

PETROGRAPHY AND DEFORMATION OF DONCHAI GROUP METAMORPHIC ROCKS IN MUANG PAN AND CHAE HOM AREA

Jiranan Homnan^{1,*}, Phisit Limtrakun², and Weerapan Srichan²

Received: November 22, 2019; Revised: March 23, 2020; Accepted: March 24, 2020

Abstract

The Donchai Group are low-grade metamorphic rocks which are distributed in Northern Thailand. Their protoliths are pelitic rocks, quartzo-feldspathic rocks, and mafic/ultramafic rocks. The Donchai Group in the study area experienced at least two metamorphism events. They show the spotted porphyroblasts that are the evidence of contact metamorphism overprinted on the early regional metamorphism. The andalusite porphyroblast aggregate sized 2-10 cm while the cordierite relicts sized 1-5 mm in diameters. The first event (D₁) created their foliation that mostly dipping to the east while the second (D₂) created the crenulation cleavages. In microscale, the microstructures show a dextral sense of shear. The mineral assemblages of metapelites are biotite, muscovite, quartz, andalusite, sillimanite, cordierite, garnet, and tourmaline. The metapsammites contain quartz, K-feldspar, plagioclase, biotite, muscovite, chlorite, apatite, zircon and titanite. The metabasites compose of plagioclase, quartz, amphibole, orthopyroxene, biotite, chlorite, and opaque minerals. From the petrographic study, the Donchai Group metamorphic rocks are metamorphosed under the greenschist facies.

Keywords: Low-grade, metamorphic rocks, deformation, petrography

Introduction

The low-grade metamorphic rocks in Thailand were inferred as Silurian-Devonian age correlated with the fossil-bearing sedimentary rocks of the Thong Pha Phum Group or also known as the Kanchanaburi series (Brown *et al.*, 1951) by using their rock units relationship in field works and the similarity of the physical characteristics. In Northern Thailand, especially Chiang Mai and Lampang Provinces, the low-grade metamorphic rocks named the Donchai Group mostly exposed near the Triassic granitic bodies (Bunopas, 1983).

The Donchai Group occurred locally in the Sukhothai fold belt which bounded by the Chiang Mai-Chiang Rai Suture Zone along the western side and by the Nan-Uttaradit Suture along another side (Chaodumrong, 2012). The Sukhothai terrane were proposed as the eastern margin of the Paleo-Tethys major ocean basin that was accumulated since Middle Devonian and closed in Late Triassic (Metcalf, 2013). The Donchai Group were believed as the Silurian-Devonian rocks because their lithology have relicts of the pelagic sediments such

¹ Master of Science Program in Geology, Faculty of Science, Chiang Mai University, 239 Huay Kaew Road, Muang District, Chiang Mai, Thailand, 50200 Tel. +66(0)53943417-9; Fax. +66(0)53943444; E-mail: jiranan_h@cmu.ac.th

² Department of Geological Sciences, Faculty of Science, Chiang Mai University, 239 Huay Kaew Road, Muang District, Chiang Mai, Thailand, 50200.

* Corresponding author

as the dark colour and fine-grained textures. Their rock types were mainly described as the metapelites and metapsammities which are slaty shale, quartz-mica schist, phyllite, quartzo-feldsparthic schist, quartzite, chloritic phyllite, and calcareous phyllite with minor sedimentary rocks (Piyasin, 1972; Piyasin, 1975; Chaodumrong *et al.*, 1985; Puthapiban *et al.*, 1996). Later, the Donchai Group were divided into four rock units, the rock unit A to D are composed of phyllite and schist, gneiss and metagabbro, schist and quartzite, and phyllite and slate respectively (Phajuy *et al.*, 2002).

Due to the tropical climate and their fine grain texture, the outcrops generally deeply weathered and hard to do a sample collection. There are few recently documentations reported the Donchai Group about their petrography and deformation style. Thus, this research aims to study the mineral assemblages, metamorphic textures, and deformation styles of the Donchai Group metamorphic rocks in Muang Pan and Chae Hom Districts, Lampang Province based on field observation and petrographic works.

Materials and Methods

The deformation characteristics were collected in field observation by a geological compass on the outcrop scales and do the sampling steps at the same times. The rock samples were selected to do the thin sections by their freshest fabrics and be the representative of each rock units. The 30 micrometers-thick thin sections were studied their textures and mineral assemblages under the polarizing microscope.

Results and Discussion

The metamorphic rocks in the study area are composed of metapelites, metapsammities, and metabasites. They exhibit foliation (S₁) in north-south trending and may incline a bit in east direction with eastward dipping (Figure 1) that relates to the D₁ deformation. The second deformation (D₂) created crenulation cleavages overprinted on the S₁ foliation. The spotted porphyroblasts were the evidence of contact metamorphism that possibly crystalized by the same D₂ event. In mesoscales, the bow-tie andalusite aggregation can be clearly observed, their crystals sized 2-10 cm (Figure 2(a)). The relict of cordierites sized 1-5 mm were found in the spotted phyllites (Figure 2(b)). In microscale, the microstructures show a dextral sense of shear which can be observed from the sillimanite mineral

variety fibrolite (Figure 3(a)) and from the S-C fabrics in phyllites (Figure 3(b)).

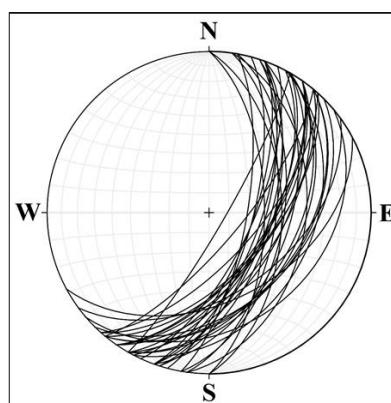


Figure 1. S₁ foliations on the stereographic projection that can be observed in the study area



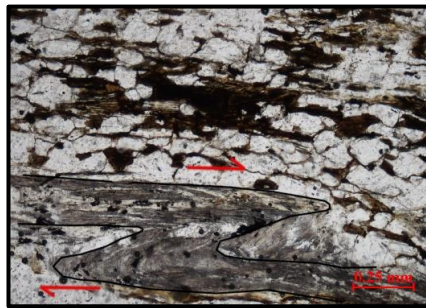
(a)



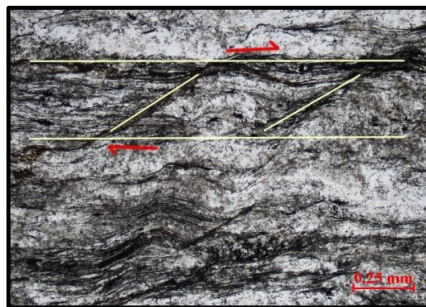
(b)

Figure 2. The spotted minerals observed in outcrop scales (a) andalusite aggregation (b) cordierite relicts

From the petrographic study, the metapelites, which are mainly phyllites, slates, and schists, show the grano-lepidoblastic textures and the porphyroblastic textures. The porphyroblast minerals are andalusite, cordierite (relict), and garnet (Figure 4) while the groundmass minerals compose of biotite, muscovite, quartz, sillimanite (fibrolite), and

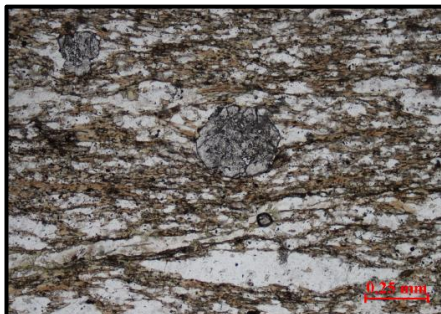


(a)

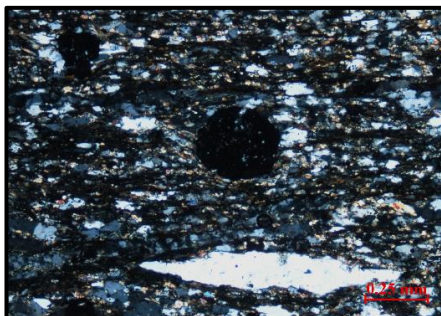


(b)

Figure 3. The microstructures observed in thin sections showing the dextral sense of shear (a) sheared fibrolite (sil) (b) S-C fabrics in phyllites



(a)



(b)

Figure 4. The photomicrograph of garnet porphyroblast in phyllites (a) ordinary light (b) cross-polarized light; grt = garnet, bt = biotite, qtz = quartz

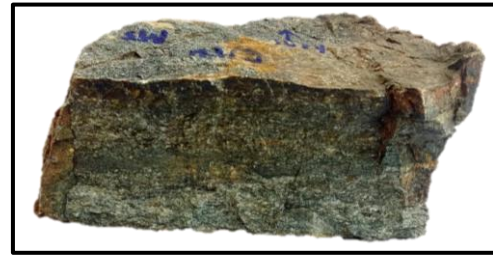


Figure 5. The mineral segregation in metabasites which can be observed in hand specimen

tourmaline. The metapsammites are gneisses and quartzites. The gneisses have originated from both sandstones and granitic protoliths comprised quartz, k-feldspar, plagioclase, biotite, muscovite, chlorite, apatite, zircon, and titanite. The sandstones that interbedded with thin-bed mudstones are the protolith of the quartzite. They are mainly consist of quartz with minor amount of biotite, muscovite, tourmaline, and zircon. The metabasites show mineral segregation which separated into light-band and dark-band (Figure 5). Their mineral assemblages are plagioclase, quartz, amphibole, orthopyroxene, biotite, chlorite, and opaque minerals.

The most mineral assemblages of the Donchai Group have occurred in the greenschist facies condition which metamorphosed under the temperature between 350-500°C and the pressure between 2-10 kbar (Yardley, 1989). The orthopyroxene in metabasites might be the remnants of the mafic/ultramafic protoliths because they do not show the equilibrium characteristics with other minerals.

The D₁ deformation was implied as they related to the initial stage of the Indosinian orogeny or the Paleo-Tethys closure event that started in Middle Triassic. The D₂ deformation might be related to the granitic intrusion during the crustal thickening or the late stage of the Indosinian orogeny in Late Triassic to Early Jurassic (Metcalfe, 2017).

Conclusions

The Donchai Group metamorphic rocks in Muang Pan and Chae Hom area, Lampang Province, Thailand were experienced at least two metamorphism events. The D₁ deformation resulted in north-south orientated foliation (S₁) that dipping to east. This event suggested as the primary stage of the Paleo-Tethys closure that occurred in the Middle Triassic. The D₂ deformation formed the crenulation cleavages and spotted minerals overprinted. They might be caused by the granitic plutons which

intruded in the Late Triassic to Early Jurassic. The microstructures evidence indicates that the Donchai Group were deformed in dextral direction. The parent rocks of the metapelites are fine-grained sedimentary rocks. They composed of andalusite, cordierite (relict), garnet, biotite, muscovite, quartz, sillimanite (fibrolite), and tourmaline. The metapsammities are metamorphosed from both sedimentary and felsic igneous rocks origin. Their mineral compositions are quartz, k-feldspar, plagioclase, biotite, muscovite, chlorite, apatite, tourmaline, zircon, and titanite. The metabasites preserved orthopyroxene minerals in the mafic/ultramafic igneous protoliths. The other minerals are plagioclase, quartz, amphibole, biotite, chlorite, and opaque minerals. From their mineral assemblages, the Donchai Group were metamorphosed under the greenschist facies with approximate 350-500°C and 2-10 kbar conditions.

Acknowledgements

This work is supported by The Igneous Rocks and Related Ore Deposits Research Laboratory (IROL), Department of Geological Sciences, Faculty of Science, Chiang Mai University and the Development and Promotion of Science and Technology Talents Project (DPST).

References

- Brown, G.F., Buravas, S., Charaljavanaphet, J., Jalichandra, N., Johnston, W.D., Sresthaputra, V., and Taylor, G.C. (1951). Geologic Reconnaissance of the Mineral Deposits of Thailand, U.S. Geological Survey, Bulletin, 984:183.
- Bunopas, S. (1983). Paleozoic succession in Thailand, geological Society of Thailand and geological society of Malaysia. Workshop on Stratigraphic Correlation of Thailand and Malaysia, September 8-10, 1983, Haad Yai, Thailand, p. 39-76.
- Chaodumrong, P., Jiumton, S., and Sanunsiang, S. (1985) Unpublished data. Geology of Thoen District Sheet 4844 III, Scale 1:50,000. Geological Survey Report. Department of Mineral Resources. Bangkok.
- Chaodumrong, P. (2012). Stratigraphy and tectonic subdivisions of Thailand, [abstract]. 12th GEOSEA 2012: Regional Congress on Geology, Mineral and Energy Resources of Southeast Asia; March 7-8, 2012; Bangkok, Thailand, 4p.
- Metcalfe, I. (2013). Review on gondwana dispersion and asian accretion: tectonic and palaeogeographic evolution of eastern tethys. *J. Asian Earth Sci.*, 66:33.
- Metcalfe, I. (2017). Tectonic evolution of Sundaland. *Bulletin of the Geological Society of Malaysia.*, 63:27-60.
- Phajuy, B., Punjasawatwong, P., Singharajwarapan, S., and Khandarosa, W. (2002) Unpublished data. Geology of the Muang Pan - Chae Hom Area, Changwat Lampang. Faculty of Science, Chiang Mai University.
- Piyasin, S. (1972). Unpublished data. Geology of Lampang Sheet NE 47-7, Scale 1:250,000. Geological Survey Division. Department of Mineral Resources. Bangkok.
- Piyasin, S. (1975) Unpublished data. Geology of Uttaradit Sheet NE 47-11, Scale 1:250,000. Geological Survey Division. Department of Mineral Resources. Bangkok.
- Puthapiban, P., Sanlayapong, S., and Lumjuan, A. (1996) Unpublished data. Paleozoic Rocks. Geology Division, Department of Mineral Resources. Bangkok.
- Yardley, B.W.D. (1989) An introduction to metamorphic petrology, Longman Group Ltd, UK, 248p.