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Revue de micropaléontologie

Revue de micropaléontologie 59 (2016) 347–358

Original article

Geological significance of the discovery of Middle Triassic (Ladinian) radiolarians from the Hong Hoi Formation of the Lampang Group, Sukhothai Zone, northern Thailand

L'importance géologique de la découverte de radiolaires du Trias moyen (Ladinien) au sein de la Formation de Hong Hoi du Groupe de Lampang, Zone de Sukhothai, Thaïlande septentrionale

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Abstract

This paper presents a newly found fauna of Ladinian (Middle Triassic) radiolarians from the Hong Hoi Formation of the Lampang Group, Sukhothai Zone, northern Thailand. The Ladinian age determined by the radiolarian fauna concords with the age previously determined by mollusks. The study section consists of intercalated sandstone and shale in the lower part and a thick conglomerate in the upper part. The radiolarian-bearing siliceous beds are intercalated within the lower unit. The lithic sandstone of the lower unit consists mainly of volcanic rock fragments, quartz, and feldspar, whereas the thickly bedded conglomerate of the upper unit is characterized by abundant gravel-sized clasts of volcanic rock and limestone. These lithic features of the study section suggest that during deposition the Hong Hoi Formation was located near a supply of volcanic materials. A forearc basin close to the Sukhothai Arc would be the most suitable environment for the deposition. The Ladinian age determined by the radiolarian fauna supports the occurrence of intensive volcanic activity within the Sukhothai Arc during the Middle Triassic.

Keywords: Radiolarians; Hong Hoi Formation; Lampang Group; Sukhothai Zone; Triassic; Thailand

Résumé

Cette publication présente une faune de radiolaires du Ladinien (Trias moyen) découverte récemment au sein de la Formation Hong Hoi du Groupe de Lampang, Zone Sukhothai, Thaïlande septentrionale. L'âge Ladinien, suggéré par les radiolaires, est en accord avec l'âge déterminé précédemment, sur la base des mollusques. La coupe étudiée consiste en intercalations de grès et d'argilites dans la partie inférieure et d'une épaisse série de conglomérats dans la partie supérieure. Les niveaux siliceux à radiolaires sont intercalés dans la partie inférieure. Les grès de l'unité inférieure sont composés essentiellement de fragments de roches volcaniques, de quartz, et de feldspathes, alors que le conglomérat à bancs épais de l'unité supérieure est caractérisé par des débris abondants de galets de roches volcaniques et de calcaire. Ces caractères lithologiques de la coupe étudiée suggèrent que durant son dépôt, la Formation de Hong Hoi était située proche d'une source de matériaux volcaniques. Un bassin

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http://dx.doi.org/10.1016/j.revmic.2016.08.002
0035-1598/

d'avant-arc, proche de l'Arc de Sukhothai, serait l'environnement sédimentaire le plus approprié pour leur dépôt. L'âge Ladinien déterminé par la faune des radiolaires soutien l'hypothèse d'une activité volcanique intense au sein de l'Arc de Sukhothai durant le Trias moyen.

Mots clés : Radiolaires ; Formation Hong Hoi ; Groue de Lampang ; Zone Sukhothai ; Trias ; Thaïlande

1. Introduction

Triassic radiolarians have a great biostratigraphic potential in both the low and high latitudes (e.g. Bragin, 2015; Hori et al., 2015) to unravel the geological and paleogeographic evolution of complex orogenic belts, such as in Thailand.

Recent geological studies in northern Thailand identified four geotectonic units. From the west to the east, these are: the Sibumasu Block, the Inthanon Zone, the Sukhothai Zone, and the Indochina Block (e.g. Metcalfe, 2011, 2013; Sone and Metcalfe, 2008; Ueno and Charoentitirat, 2011). The Sukhothai Zone is considered to be an island arc system that developed during the Permian–Triassic along the margin of the Indochina Block (Barr and Macdonald, 1991; Ueno, 1999; Sone and Metcalfe, 2008). This zone is delineated by the Chiang Rai Tectonic Line to the west and by the Nan-Uttaradit Suture Zone to the east (Fig. 1A and B). The Sukhothai Zone *sensu* Ueno (1999, 2002) is approximately equivalent to the Sukhothai Zone *sensu* Barr and Macdonald (1991) and the Sukhothai Fold Belt *sensu* Bunopas (1981); Sone and Metcalfe (2008) followed this geotectonic interpretation, designating the area as the Sukhothai Zone. The latter is primarily composed of deformed Paleozoic–Mesozoic sedimentary rocks, volcanic rocks, and Triassic granitoids of I-type affinity. The lithologies of the siliciclastic and volcanic rocks indicate a subduction-related tectonic setting, with the zone considered to be a Permian–Triassic magmatic arc that developed along the margin of the Indochina Block.

The Sukhothai Zone occupies the eastern half of northern Thailand and contains widely distributed Permo–Triassic marine clastics and volcaniclastics with NE–SW trends (Fig. 2). The Triassic strata in the Lampang-Phrae Basin of the Sukhothai Zone have conventionally been referred to as the Lampang Group. Recently, Chonglakmani (2011) suggested for the Triassic strata in the Phrae sub-basin to the east can be referred to as the Song Group, with the Lampang Group being restricted to those strata exposed in the Lampang sub-basin, to the west. Geological study of the sedimentary sequences in this area is important for elucidating the geological development of the subduction-related arc setting along the Indochina Block, and precise stratigraphy and chronology are essential for accomplishing this. Although an outline of the stratigraphic divisions and their geological ages have been proposed, detailed lithostratigraphic and chronostratigraphic studies have not yet been conducted.

For this study, we examined the Lampang Group in the Sukhothai Zone, northern Thailand, extracting a radiolarian fauna from the clastics of the Hong Hoi Formation, one of the formations composing the Lampang Group. Previously, the ages available from the Lampang Group were based on macrofossils, such as ammonoids and bivalves. In this study, we examine the age suggested by a radiolarian fauna, its correspondence with the age established on previously reported faunas, and then consider the lithostratigraphy of the Hong Hoi Formation to elucidate the sedimentary and tectonic evolution of the Sukhothai arc during the Triassic.

2. Geological setting

The Lampang and Phrae sub-basins in northern Thailand (Figs. 1B and 2) are part of the Sukhothai Zone and are primarily composed of Permo–Triassic clastic and volcaniclastic sequences (Fig. 2). The thick Permian succession of the Ngao Group mainly consists of N–S trending siliciclastics and limestones, and underlies the Lampang Group.

The marine Triassic succession of the Lampang Group in the study area consists mainly of sandstone, shale, limestone, and conglomerate. Named by Piyasin (1971), this unit has been variously interpreted as a succession overlying conformably Permian–Triassic volcanics or unconformably Paleozoic sedimentary sequences. It is disconformably overlain by Triassic–Jurassic red beds (Chonglakmani, 2011; Piyasin, 1971). Chonglakmani (2011) restricted the use of the term Lampang Group to the Triassic units exposed in the Lampang sub-basin, with the Lampang Group subdivided into four formations: the Phra That, Pha Kan, Hong Hoi, and Doi Long formations (Fig. 3). The Lampang Group *sensu* Chonglakmani (2011) has been dated as Griesbachian to Middle Carnian, primarily based on ammonoids, bivalves, foraminifers and conodonts (Carey et al., 1995; Chonglakmani and Grant-Mackie, 1993; Kobayashi et al., 2006; Kummel, 1960; Miyahigashi et al., 2012).

The Phra That Formation, the lowest unit of the Lampang Group (Fig. 3), is primarily composed of sandstone, siltstone, and conglomerate, with some minor components of limestone (Piyasin, 1971). This unit overlies the Permo–Triassic volcanic rocks of the Permian Group and underlies the Pha Kan Formation. Late Griesbachian to Early Anisian bivalves were reported from these clastic rocks (Chonglakmani and Grant-Mackie, 1993). The Pha Kan and Doi Long formations consist predominantly of limestone with minor sandstone and shale whereas in the intermediate Hong Hoi Formation limestone beds are subordinate. The Pha Kan limestone is gray to black, thin-bedded to massive, and oncoidal in places. The limestone of the Doi Long Formation is light gray to gray and predominantly massive, but gradually becomes well-bedded near the base and the top. The Pha Kan limestone contains a diagnostic ammonoid of late Anisian age (Chonglakmani and Grant-Mackie, 1993). A biostratigraphic study (Carey et al., 1995) demonstrated that the lower part of this unit contains the Early Olenekian (Smithian)