



Research paper

Sedimentary environments of the Middle Permian phosphorite–chert complex from the northeastern Yangtze platform, China; the Gufeng Formation: a continental shelf radiolarian chert

Masao Kametaka^{a,*}, Masamichi Takebe^b, Hiromi Nagai^c,
Sizhao Zhu^d, Yukio Takayanagi^e

^a*Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba 305-8567, Japan*

^b*Matsue National College of Technology, Matsue 690-8518, Japan*

^c*Nagoya University Museum, Nagoya 464-8601, Japan*

^d*Department of Earth Sciences, Nanjing University, Nanjing 210008, Jiangsu, P.R. China*

^e*Aichi Prefectural Office, Sannomaru 3-1-2, Naka-ku, Nagoya 460-8501, Japan*

Received 15 January 2004; received in revised form 21 October 2004; accepted 10 December 2004

Abstract

Radiolarian chert deposited on a continental shelf occurs in the Middle Permian Gufeng Formation on the northeastern Yangtze platform, China. The sedimentary environments of radiolarian cherts from accretionary complexes have been well studied; however, there are few studies about radiolarian chert deposited on continental shelves. Therefore we have completed a sedimentological and geochemical study of the Gufeng Formation.

The Gufeng Formation is subdivided into the Phosphate Nodule-bearing Mudstone Member (PNMM) and the Siliceous Rock Member (SRM) in ascending order. The basal PNMM consists of glauconite-bearing mudstone, which indicates deposition under aerobic shallow-marine conditions, whereas the upper PNMM is composed of mudstone including abundant phosphate nodules, suggesting deposition near the outer shelf in suboxic conditions. The SRM consists mainly of alternating beds of black chert, mudstone, and siliceous mudstone, with minor tuffaceous mudstone and porous chert beds. The black chert contains abundant radiolarians, sponge spicules, and organic matter. Framboidal pyrite occurs in the black chert. Porous chert in the SRM includes abundant rhombohedral cavities, which are dolomite moulds surrounded by quartz, suggesting dolomitization before silicification during early diagenesis.

The Gufeng Chert is characterized by high Si, Mo, Ni, Cu, and Zn contents, and extremely low Mn content. The Gufeng Chert has high normal paraffin concentrations with petroleum-like markers. These geochemical features suggest that the Gufeng Chert was deposited under sulfate-reducing conditions; and is not hydrothermal, but rather biogenic in origin.

* Corresponding author. Tel.: +81 29 861 3662; fax: +81 29 861 3579.

E-mail address: kame@ni.aist.go.jp (M. Kametaka).

The sedimentological and geochemical data suggest that the Gufeng Formation was deposited mainly on the outer shelf in suboxic–anoxic conditions caused by organic matter produced during upwelling. The upwelling probably led to high radiolarian productivity. Abundant silica and organic matter were deposited in the Gufeng basin. Compared with chert from other sites, the Gufeng Chert shows many similarities with chert from platformal basins, but not with chert from accretionary complexes. Especially, with respect to age, rock type, stratigraphy, and geochemical features, the chert of the Gufeng Formation is similar to that of the Phosphoria Formation in the western U.S.A., which is a world-class phosphorite giant. These similarities suggest that upwelling occurred around the eastern margins of Panthalassa and the Paleotethys concurrently during the Middle Permian.

In general, shelf-type radiolarian chert, represented by the Gufeng Chert, usually shows some of the following features: dark color, lack of rhythmical bedding, association with phosphorite, platformal limestone, felsic tuff, abundant organic matter, and sulfides. Shelf-type radiolarian chert is deposited in a poorly aerated restricted basin, or in an oxygen-minimum zone.

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Keywords: Middle Permian; Radiolarian chert; Yangtze platform; Sedimentary environments; Sulfate-reducing conditions; Upwelling

1. Introduction

The sedimentary environments of chert have been discussed on the basis of major element composition (e.g., Adachi et al., 1986; Yamamoto, 1987), trace and rare earth element compositions (e.g., Shimizu and Masuda, 1977; Murray, 1994), and normal paraffin compositions (e.g., Yamamoto et al., 1997; Takayanagi, 1998). Bedded radiolarian chert in accretionary complexes is considered to be deposited on the open-ocean floor and accreted along the continental margin (Matsuda and Isozaki, 1991). Radiolarian ooze accumulating on the ocean floor may be the modern analogue of the radiolarian chert in orogenic belts. Discussions have focused on geochemical comparison between chert in accretionary complexes and modern deep-marine sediments. Few studies have analyzed the geochemical features of chert from platform regions even though those cherts are known to be present in many platformal basins. Therefore, we have investigated the radiolarian chert of the Gufeng Formation in the Yangtze platform, South China.

The Permian formations on the northeastern Yangtze platform contain platformal limestone and coal-bearing sandstone that were deposited in shallow marine and terrestrial environments. The Gufeng Formation, which contains radiolarian chert, is intercalated between the limestone and sandstone; hence, the Gufeng Formation probably was not deposited in a deep-marine environment. In order to elucidate the paleoenvironments of the Yangtze platform during the Permian, it is important to clarify the depositional environments of the Gufeng Formation.

There are various models for the depositional environments and the origin of chert in the Gufeng Formation. Because of the presence of abundant radiolarians and organic matter, Kong and Gong (1987) considered that the Gufeng Formation was deposited in a narrow rift basin deeper than the CCD, under anoxic conditions. Zhu (1989) suggested that the bedded chert in the Gufeng Formation was formed through organic chemical sedimentation and early diagenetic differentiation in an intraplatformal basin. Lu and Qu (1990) proposed that the Gufeng Formation was deposited under anoxic environments formed by transgression and ocean upwelling. Jiang et al. (1994), who studied the lithostratigraphy and geochemical features of the Permian formations, concluded that the chert of the Gufeng Formation was formed by the accumulation of radiolarian remains in a locally subsided basin or trough on the platform. They also mentioned the influence of upwelling and hydrothermal activity. Xia et al. (1995) emphasized a hydrothermal origin for chert in the Gufeng Formation because of the presence of tuffaceous rocks and Fe-enrichment in the formation. Wang et al. (1997) studied the radiolarian assemblages of the Gufeng Formation and mentioned the effect of the equatorial upwelling. He et al. (1999) also studied the radiolarians and suggested that the depositional environment of the Gufeng Formation was slope or deep sea.

We investigated the Gufeng Formation and reported about the radiolarian fossils (Nagai et al., 1998), the presence of porous chert (nectic chert of Zhu et al., 1999) and the petrographical features of the

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