New Zealand Journal of Geology and Geophysics

ISSN: 0028-8306 (Print) 1175-8791 (Online) Journal homepage: http://www.tandfonline.com/loi/tnzg20

New radiolarian age information for the Chrystalls Beach Complex, southwest of Dunedin, New Zealand

Mitsumasa Ito , Yoshiaki Aita & Shigeki Hada

To cite this article: Mitsumasa Ito , Yoshiaki Aita & Shigeki Hada (2000) New radiolarian age information for the Chrystalls Beach Complex, southwest of Dunedin, New Zealand, New Zealand Journal of Geology and Geophysics, 43:3, 349-354, DOI: 10.1080/00288306.2000.9514892

To link to this article: http://dx.doi.org/10.1080/00288306.2000.9514892

New Zealand Journal of Geology & Geophysics, 2000, Vol. 43: 349–354
0028–8306/00/4303–0349 $7.00/0

New radiolarian age information for the Chrystalls Beach Complex, southwest of Dunedin, New Zealand

MITSUMASA ITO
Division of Global Development Science
Graduate School of Science and Technology
Kobe University
Kobe 657–8501, Japan

YOSHIAKI AITA
Department of Geology
Faculty of Agriculture
Utsunomiya University
Utsunomiya 321–8505, Japan

SHIGEKI HADA
Research Institute for Higher Education
Kobe University
Kobe 657–8501, Japan

Abstract On the basis of lithology, structural style, and fossil evidence, northern and southern units are recognised within the Chrystalls Beach Complex exposed on the coast south of Akatore Creek, southwest of Dunedin, South Island, New Zealand. Radiolarians including *Spongopallium* sp. cf. *S. contortum* Dumitrica, Kozur & Mostler, *Eptingium*(?) sp., *Norispongus*(?) sp., and *Pseudostylosphaera*(?) sp. have been discovered in phosphatic nodules in metamorphosed argillite of the northern unit of the complex. They are regarded as characteristic species of the Middle Triassic (Anisian–Ladinian). It has previously been known that the more weakly metamorphosed southern unit of the Chrystalls Beach Complex contains moderately well preserved Middle Triassic (Early Ladinian) radiolarian faunas. Together with forms of Tethyan affinity, the faunas in the southern unit contain non-Tethyan forms including *Glomeropyle* spp. Aita & Bragin, possibly of Southern Hemisphere high-latitude origin. These non-Tethyan forms are also known from the Mahinepua section of the Waipapa Terrane in Northland. Distinctive non-Tethyan forms such as *Glomeropyle* Aita & Bragin have not yet been found in the northern unit, the fauna of which includes species that are known from the European Tethys area and which also occur in the southern unit.

Keywords Chrystalls Beach Complex; Middle Triassic; radiolarians; Akatore Creek; Waipapa Terrane; Caples Terrane; Torlesse Terrane

G99036
Received 10 August 1999; accepted 18 May 2000

INTRODUCTION

Strata exposed on the coastline between Chrystalls Beach and Taieri Mouth, southwest of Dunedin, New Zealand, were called the Chrystalls Beach Complex by Nelson (1982). He regarded this as having the characteristics of an accretionary melange. It commonly has been placed in the Caples Terrane.

Paleontologic and biostratigraphic studies in the Chrystalls Beach Complex have been made by Benson & Chapman (1938), Campbell & Campbell (1970), and Hada et al. (1988). Recent works by Kuranaga (1993), Aita in Matsuoka et al. (1996), and Aita & Bragin (1999) have revealed that radiolarian fossils extracted from phosphatic nodules in the weakly metamorphosed southern part of the complex, referred to here as the southern unit, indicate a Middle Triassic age (Early Ladinian) (Fig. 1B). However, age-diagnostic radiolarian fossils have not until now been reported from the northern unit of the Chrystalls Beach Complex. The previously recorded fossils in the northern unit were radiolarians and indeterminate globigerinid foraminifera from south of Akatore Creek (Benson & Chapman 1938), and an agglutinated tube fossil, *Titahia corrugata* Webby, from the Quoin Point area (Campbell & Campbell 1970) (Fig. 1B). Another tube fossil, *Torlessia* sp., occurs in the southern unit, and Campbell & Campbell (1970) suggested a Late Triassic age for both. The basis for this suggestion has since been modified to include Middle Triassic by the discovery by Campbell & Pringle (1982) of *Torlessia* sp. in a fossil fauna of Middle to early Late Triassic age in Canterbury.

In this paper, we discuss the age of the northern unit of the complex based on the newly discovered radiolarians, and we assess the significance of this and the protolith to terrane relationships in New Zealand.

GEOLOGIC SETTING

The Chrystalls Beach Complex consists predominantly of sandstone, interbedded sandstone and mudstone, and lesser amounts of massive mudstone, conglomerate, varicoloured argillite, metabasalt, and chert. The rocks have undergone metamorphism, the grade of which increases progressively northwards from indeterminate prehnite-pumpellyite or pumpellyite-actinolite facies near Chrystalls Beach to pumpellyite-actinolite facies near Akatore Creek. Northern and southern units are here recognised within the complex, as shown in Fig. 1B. Their boundary is provisionally sited on the fault zone between *Torlessia*-bearing interbedded sandstone and mudstone and black chert 1 km south of Watsons Beach. This fault is referred to here as the Watsons Beach Fault. It is mainly a brittle-fracture, northwest-trending, low-angle fault. Small-scale tight fold and kinematic indicators of the sense of non-coaxial shear, such as σ-type porphyroclasts (e.g., Passchier & Simpson 1986) and shear bands suggest a reverse dip-slip fault with a

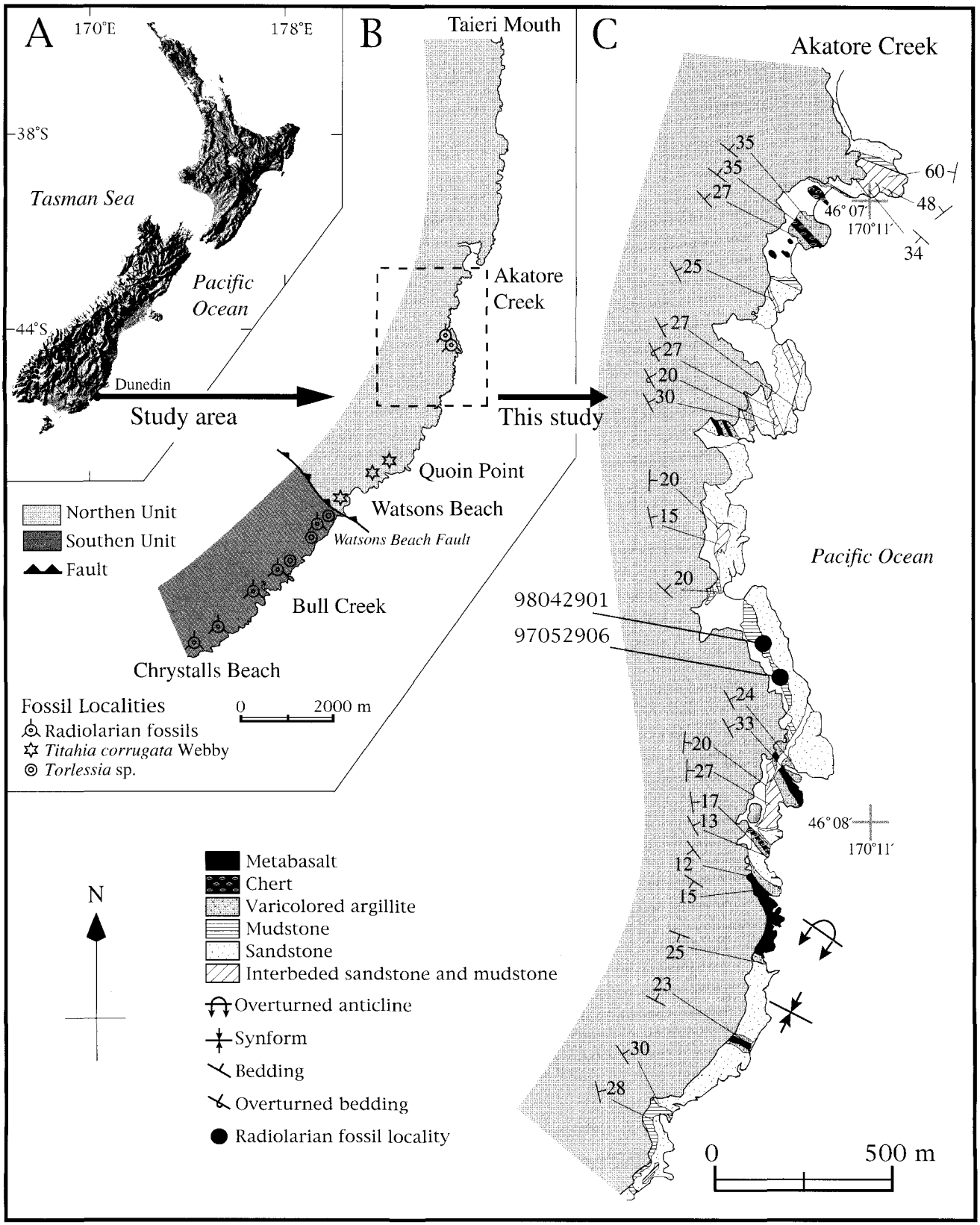


Fig. 1 **A**, Index map of New Zealand. **B**, Strip map of coastal section between Chrystalls Beach and Taieri Mouth, showing the northern and southern units of the Chrystalls Beach Complex, Watsons Beach Fault, and fossil localities. **C**, Map of the coastline between north of Quoin Point and Taieri Mouth, showing geology and radiolarian fossil localities. Grid references refer to the New Zealand standard thousand-metre grid, sheet I45, Taieri Mouth.

sinistral oblique component (Ito et al. in prep. "Structural features of the Chrystalls Beach Complex, southwest of Dunedin, New Zealand").

Strata of the northern unit of the complex on the south side of Akatore Creek are composed of sandstone and interbedded sandstone and mudstone, accompanied by metabasalt, varicoloured argillite, and chert. Similar lithologies occur on the north side of Akatore Creek (Fig. 1C), where they form part of the northern unit, and also in the southern unit of the complex. Stratal disruption is characteristic in the layers of the sandstone/mudstone association. Irregularly shaped cloud-like mudstone patches are frequently observed in sandstone of this association in the northern unit. In the southern unit, stratal disruption in the layers of the sandstone/mudstone association is associated with slump beds consisting of dispersed sandstone blocks in mudstone with slump-induced folds. Metabasalt and chert occur as lenticular blocks and slabs within the varicoloured argillites. Fault relationships are often observable at the contacts between the varicoloured argillites containing metabasalt and/or chert and the surrounding sandstone or interbedded sandstone and mudstone.

The northern unit of the Chrystalls Beach Complex to as far north as the south side of Taieri Mouth has a generally homoclinal structure striking N–NNW and dipping at low angles towards the east. However, 2.5 km south of Akatore Creek, the hinge of a large recumbent anticlinal fold facing towards the northeast is found in metabasalt and varicoloured argillite (Fig. 1C). The coastal clastic sequence showing homoclinal structure overlies the metabasalt-bearing argillite that forms the core of the recumbent fold. Based on the arrangement of parasitic folds and the relationship between cleavage and bed polarity, the clastic sequence corresponds to the upper normal limb of the downward-facing synformal anticline. All the varicoloured argillites containing metabasalt and/or chert in the northern unit are inferred to constitute basically the same horizon underlying the clastic sequence in the area, although it is rotatively segmented by later high-angle faults.

Detailed studies of the Chrystalls Beach Complex reveal significant structural differences between the northern and southern units, particularly on the fold orientation and the relationship between folding and penetrative stretching lineations. The northern unit as exposed as far as the south side of Taieri Mouth is dominated by the upper limb of a northwest–southeast-trending recumbent fold with parasitic fold axes, and regional stretching lineations are approximately parallel. The southern unit is marked by a large-scale, gently inclined isoclinal fold with half wavelength of c. 5 km, and its northwest–southeast-trending axes are orthogonal to the stretching lineations (Ito et al. in prep.).

MATERIALS AND METHOD

Samples used in this research are 32 phosphatic nodules and 12 chert samples collected from the northern unit of the Chrystalls Beach Complex on the coastline between a point north of Quoin Point and Taieri Mouth (Fig. 1C). Phosphatic nodule samples were treated with 30% nitric acid for 10–24 h. Chert samples were treated with 5% hydrofluoric acid for 24 h. Residues were washed and sieved using #35 and #200 nylon mesh and dried in an oven. Radiolarians were picked out under a binocular microscope and identified with a scanning electron microscope. Although one-third of phosphatic nodules yielded recrystallised radiolarian fossils, only two samples included age-diagnostic species. A few chert samples also yielded radiolarian fossils, but poor preservation prevented determination of their age.

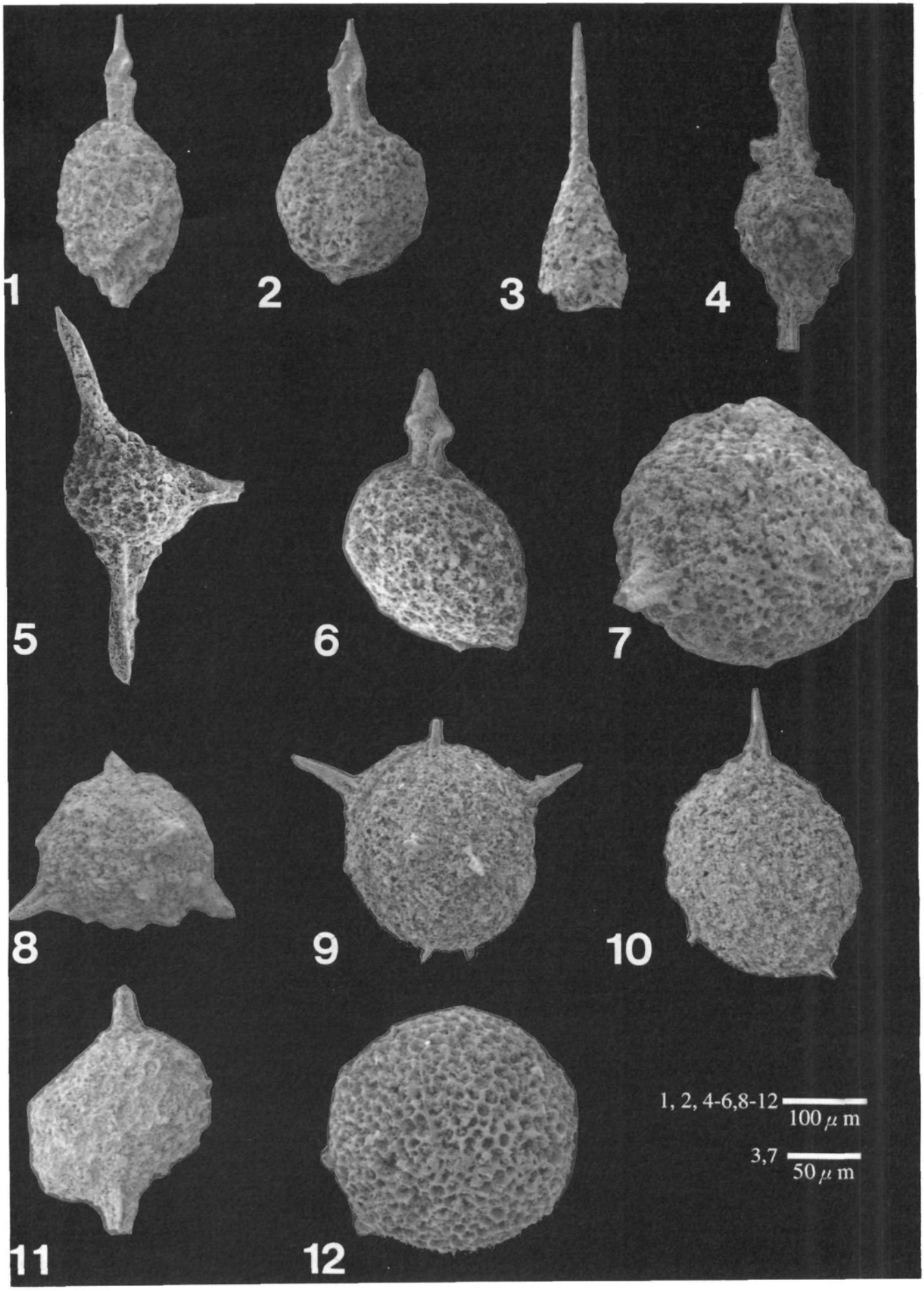
OCCURRENCE OF RADIOLARIANS

Phosphatic nodules and lenticular phosphatic bands in the northern unit of the Chrystalls Beach Complex, like those in the southern unit, often occur within varicoloured argillite, black massive mudstone, and mudstone of interbedded sandstone and mudstone, and have yielded radiolarian fossils. However, the preservation is not usually as good as in the southern unit because of the higher metamorphic grade. Towards the north of the section, nodules containing radiolarians have been collected 1.7 km north of Akatore Creek (NZMS 260 metric grid ref. I45/932529, Taieri Mouth sheet) (D. G. Bishop and D. S. Coombs pers. comm. 1998), and 2 km north of Akatore Creek (grid ref. I45/931533) by the present writers, but preservation in these was too poor for identification purposes.

Two black phosphatic nodules, sample 97052906 collected from a pale greenish argillite 1.7 km south of Akatore Creek (grid ref. I45/923495) and sample 98042901 collected from the same argillite 1.5 km south of Akatore Creek (grid ref. I45/922496) (Fig. 1), yielded age-diagnostic species which include *Spongopallium* cf. *contortum* Dumitrica, Kozur & Mostler, *Eptingium*(?) sp., *Norispongus*(?) sp., and *Pseudostylosphaera*(?) sp. (Fig. 2). *Spongopallium contortum* is known from the Recoaro Limestone, of typical Tethyan affinity in the Southern Alps of Europe (Baumgartner et al. 1997), although the form from the northern unit is questionably assigned due to imperfection of polar spines. *Spongopallium contortum* and unnamed nassellaria (Fig. 2.3) with a long apical horn are also known from the Mahinepua section of the Waipapa Terrane east of Whangaroa in the northern part of Northland (Aita & Bragin 1999). The forms named are regarded as characteristic species of the Middle Triassic (Anisian–Ladinian), the same age as those in the southern unit of the Chrystalls Beach Complex.

Among previously reported radiolarians from the well-preserved fauna in phosphatic nodules in the southern unit near Chrystalls Beach and Bull Creek are *Silicarmiger costatus* Dumitrica, Kozur & Mostler, *Parentactinia inerme* Dumitrica, *Laxtorum*(?) sp., and *Hozmadia* sp. These indicate an Early Ladinian age (Kuranaga 1993). The fauna includes many forms similar to those described from the European Tethys area. Hada et al. (1988) and Kuranaga (1993) concluded that the fauna of the southern unit also contains numerous undescribed species characterised by large shell size and thick-walled shells typical of a high-latitude fauna. Included here are abundant specimens and a number of forms of the new genus *Glomeropyle* Aita & Bragin. This genus has not been recognised in Middle Triassic sequences of Europe, Japan, Southeast Asia, or North America, and it is known only from northern and southern high-latitude localities such as Omolon Massif, Northern Siberia (Aita & Bragin 1999).

No distinctive non-Tethyan species such as *Glomeropyle* sp. Aita & Bragin have so far been found in the northern unit of the Chrystalls Beach Complex.


1
2
3
4
5
6
7
8
9
10
11
12
1, 2, 4-6,8-12
100 μ m
3,7
50 μ m

DISCUSSION

There is general consensus that the Otago Schist, part of the Haast Schist of southern New Zealand, is a metamorphic welt straddling the Caples Terrane on the south and west and Torlesse Terrane on the north and east. A possible position for the Caples/Torlesse Terrane boundary in the Otago Schist has been presented by Mortimer & Roser (1992) and Mortimer (1993), based on geochemical data supported by petrographic, lithological, and structural information. The terrane affinities of the Chrystalls Beach Complex were difficult to determine on this evidence, and Mortimer & Roser (1992) and Roser et al. (1993) included the Chrystalls Beach Complex in an area of uncertain terrane affinity. This procedure was supported by Adams & Graham (1997) on the basis of initial strontium isotope characteristics and the age of metamorphism. Further geochemical and petrographic data on psammites in the Chrystalls Beach–Brighton block are presented by Coombs et al. (2000, this issue). These data indicate geochemical similarity between the southern and northern units, significant differences from Torlesse geochemistry, and major differences from the much less silica rich compositions characteristic of most type Caples Group and Waipapa Group psammites as hitherto known. In QFL diagrams, psammites from both the northern and southern Chrystalls Beach Complex units plot in the same field, a field indicating a petrofacies different from Torlesse sediments.

The only dated fossils known in type Caples Group sediments and their immediate southeastward extension are of Permian and possible Permian age in clasts and melange (Turnbull 1979; Ford et al. 1999), whereas fossils in the Torlesse Terrane adjacent to the Otago Schist range in age from late Paleozoic to Late Triassic. As emphasised by various authors (e.g., Bishop et al. 1976), typical terrigenous sandstones of the Caples Terrane differ from those of the Torlesse Terrane in that they are mostly lithic-volcaniclastic rather than quartzofeldspathic of inferred continental source. This difference demands spatially separate sedimentary basins and source regions. It implies that the Torlesse Terrane is allochthonous and has probably moved at least hundreds of kilometres from its depositional source to a position oceanward of Caples and other New Zealand terranes (Bishop et al. 1976; Coombs et al. 1976; MacKinnon 1983).

The only previously recorded fossils in the Chrystalls Beach Complex were radiolarians and indeterminate globigerinid foraminifera (Benson & Chapman 1938) and agglutinated tube fossils *Torlessia* sp. and *Titahia corrugata* Webby (Campbell & Campbell 1970) of probable Mid–Late Triassic age.

From studies of radiolarians in phosphatic nodules hosted within the weakly metamorphosed southern unit of the Chrystalls Beach Complex, it was initially suggested that both Triassic and Jurassic ages are represented (Hada et al. 1988). However, Kuranaga (1993) re-examined the same samples under the supervision of one of the present authors (YA) and established that the fauna is of Middle Triassic age (Early Ladinian). The radiolarian fauna of the southern Chrystalls Beach unit is remarkably similar to that in the basal part of the Mahinepua Peninsula section east of Whangaroa in the Waipapa Terrane of Northland (Aita & Bragin 1999). The faunas recovered from phosphatic nodules in argillites both at Mahinepua and in the southern unit of the Chrystalls Beach Complex are characterised not only by species that are well known from the European Tethys area, but also by forms belonging to the genus *Glomeropyle* Aita & Bragin. The latter are completely non-Tethyan (Aita & Bragin 1999), but are known from northern and southern high latitudes. In contrast to these occurrences in argillites, Late Triassic to Early Jurassic radiolarian faunas in chert in the Waipapa Terrane near Waiheke Island close to Auckland have strong Tethyan affinity (Spörli et al. 1989). Unfortunately, because of poor preservation, we are not able to establish the affinities of the radiolarian faunas in chert beds in the Chrystalls Beach area. In striking contrast to these Waipapa Terrane occurrences, both chert intermingled with varicoloured argillites and associated terrigenous sequences of Late Triassic age in the Torlesse Terrane of the Red Rocks and Rimutaka Range in the southern North Island have yielded Tethyan faunas (Grapes et al. 1990; Aita & Spörli 1994). In terms of known radiolarian faunas, the southern unit of the Chrystalls Beach Complex has possible affinity to the Waipapa Terrane as developed at Mahinepua.

Distinct species of non-Tethyan faunas, such as *Glomeropyle* Aita & Bragin, which are characteristic of the southern unit, have not yet been found in the northern unit, the fauna of which includes species that are known from the European Tethys area. Detailed structural studies of the Chrystalls Beach Complex suggest the possibility of significant structural differences between the northern and southern units. Further study is required to elucidate the meaning of this. Coombs et al. (2000) detect no geochemical evidence for a terrane boundary within the Chrystalls Beach area.

On the basis of strontium isotope ratios and initial Rb-Sr ages of psammites in the central North Island and schists of Marlborough and elsewhere, Adams et al. (1999) suggested the possibility that elements of the Waipapa Terrane intervene between the Caples and Torlesse Terranes in the Otago Schist. They support correlation of the Western Marlborough Schist (Pelorus Group) with Caples Terrane rocks in Otago and Southland. Eastern Marlborough Schist is correlated with metasediments they ascribe to Waipapa Terrane in the central North Island and possibly Otago Schist of uncertain terrane affinity. On that interpretation, both the northern and southern units of the Chrystalls Beach Complex might be tectonically introduced parts of the Waipapa Terrane. However, Coombs et al. (2000) show that in lithofacies and psammite geochemistry, both units, while similar to each other, are very different from either type-area Caples or large areas of Waipapa Terrane rocks as generally understood in the North Island. Further investigation of these relationships is called for.

◀ **Fig. 2** Scanning electron micrographs of Middle Triassic radiolarians from phosphate nodules of the northern unit of the Chrystalls Beach Complex, south of Akatore Creek. Sample no. 97052906: **1**, *Spongopallium*(?) sp.; **2**, *Spongopallium* sp. cf. *S. contortum* Dumitrica, Kozur & Mostler; **3**, *Nassellaria* gen. et sp. indet.; **4**, *Pseudostylosphaera*(?) sp.; **5**, *Eptingium*(?) sp.; **6–8**, Spumellaria gen. et sp. indet. Sample no. 98042901: **9**, *Norispongus*(?) sp.; **10–12**, Spumellaria gen. et sp. indet.

ACKNOWLEDGMENTS

This paper owes very much to the thoughtful and helpful comments of D. S. Coombs and C. A. Landis of the Department of Geology, University of Otago. We thank T. Sakai of the Department of

Geology, Utsunomia University, for his encouragement and valuable advice.

REFERENCES

Adams, C. J.; Graham, I. J. 1997: Age of metamorphism of Otago Schist in eastern Otago and determination of protoliths from initial strontium isotope characteristics. *New Zealand Journal of Geology and Geophysics 40*: 275–286.

Adams, C. J.; Graham, I. J.; Johnston, M. R. 1999: Age and isotopic characterisation of geological terranes in Marlborough Schist, Nelson/Marlborough, New Zealand. *New Zealand Journal of Geology and Geophysics 42*: 33–55.

Aita, Y.; Bragin, N. Yu. 1999: Non-Tethyan Triassic Radiolaria from New Zealand and northeastern Siberia. *Geodiversitas (Earth Science Journal of Natural History Museum of Paris) 21 (4)*: 503–526.

Aita, Y.; Spörli, K. B. 1994: Late Triassic Radiolaria from the Torlesse Terrane, Rimutaka Range, North Island, New Zealand. *New Zealand Journal of Geology and Geophysics 37*: 155–162.

Baumgartner, P. O.; Dumitrica, P.; Gorican, S.; O'Dogherty, L. 1997: Mesozoic radiolarian-bearing sediments of the southern Alps (Switzerland, N-Italy). INTERRAD VIII, pre-meeting field trip guide. Pp. 16–21.

Benson, W. N.; Chapman, F. 1938: Note of the occurrence of radiolarian limestone among the older rocks of south-eastern Otago. *Transactions of the Royal Society of New Zealand 67*: 373–374.

Bishop, D. G.; Bradshaw, J. D.; Landis, C. A.; Turnbull, I. M. 1976: Lithostratigraphy and structure of the Caples terrane of the Humboldt Mountains, New Zealand. *New Zealand Journal of Geology and Geophysics 19*: 827–848.

Campbell, J. K.; Campbell, J. D. 1970: Triassic tube fossils from Tuapeka rocks, Akatore, South Otago. *New Zealand Journal of Geology and Geophysics 13*: 392–399.

Campbell, J. D.; Pringle, I. J. 1982: An association of *Torlessia* and late Middle-early Upper Triassic fossils at Pudding Hill Stream, central Canterbury. *Journal of the Royal Society of New Zealand 12*: 5–10.

Coombs, D. S.; Landis, C. A.; Norris, R. J.; Sinton, J. M.; Borns, D. J.; Craw, D. 1976: The Dun Mountain ophiolite belt, New Zealand, its tectonic setting, constitution and origin, with special reference to the southern portion. *American Journal of Science 276*: 561–603.

Coombs, D. S.; Landis, C. A.; Hada, S.; Ito, M.; Roser, B. P.; Suzuki, T.; Yoshikura, S. 2000: The Chrystalls Beach–Brighton coastal block, southeast Otago, New Zealand: petrography, geochemistry and terrane correlation. *New Zealand Journal of Geology and Geophysics 43*: 355–372 (this issue).

Ford, P. B.; Lee, D. E.; Fischer, P. J. 1999: Early Permian conodonts from the Torlesse and Caples Terranes, New Zealand. *New Zealand Journal of Geology and Geophysics 42*: 79–90.

Grapes, R.H.; Lamb, S. H.; Campbell, H. J.; Spörli, K. B.; Simes, J. E. 1990: Geology of the red rocks–turbidite association, Wellington peninsula, New Zealand. *New Zealand Journal of Geology and Geophysics 33*: 377–391.

Hada, S.; Yoshikura, S.; Aita, Y.; Sato, E. 1988: Geology and paleontology of the Chrystalls Beach complex, South Island, New Zealand. *In*: Preliminary report on the accretion complex geology of the Otago coast section in the South Island, New Zealand (No. 1). Co-operative Research Group of Japan and New Zealand, Department of Geology, Faculty of Science, Kochi University, Japan. Pp. 21–28.

Kuranaga, Y. 1993: Radiolarian faunas of the Chrystalls Beach Complex, South Island, New Zealand. Unpublished graduate thesis, lodged in the Library, Kochi University, Japan. 32 p., 10 pl.

MacKinnon, T. C. *1983*: Origin of the Torlesse terrane and coeval rocks, South Island, New Zealand. *Geological Society of America Bulletin 94*: 967–985.

Matsuoka, A.; Aita, Y.; Munasri, S.; Wakita, K.; Shen, G.; Ujiie, H.; Sashida, K.; Vishenevskaya, V. S.; Bragin, N. Yu.; Cordey, F. 1996: Mesozoic radiolarians and radiolaria-bearing sequences in the circum-Pacific region: a report of the symposium "Radiolarians and orogenic belts". *The Island Arc 5*: 203–213.

Mortimer, N. 1993: Geology of the Otago Schist and adjacent rocks. Scale 1:500,000. *Institute of Geological & Nuclear Sciences Geological Map 7*. Lower Hutt, New Zealand. Geological & Nuclear Sciences Ltd.

Mortimer, N.; Roser, B. P. 1992: Geochemical evidence for the position of the Caples-Torlesse boundary in the Otago Schist, New Zealand. *Journal of the Geological Society, London 149*: 967–977.

Nelson, K. D. 1982: A suggestion for the origin of mesoscopic fabric in accretionary melange, based on features observed in the Chrystalls Beach Complex, South Island, New Zealand. *Geological Society of America Bulletin 93*: 625–634.

Passchier, C. W.; Simpson, C. 1986: Porphyroclast systems as kinematic indicators. *Journal of Structural Geology 8*: 831–844.

Roser, B. P.; Mortimer, N.; Turnbull, I. M.; Landis, C. A. 1993: Geology and geochemistry of the Caples Terrane, Otago, New Zealand: Compositional variations near a Permo-Triassic arc margin. *In*: Balance, P. F. *ed.* South Pacific sedimentary basins. Sedimentary basins of the world. Elsevier, Amsterdam. Pp. 3–19.

Spörli, K. B.; Aita, Y.; Gibson, G. W. 1989: Juxtaposition of Tethyan and non-Tethyan Mesozoic radiolarian faunas and non-Tethyan Mesozoic radiolarian faunas in melanges, Waipapa terrane, North Island, New Zealand. *Geology 17*: 753–756.

Turnbull, I. M. 1979: Stratigraphy and sedimentology of the Caples terrane of the Thomson Mountains, northern Southland, New Zealand. *New Zealand Journal of Geology and Geophysics 22*: 555–574.