Available online at www.sciencedirect.com
ScienceDirect
Palaeoworld 20 (2011) 146–157
Palaeoworld
www.elsevier.com/locate/palwor

Research paper

Direct age determination for an Upper Permian accretionary complex (Kirinai Formation), Kitakami Mountains, Northeast Japan

Satoshi Nakae [a,*], Toshiyuki Kurihara [b]

[a] *AIST, Institute of Geology and Geoinformation, Geological Survey of Japan, Central-7, Higashi 1-1-1, Tsukuba 305-8567, Japan*
[b] *Graduate School of Science and Technology, Niigata University, Ikarashi, Nishi-ku, Niigata 950-2181, Japan*

Received 22 January 2010; received in revised form 8 November 2010; accepted 15 December 2010
Available online 21 December 2010

Abstract

This study presents the first direct age determination for the Kirinai Formation in the Kitakami Mountains, Northeast Japan, and a new model that correlates the Kirinai Formation with Upper Permian accretionary complexes of the Ultra-Tamba belt, Southwest Japan. The correlation is based on similarities in lithology, age, and structural relationships. The Kitakami Mountains are geotectonically divided into several belts, with subduction-related complexes occurring in the North Kitakami and Nedamo belts, whereas Ordovician ophiolites and stratigraphically overlying Paleozoic–Mesozoic sedimentary sequences are respectively exposed in the so-called "Hayachine tectonic belt" and South Kitakami belt. The Kirinai Formation, previously thought to belong to the North Kitakami belt, is tectonically underlain by the Jurassic Kamaishi and Tassobeguchi formations of the North Kitakami belt, and is overlain by the Lower Carboniferous Nedamo Complex of the Nedamo belt. The Kirinai Formation is lithostratigraphically subdivided into three members: a lower member dominated by black phyllitic mudstone with minor amount of bedded siliceous mudstone, a middle member consisting mainly of greenish gray massive sandstone and phyllitic mudstone, and an upper member composed of phyllitic mudstone locally intercalated with felsic tuff. The radiolarian fauna obtained from the lower member includes age-diagnostic species such as *Follicucullus* sp. cf. *F. dilatatus* Rudenko and *Albaillella* sp. cf. *A. protolevis* Kuwahara, corresponding to the interval from the *Neoalbaillella ornithoformis* Assemblage Zone to the lower part of the *Neoalbaillella optima* Assemblage Zone of Kuwahara et al. (1998). These findings indicate a Changhsingian (Upper Permian) assignment for the lower member of the Kirinai Formation. This newly obtained age and the obtained correlations provide the key to understanding the original relationships among the various subduction-related complexes in Japan.

Keywords: Radiolarian; Upper Permian; Kirinai Formation; Kitakami Mountains; Northeast Japan

1. Introduction

Proto-Japan developed along the eastern margin of the paleo-Asian continent with the initiation of oceanic plate subduction in the Early Paleozoic (ca. 500 Ma). Subsequently, various oceanic plates were subducted towards the core area of Paleozoic rocks in the paleo-Asian continent, and sediment accretion and following high-P/low-T metamorphism occurred in association with subduction (e.g., Isozaki, 1996), forming subduction-related (accretionary and metamorphic) complexes. In this way, the geological history of proto-Japan (which grew from the core area of Paleozoic sedimentary rocks upon the continental margin towards the paleo-Pacific) is recorded in the present-day Japanese Islands; i.e., older subduction-related complexes occur on the continental side of the Japanese Islands, and younger complexes occur on the Pacific Ocean side (e.g., Ichikawa, 1990). Such a regularly juxtaposed distribution of subduction-related complexes has been documented in Southwest Japan. This model is useful for understanding the geotectonic evolution of a subduction-related orogen; however, the problem with this model is that the juxtaposition of subduction-related complexes has yet to be verified in Northeast Japan. To address this problem, it is necessary to determine whether a regular juxtaposition of complexes is recognized in the Kitakami Mountains of Northeast Japan, where representative subduction-related complexes are exposed.

In the Kitakami Mountains, on the Pacific side of northern Northeast Japan (Fig. 1), there occur (from west to east) Ordovician ophiolitic rocks and an overlying Paleozoic sedimentary sequence that were derived from the paleo-Asian continental

* Corresponding author.
E-mail address: nakae-satoshi@aist.go.jp (S. Nakae).

1871-174X/$ – see front matter
doi:10.1016/j.palwor.2010.12.003

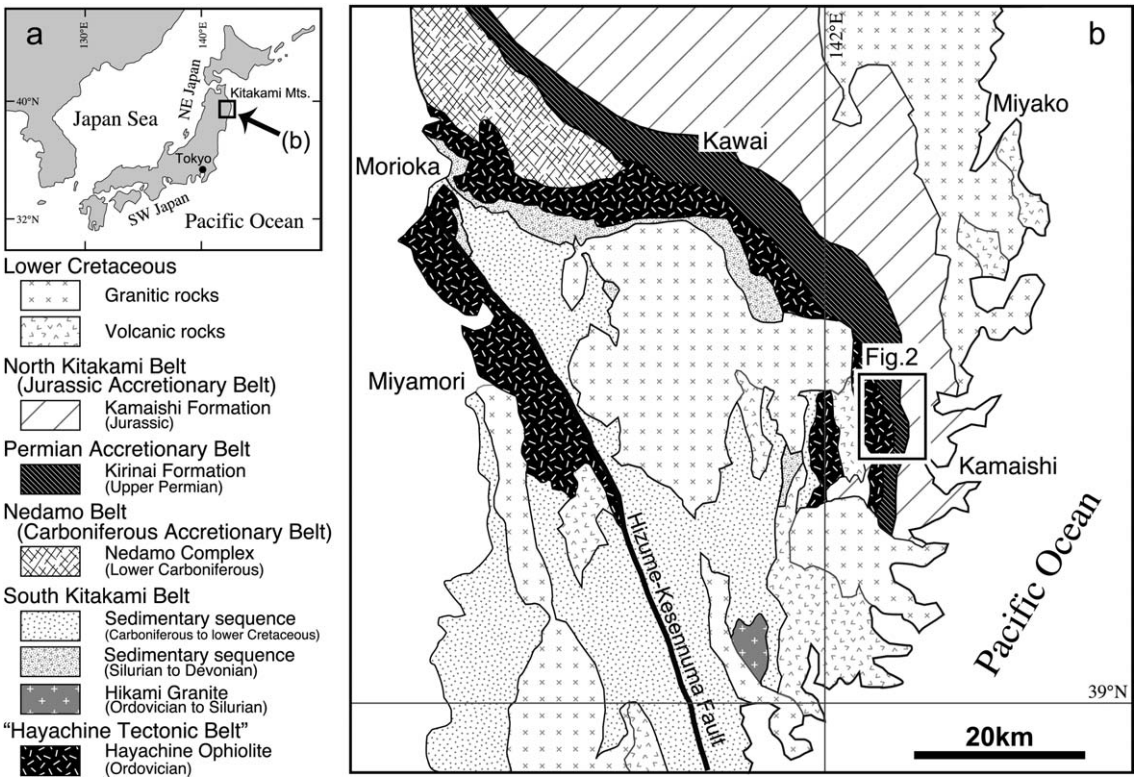

Fig. 1. (a) Location of the Kitakami Mountains in Northeast Japan. (b) Geotectonic map of the Kitakami Mountains, showing the location of study area west of Kamaishi City (rectangle).

margin, and a Jurassic accretionary complex that formed along the subduction zone (Okami et al., 1986; Okami and Ehiro, 1988; Kawamura et al., 1990; Minoura, 1990). For a long time, no Paleozoic subduction-related complexes were identified between the ophiolitic rocks and the accretionary complex, despite the known juxtaposition of subduction-related complexes in Southwest Japan. However, recent studies reported a Lower Carboniferous accretionary complex located between the Ordovician ophiolitic and Jurassic accretionary rocks in the northwestern Kitakami Mountains (Hamano et al., 2002; Uchino et al., 2005). This finding provides not only a crucial insight into the architecture and geotectonic evolution of the Kitakami Mountains, but also an important key in terms of correlating rocks between Southwest and Northeast Japan. In this context, it is important to investigate the boundary zone between the Ordovician ophiolitic and Jurassic accretionary rocks in discussing the regular juxtaposition of subduction-related complexes in the Japanese Islands.

Based on the results of geological mapping and lithological observations of the Kirinai Formation in the Kamaishi area, eastern Kitakami Mountains, this paper (1) determines the age of a phyllitic mudstone within the Kirinai Formation based on the radiolarian assemblage, (2) considers the tectono-stratigraphic significance of the boundary zone between the ophiolitic and Jurassic accretionary rocks, and (3) seeks to correlate the Kirinai Formation with equivalent rocks in Southwest Japan.

2. Geological framework of the Kitakami Mountains

The Kitakami Mountains are widely underlain by Paleozoic to Mesozoic sedimentary rocks and minor metamorphic rocks, which are covered by volcanic rocks and intruded by granitoids that are mainly the products of Cretaceous island-arc magmatism. Geotectonically, the mountains are divided into two distinct domains (the South Kitakami and North Kitakami belts) separated by a NW–SE-trending ophiolite belt (the so-called "Hayachine tectonic belt") (Fig. 1). Previous studies have reported that the South and North Kitakami belts consist of distinct strata, with contrasting lithology, age and origin, representing distinct sedimentary environments (Minato, 1950; Kawamura et al., 1990; Minoura, 1990). The South Kitakami belt is dominated by a Silurian to lowermost Cretaceous deep- to shallow-marine sedimentary sequence, whereas the North Kitakami belt is dominated by a Jurassic accretionary complex. Recently, however, a Lower Carboniferous accretionary complex was discovered in a narrow part of the "Hayachine tectonic belt" (Hamano et al., 2002; Uchino et al., 2005), located along the southwestern margin of the North Kitakami belt; this area has been termed the Nedamo belt (Ehiro and Suzuki, 2003).

2.1. South Kitakami belt

The South Kitakami belt is situated in the southwestern part of the Kitakami Mountains. The belt contains a Silurian to lowermost Cretaceous sedimentary sequence that unconformably overlies basement rocks (ca. 440 Ma Hikami Granites). The Paleozoic sequence is lithologically subdivided into two parts: formations of Siluro-Devonian clastic rocks of the deep-marine realm, associated with basalts and limestones, and overlying formations of Carbonifero-Permian clastic rocks of the