Okumura et al. | 1998 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 35  | Kamae   | Okumura et al. | 1985 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 41  | Tomochi | Saito et al. | 2005 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 44  | Nobeoka | Okumura et al. | 2010 | -         |    |                |             |          |          |              |         |          |          |            |           |         | -          |
| 51  | Shibanuma | Saito et al. | 1996 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 59  | Murasho | Hara et al. | 2009 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 60  | Osuzuyama | Kimura et al. | 1991 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 68  | Tsuma and Takanabe | Endo and Suzuki | 1986 | +         |    |                |             |          |          |              |         |          |          |            |           |         | -          |
| 90  | Sueyoshi | Saito et al. | 1994 | +         | +  | -              | -           | -        | -        | -            | -       | -        | -        | -          | -         | -       | -          |
| 100 | Kaimon Dake | Kawanabe and Sakaguchi | 2005 | -         |    |                |             |          |          |              |         |          |          |            |           |         | -          |
Erimo-Misaki district (Igi and Kakimi, 1956) and from chert of the Sorachi Group in the Horokanai district (Igi et al., 1958). They regarded the Hidaka and Sorachi groups as pre-Cretaceous and Upper Jurassic, respectively.

Mid-Mesozoic accretionary complexes are widely exposed in the Japanese Islands and generally contain Permian, Triassic and Jurassic radiolarians (e.g. Kojima et al., 2016). Because of their importance for age determination to draw the geological maps, their occurrences have been reported by several maps in most areas (Fig. 5).

Yamada (1966) presented a thin section photograph of radiolarian remains within phyllite of the Sangun metamorphic rocks in the Chizu district (Fig. 6A), which was the first illustration of radiolarians in the geological maps of the series. Sakamoto et al. (1984) presented Jurassic radiolarians (Fig. 6B) from siliceous rocks in the Nagoya-Hokubu district. This was the first radiolarian description with scanning electron microscopy (SEM) images in the geological maps of the series.

2.2 Geological Maps of the Quadrangle Series (1:200,000)

The Geological Maps of the Quadrangle Series (1:200,000) have been published since the 1880s (Fig. 1). Since the 1950s, new version of the series has been published. However, the series published before 2000 contains the geological map only but not the explanation text. The explanation text of 21 geological maps contain descriptions of radiolarians (Table 2).

Radiolarian images are not generally shown in the series because of a space constraint. Saito et al. (2007b) showed Eocene radiolarian images reprinted from Saito et al. (2007a).

2.3 Bulletin of the Geological Survey of Japan

The Bulletin of the Geological Survey of Japan is an open access monthly–bimonthly journal that has been published since 1950. Research achievements by primarily GSJ’s researchers have been published in this journal. Among the 709 issues of this journal from 1950 to 2019, 75 articles contain descriptions of radiolarians (Table 3). Article including radiolarian description increased in the early 1980s (Fig. 4) as in the case of the Geological Maps of the Quadrangle Series (1:50,000).

Some articles contain abundant radiolarian images (e.g. Hori, 2004b, c, d; Motoyama et al., 2010; Nakae, 2013a, b; Kurimoto et al., 2015). Radiolarian images have covered some volumes of the Bulletin of the Geological Survey of Japan (e.g. vol. 55, no. 9/10; vol. 68, no. 2; vol. 70, no. 1/2). Sugiyama and Saito (1994) described two new species, i.e. Podocyrtis (Lampterium) mirabilis Sugiyama and Saito and Lophocyrtis? caviundus Sugiyama and Saito from the Paleogene in the Suez Yoshi district. Kamikuri (2019b) described new species, Lychnocanoma californica Kamikuri, from the upper Miocene in the eastern North Pacific.
Fig. 4  Quinquennial number of GSJ publications that contain the term RADIOLARIA in Japanese (="放射虫").

Fig. 5  Age distribution of radiolarian descriptions in GSJ publications.
Fig. 6  Notable figures of radiolarian research by GSJ. A: First photograph of radiolarians within phyllite (thin section) in the Geological Maps of the Quadrangle Series (1:50,000) (reprints from Yamada, 1966). B: First SEM images of radiolarians in Geological Maps of the Quadrangle Series (1:50,000) (reprints from Sakamoto et al., 1984). C: First SEM images of radiolarians in GSJ publications (Chishitsu News) (reprints from Sakai et al., 1982). D: Illustrations of cartoon radiolarians shown in Chishitsu News (reprints from Wakita and Kawamura, 1985). E: Possible first images of radiolarian individuals in GSJ publications (Cruise Report) (reprints from Arita and Mizuno, 1977).
2. 4 Chishitsu News and GSJ Chishitsu News

Chishitsu News and GSJ Chishitsu News are monthly newsletters published by GSJ. Chishitsu News was published from 1953 to 2011. From 2011 and onward, GSJ Chishitsu News has been published as a successor to Chishitsu News.

In total, 14 and 21 articles containing radiolarian descriptions were published in Chishitsu News and GSJ Chishitsu News, respectively (Tables 4, 5). Fukuda and Natori (1977) showed a transmitted photomicrograph of Neogene radiolaria reprinted from Nakaseko and Sugano (1973). This was possibly the first isolated radiolarian images presented in the GSJ publications. Sakai et al. (1982) introduced a micropaleontological study on conodont and radiolaria and described their significance in Chishitsu News at the dawn of the Radiolarian Revolution. They also showed SEM images (Fig. 6C), which were the first SEM images published in the GSJ publications. Wakita and Kawamura (1985) wrote an essay about radiolarians, which included some SEM images, thin section and cartoons (Fig. 6D).

Since 1997, the Geological Museum owned by GSJ has displayed radiolarian exhibits, such as panels and models (Toshimitsu and Saito, 1997). The Geological Museum also made a poster showing radiolarians with reconstructed oceanic plate stratigraphy in Jurassic accretionary complexes (Fig. 7). Special exhibitions related to radiolarians have often been displayed in the museum (e.g. Shibahara et al., 2012; Ito et al., 2017).

2. 5 Cruise Report

GSJ had published the Cruise Report from 1972 to 1997. Twenty-four issues of the Cruise Report were published during this time period. Among them, seven articles contain descriptions of radiolarians (Table 6).

Arita and Mizuno (1977) showed photomicrographs of living radiolarians from the central–eastern part of the Central Pacific Basin (Fig. 6E). These were possibly one of the first isolated radiolarian images in the GSJ publications like Fukuda and Natori (1977).

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Table 3  Bibliographic list from the Bulletin of the Geological Survey of Japan that include radiolarian descriptions.

| Author(s)          | Bibliography | Year | Vol. | No. | Pages       | Text Occurrence list | Images | Radiolarian age |
|--------------------|--------------|------|------|-----|-------------|----------------------|--------|-----------------|
| Hara and Hara      |              | 2019 | 70   | 1/2 | 117–123     | +                    | +      | +               |
| Hara et al.        |              | 2012 | 63   | 11/12| 301–308     | + + + + +           | + + + + + |
| Hattori            |              | 1993 | 44   | 7   | 455–469     | +                    | +      |                 |
| Hori N.            |              | 2004a| 55   | 9/10| 271–285     | +                     | + + +   |                 |
|                    |              | 2004b| 55   | 9/10| 287–301     | + + + + +           | + + + +  |                 |
|                    |              | 2004c| 55   | 9/10| 303–334     | + + +                | + + + +  |                 |
|                    |              | 2004d| 55   | 9/10| 335–388     | + + +                | + + + +  |                 |
|                    |              | 2005 | 56   | 1/2 | 37–83       | + + +                | + + +    |                 |
| Hori N. et al.     |              | 2002 | 53   | 9/10| 689–724     | + + + + +           | + + + +  |                 |
| Hori R. S.         |              | 1993 | 44   | 9   | 555–570     | +                    | + +     |                 |
| Imoto and Saijyo   |              | 1993 | 44   | 9   | 547–554     | +                    | + +     |                 |
| Ishiga and Yamakita|              | 1993 | 44   | 7   | 419–423     | +                    | + +     |                 |
| Ishiga et al.      |              | 1993 | 44   | 12  | 721–726     | +                    | + + + +  |                 |
| Ito                |              | 2019a| 70   | 1/2 | 225–247     | + + + + + +         | + + + +  |                 |
| Kakuwa             |              | 1993 | 44   | 9   | 533–546     | +                    | + + + +  |                 |
| Kametaka et al.    |              | 2005 | 56   | 7/8 | 237–243     | + + +                | + +     |                 |
| Kamikuri           |              | 2019a| 70   | 1/2 | 137–161     | + + +                | + +     |                 |
|                    |              | 2019b| 70   | 1/2 | 163–194     | + + +                | + +     |                 |
| Kashiwagi and Kurimoto|          | 2003 | 54   | 7/8 | 279–293     | + + +                | + +     |                 |
| Kimura             |              | 1997 | 48   | 6   | 313–337     | +                    | + + + +  |                 |
| Kimura and Nakae   |              | 1993 | 44   | 12  | 727–743     | + + + +               | + +     |                 |
| Kojima et al.      |              | 1994 | 45   | 2   | 63–97       | + + +                | + + +   |                 |
| Kojima and Saito   |              | 2000 | 51   | 4   | 143–165     | +                    | + +     |                 |
| Kurimoto           |              | 1987 | 38   | 2   | 69–80       | + + +                | + +     |                 |
|                    |              | 1989 | 40   | 2   | 55–63       | + + +                | + +     |                 |
|                    |              | 1994a| 45   | 5   | 235–255     | + + + + +           | +       |                 |
| Kurimoto and Kuwahara|            | 1991 | 42   | 2   | 69–73       | + + +                | + +     |                 |
| Kurimoto et al.    |              | 2015 | 66   | 3/4 | 41–79       | + + +                | + + +   |                 |
| Matsuzaki and Itaki|              | 2019 | 70   | 1/2 | 195–209     | + + +                | + + +   |                 |
| Mizutani           |              | 2019 | 70   | 1/2 | 261–265     | +                    | + +     |                 |
| Motoyama           |              | 2019 | 70   | 1/2 | 125–136     | +                    | + +     |                 |
| Motoyama and Itaki |              | 2019 | 70   | 1/2 | 1–4         | +                    | + +     |                 |
| Motoyama and Maruyama|            | 2019 | 46   | 7   | 333–374     | + + +                | + + +   |                 |
| Motoyama et al.    |              | 2010 | 61   | 3/4 | 87–103      | + + +                | + +     |                 |
| Musashino          |              | 1993 | 44   | 12  | 699–705     | +                    | + +     |                 |
| Muto et al.        |              | 2019 | 70   | 1/2 | 43–89       | +                    | +       |                 |
| Nakae              |              | 1993 | 44   | 7   | 471–481     | +                    | + +     |                 |
|                    |              | 2000 | 51   | 4   | 113–128     | + + +                | +       |                 |
|                    |              | 2001 | 52   | 6/7 | 245–252     | + + +                | +       |                 |
|                    |              | 2002 | 53   | 1   | 51–59       | + + +                | +       |                 |
|                    |              | 2006 | 57   | 1/2 | 29–50       | +                    | + +     |                 |
|                    |              | 2011 | 62   | 11/12| 441–453     | + + +                | +       |                 |
|                    |              | 2012 | 63   | 9/10| 269–281     | + + +                | +       |                 |
|                    |              | 2013a| 64   | 3/4 | 85–112      | + + +                | +       |                 |
|                    |              | 2013b| 64   | 5/6 | 151–190     | + + +                | +       |                 |
|                    |              | 2016 | 67   | 3   | 81–100      | + + +                | +       |                 |
Table 3  Continued.

| Author(s)             | Bibliography               | Images | Radiolarian age |
|-----------------------|-----------------------------|--------|-----------------|
|                       |                            | Text   | Occurrence list | SEM | Transmitted | Thin section | Devonian | Carboniferous | Permian | Triassic | Jurassic | Cretaceous | Paleogene | Neogene | Quaternary |
| Nakae and Kurihara   | 2017 68 2 57–86 + + + + + | +      |                | +   | +          |              |          |               | +       |          |          |            |           |          |            |
| Nakato et al.        | 2005 56 5/6 225–236 +     | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Noda and Kurihara   | 2016 67 4 119–131 + + +   | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Saito                | 1993 44 9 571–596 + + +   | +      |                | +   | +          |              |          |               | +       |          |          |            |           |          |            |
| Suto et al.          | 2005 56 11/12 375–409 +   | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Sugiyama K. and Saito| 1994 45 7 383–404 + + +   | +      |                | +   | +          |              |          |               | +       |          |          |            |           |          |            |
| Takahashi M. et al.  | 1999 50 3 225–243 +       | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Takemura             | 2019 70 1/2 267–272 +     | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Takeuchi M. and Takizawa| 1991 42 9 439–472 +     | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Teraoka and Kurimoto | 1986 37 8 417–453 + + +   | +      |                | +   | +          |              |          |               | +       |          |          |            |           |          |            |
| Tominaga et al.      | 2019 70 3 299–314 + + +   | +      |                | +   | +          |              |          |               | +       |          |          |            |           |          |            |
| Tuzino               | 2010 61 3/4 125–136 +     | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Uchino               | 2017a 68 2 23–24           | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Uchino and Hori      | 2011 62 3/4 191–196 + + +  | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Uchino and Ishida    | 2017 68 2 25–39 + +       | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Uchino and Kurihara  | 2019 70 1/2 109–115 + + + | +      |                | +   | +          |              |          |               | +       |          |          |            |           |          |            |
| Wakita               | 1983 34 7 329–342 + + +   | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| 1988a 39 6 367–421 + | + + + + + +                | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| 1988b 39 11 675–757 +| + + + + + +                | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Wakita and Isomi     | 1986 37 6 325–333 + +     | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Wakita and Okamura   | 1982 33 4 161–185 + + +   | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Yanagisawa           | 1999 50 3 167–213 + +     | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| 2003a 54 1/2 1–13    | + + + + + +                | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Yanagisawa et al.    | 1989 40 8 405–467 + +     | +      |                | +   | +          |              |          |               | +       |          |          |            |           |          |            |
| 2003a 54 1/2 29–47   | + + + + + +                | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| 2003b 54 11/12 351–364| + + + + + +                | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Yao                  | 2019 70 1/2 246–260 +     | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
| Yoshii et al.        | 1997 48 10 567–584 +      | +      |                | +   |            |              |          |               | +       |          |          |            |           |          |            |
Table 4  Bibliographic list from Chishitsu News that include radiolarian descriptions.

| Author(s)               | Bibliography | Contents                                                                 | Images                     | Age             |
|-------------------------|--------------|--------------------------------------------------------------------------|----------------------------|-----------------|
| Endo and Sarashina      | 2007 632     | Structure and function of proteins                                       |                            |                 |
| Fukuda and Natori       | 1977 273     | Report on international congress about the Neogene in the Pacific        | Transmitted photomicrograph | Neogene         |
| Hara et al.             | 2005 611     | Geology of Lao                                                           |                            |                 |
| Kanie                   | 2007 633     | Cenozoic stratigraphy of the Ryukyu Arc                                  |                            |                 |
| Kanie                   | 1998 532     | Mollusks research in museum                                              |                            |                 |
| Kano K. et al.          | 2003 584     | Outline of the Geological map of Japan (1:2,000,000)                     | SEM images                 | Devonian?       |
| Kashiwagi et al.        | 2004 604     | Geology of Mongolia                                                      | Sketches; SEM images       | Mainly Permian  |
|                          | 2005 605     | Geology of Mongolia                                                      |                            | to Jurassic     |
| Katada et al.           | 1970 186     | Thin section of limestone and chert                                      | Thin section               |                 |
| Kishimoto               | 1991 437     | Mineral resources in China                                               |                            |                 |
| Kurimoto                | 1994b 482    | Radiolarian biostratigraphy and the Geological maps of Quadrangle Series, 1:50,000 |                            |                 |
| Matsuura et al.         | 1996 498     | Outline of the Geological map of the Hirone district (Quadrangle Series, 1:50,000) | SEM images                 |                 |
| Nakajima                | 1986 387     | Geology around Himalayan                                                |                            |                 |
| Nakano et al.           | 2005 612     | Outline of the Geological map of the Minakuchi district (Quadrangle Series, 1:50,000) |                            |                 |
| Nohara et al.           | 1983 343     | Research on deep sea mineral resource                                   | Transmitted photomicrograph | Quaternary      |
| Saito                   | 1997 514     | Research progress of the Jurassic accretionary complex of Japan          |                            |                 |
| Saito and Nishioka      | 1995 487     | Outreach with using geological maps                                       |                            |                 |
| Saito and Ozaki         | 2000 548     | Outreach with using geological maps                                       |                            |                 |
| Saito et al.            | 1997 514     | Exhibition of the Geological Museum                                      |                            |                 |
|                          | 2006 619     | Outline of the Geological map of the Tomochi district (Quadrangle Series, 1:50,000) |                            |                 |
|                          | 2008 647     | Outline of the Geological map of the Yakushima (1:200,000)               | SEM images                 | Jurassic        |
| Sakai et al.            | 1982 337     | Research progress of radiolaria and conodont                            | SEM images                 | Jurassic        |
| Sato T.                 | 1991a 438    | Research progress of Paleozoic–Mesozoic in Japan                         |                            |                 |
|                          | 1991b 440    | Research progress of Paleozoic–Mesozoic in Japan                         |                            |                 |
| Shinbo                  | 2006 624     | Observation of foraminifera in beach sands                               | Thin section               |                 |
| Takechi                 | 2010 666     | Fossil in Okayama Prefecture                                             |                            |                 |
Table 4  Continued.

| Author(s)                                      | Bibliography Year | No. | Pages | Contents                                                                 | Images                  | Age                     |
|------------------------------------------------|-------------------|-----|-------|---------------------------------------------------------------------------|-------------------------|-------------------------|
| Tanaka Y.                                      | 2007              | 634 | 29–34 | Biogenic particles including radiolarian one                             |                         |                         |
| Takahashi Koz.                                 | 2002              | 576 | 37–43 | Diatom and radiolarian (including Phaeodarian)                           | SEM images              | Recent                  |
| Takahashi Yut.                                 | 1996              | 506 | 7–14  | Geology of the Iide Mountains                                            |                         |                         |
|                                                | 2005              | 607 | 57–62 | Outline of the Geological map of the Suhara district (Quadrangle Series, 1:50,000) |                         |                         |
| Teraoka                                        | 2004              | 599 | 40–48 | Geology of Shimanto accretionary complex                                |                         |                         |
| Tokuhashi                                      | 2008              | 645 | 26–52 | Report on excursion of 17th International Sedimentology Congress 2006, Fukuoka |                         |                         |
| Toshimitsu and Saito                          | 1997              | 514 | frontispiece | Exhibition of the Geological Museum                                      | Hand-size model         | Mainly Mesozoic         |
| Wakita                                         | 2001              | 567 | 52–66 | Geology of Indonesia                                                    |                         |                         |
|                                                | 2002a             | 574 | 53–67 | Geology of Indonesia                                                    |                         |                         |
|                                                | 2002b             | 576 | 44–59 | Geology of Indonesia                                                    |                         |                         |
| Wakita and Kawamura                            | 1985              | 376 | 60–66 | Research progress of radiolaria                                          | SEM images; Thin section; Cartoon | Devonian–recent        |
| Yamada                                         | 2009              | 660 | 32–47 | Geological map compiled by T. Harada                                    |                         |                         |
|                                                | 2011              | 679 | 8–22  | Geological map compiled by T. Kochibe and others                        |                         |                         |
| Yoshida F.                                     | 2003              | 592 | 61–63 | Photographs of Shirasaki coast                                           |                         |                         |
Table 5  Bibliographic list from GSJ Chishitsu News that include radiolarian descriptions.

| Author(s)               | Bibliography | Contents                                                                 | Images            | Age          |
|-------------------------|--------------|--------------------------------------------------------------------------|-------------------|--------------|
| Hara and Ito            | 2018 7 11    | International training course in the Kanto Mountains including field excursion and observation on radiolarian fossil | SEM images        | Permian      |
| Itaki                   | 2019 8 5     | Artificial intelligence technology for accurate identification and sampling of radiolarians | Transmitted photomicrograph | Quaternary   |
| Ito                     | 2017a 6 5    | Author's radiolarian research in China                                    |                   |              |
|                         | 2017b 6 5    | Chinese signage of words of sedimentology including "radiolarian ooze"    |                   |              |
|                         | 2017c 6 11   | Chinese signage of words of paleontology including "radiolarian"         |                   |              |
|                         | 2017d 6 11   | Chinese local name based on scientific name with examples of Permian radiolarians |                   |              |
|                         | 2019b 8 7    | Report on the 5th International Palaeontological Congress, with observation of samples of Deflandre (1952) | Transmitted photomicrograph | Carboniferous |
| Kano K.                 | 2013 2 8     | Outline of the Geological map of the Aniai district, 2nd Edition (Quadrangle Series, 1:50,000) |                   |              |
| Kato                    | 2012 1 10    | Excursion in the Chichibu area including "radiolarian slate" noted by K. Hosaka |                   |              |
| Kawabata                | 2016 5 8     | Introduction of new staffs of the Geological Survey of Japan in 2016    |                   |              |
| Nakashima et al.        | 2015 4 8     | Lecture of Cenozoic stratigraphy in Japan                                |                   |              |
| Ozaki                   | 2019 8 2     | Outline of the Geological map of the Minobu district (Quadrangle Series, 1:50,000) |                   |              |
| Takahashi M.            | 2017 6 5     | Discussion on tectonic boundary between Northeast and Southwest Japan    |                   |              |
| Takahashi Yut. et al.   | 2018 7 11    | International training course in the Abukuma Mountains                    |                   |              |
| Toshimitsu et al.       | 2019 8 12    | Chronological timetable of the Geological Museum                          |                   |              |
| Tuzino et al.           | 2019 8 10    | Exhibition of rocks (inc. radiolarian chert) in the Geological Museum    |                   |              |
| Uchino                  | 2015 4 3     | Origin of "Shiraishi" in the "Shikinen Sengu ceremony" at Ise Jingu      |                   |              |
|                         | 2017b 6 9    | Vegetation on chert in the Toba District                                 |                   |              |
|                         | 2018 7 4     | Outline of the Geological map of the Toba district (Quadrangle Series, 1:50,000) |                   |              |
| Uchino and Kawamura     | 2014 3 11    | Outline of the Geological map of the Hayachine San district (Quadrangle Series, 1:50,000) |                   |              |
| Utsunomiya              | 2018 7 9     | Report on the 16th International Nannoplankton Association Meeting        |                   |              |
Fig. 7 Reprinted poster of “Reconstructed Oceanic Plate Stratigraphy in Jurassic accretionary complexes and radiolarian fossils in Japan” made by the Geological Museum of GSJ.
Table 6 Bibliographic list from the Cruise Report that include radiolarian descriptions.

| Author(s)          | Bibliography                                  | Ocean area | Occurrence list | Images                        | Age        |
|--------------------|----------------------------------------------|------------|-----------------|-------------------------------|------------|
| Arita and Mizuno   | 1977 8 301–308 Central Pacific               |            | Transmitted photomicrograph | Quaternary                  |
| Hasegawa S. et al. | 1976 7 80–85 Southern Kurile Trench and Slope|            |                 | Quaternary                  |
| Inoue et al.       | 1972 1 20–33 Northwest Pacific               |            |                 |                              | Quaternary |
| Nishimura          | 1984 20 67–89 Magellan Trough               |            | Smear slide     | Quaternary                  |
|                   | 1986 21 56–83 Central Pacific               |            | Transmitted photomicrograph; SEM image | Quaternary |
| Nishimura and Ikehara | 1992 22 85–96 Central Pacific              |            |                 |                              | Quaternary |
| Takayangi et al.   | 1982 18 301–308 Wake-Tahiti Transect in the Central Pacific |            |                 |                              | Quaternary |

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Appendix: How to access and download the publications mentioned in this article

A1. Geological Map of the Quadrangle Series (1:50,000 and 1:200,000)

Access the web page (https://gbank.gsj.jp/datastore/download.php?lang=en) and do as follows. The numbers correspond to the numbers in the circles in Fig. A1.
1: Enter or copy-paste a district name.
2: Click the “search” button.
3: Select the check box that you need.
4: Click the “download” button.

Fig. A1  Image captures of the webpage for search and download of geological maps from GSJ.
A2. Bulletin of the Geological Survey of Japan (1950 to 2011, vol. 52, no. 2/3)

Access the web page (https://www.gsj.jp/en/publications/bull-gsj/index.html) and download the article of interest.

A3. Bulletin of the Geological Survey of Japan (2011, vol. 52, no. 4/5 to present)

Access the web page (https://www.gsj.jp/en/publications/bulletin/index.html) and download the article of interest.

A4. Chishitsu News [Japanese only]

Access the web page (https://www.gsj.jp/publications/pub/chishitsunews/news-contents.html) and download the article of interest.

A5. GSJ Chishitsu News [Japanese only]

Access the web page (https://www.gsj.jp/publications/gcn/gcn.html) and download the article of interest.

A6. Cruise Report

Access the web page (https://www.gsj.jp/en/publications/cruise-rep/index.html) and download the article of interest.

地質調査総合センターにおける放射虫研究の歴史及び
1950年~2019年（昭和25年~令和元年）の関連出版物目録

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要 旨

1882年（明治15年）に設立された地質調査所（現産業技術総合研究所地質調査総合センター）は、2017年に創立135周年を迎えた。その歴史の中で、地質図、論文、ニュース誌など、数多くの出版物を刊行してきた。本論では、これら
の出版物の中で放射虫に関係するものを編めた。1950年（昭和25年）から2019年（令和元年）の間の出版物の中で、「放射虫」という単語は、5万分の1地質図幅では252編、20万分の1地質図幅では21編、地質調査所月間報告及び地質調査研究報告では75編、地質ニュースでは14編、GSJ地質ニュースでは21編、Cruise Reportでは7編の論文・記事で記述されている。放射虫研究にかかわる出版物の数は1980年代に増加しており、これはいわゆる放射虫革命と同時期である。
