



New discovery of late early ordovician graptolites and discussion on stratigraphic sequence of paleozoic sediments in the Dinh Ca - Trang Xa Section, Vo Nhai District, Thai Nguyen Province, Northeast Vietnam

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ABSTRACT

Sandstone, quartzitic sandstone rhythmically interbedded with siltstone, calcareous siltstone and cherty shale are largely exposed in the Dinh Ca - Trang Xa area, Vo Nhai District, Thai Nguyen Province, NE Vietnam. In previous studies, they were described as Mo Dong or Than Sa Formations (Middle-Upper Cambrian). The graptolite faunas newly discovered from the Dinh Ca Market - Na Mo - Dong Bo cross section are composed of *Expansograptus urbanus* (Monsen), *Expansograptus abnormis* (Hsu), *Tetragraptus quadribrachiatus* (Hall), *T. approximatus* Nicholson, *T. pacificus* Ruedemann, *T. decipiens* T.S. Hall, *Schizograptus* sp., belonging to the *quadribrachiatus* Biozone, indicating Floian Stage or late Early Ordovician. This serves as the basis for age determination and for establishing new lithostratigraphic units termed as the Dinh Ca Formation (O_1 *dc*) and the Ba Nhat Member. The stratigraphic sequence of Paleozoic sediments in the Dinh Ca - Trang Xa area is also discussed in this paper.

Keywords: Graptolite faunas, late Early Ordovician, Dinh Ca Formation, Ba Nhat Member, Thai Nguyen, Vietnam.

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1. Introduction

The location of graptolite Ordovic fauna collection and study of stratigraphic sequence including Ordovician, Devonian, and Carboniferous-Permian is shown in Figure 1. The area consists of low hilly and mountainous areas, ranging in elevation from 50 - 500m, and comprising mainly terrigenous, carbonate and cherty shale rocks. They are largely exposed

around the Dinh Ca Town, and in the Tien Phong, Phu Thuong, Ba Nhat, Tan Thanh, Na Mo, Dong Bo, Mo Dinh, Dong En, Lang Den, Trang Xa villages of Vo Nhai District, Thai Nguyen Province, about 30 km northeast of Thai Nguyen City, and 100 km from Ha Noi. Geographically, the study area is in the northeastern region of Viet Nam, belongs to the Song Hien Structure-facial Zone (Dovjikov et al., 1965), the Bac Son Miogeosynclinal Fold Zone (Le Duy Bach, 1985); or the Early Paleozoic Intracontinental Orogenic Belt of

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Northeast Viet Nam (Tran Van Tri, Vu Khuc (Eds.) 2011).

In this study, the new findings of Ordovician graptolite faunas are used to propose a

new stratigraphic nomenclature for the Ordovician succession. The stratigraphic sequence of Paleozoic sediments in the Dinh Ca-Trang Xa area are also discussed here.

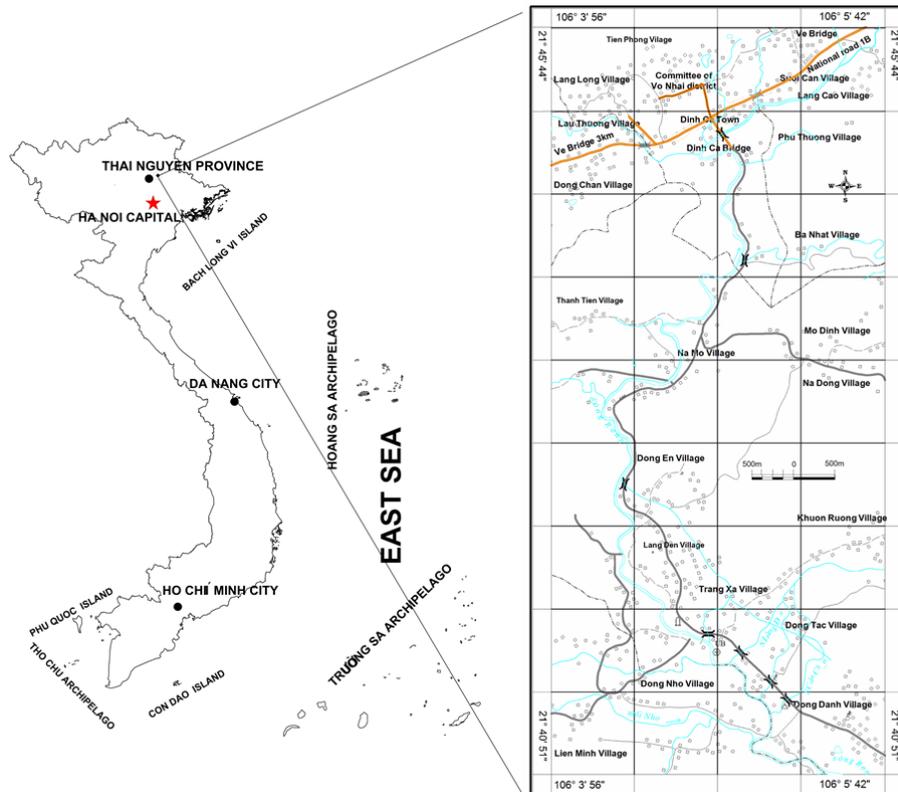


Figure 1. Sketch map showing outcrops of Paleozoic sediments in the Dinh Ca - Trang Xa area

2. Geological setting

The Dinh Ca - Trang Xa area is chiefly Paleozoic sediments, which were mapped by Doan Ky Thuy et al. (1976, 2000) at 1:200.000 scale of the Lang Son Geological Sheet (Figure 2), and divided into the following lithostratigraphic units (Doan Ky Thuy (Ed.) 1976, 2000):

The Mo Dong Formation ($\epsilon_2 md$) composed of quartzite, quartzitic sandstone, siltstone, clay shale, 300 m thick, is considered as the lowermost formation of Cambrian sediments in the Dinh Ca - Trang Xa area.

The Than Sa Formation ($\epsilon_3 ts$) is composed of two sub-formations, with the Lower Sub-formation ($\epsilon_3 ts1$) comprising clay shale, thin beds of polymictic sandstone, 500 m thick, and the Upper Subformation ($\epsilon_3 ts2$) containing polymictic sandstone, grey clayish shale, 350 m thick. The formation lies conformably on the Mo Dong Formation ($\epsilon_2 md$), and has a tectonic contact with the Song Cau Group (D1 sc) and the Mia Le Formation (D1 ml).

The Na Mo Formation (O nm) composed of sandstone, quartzitic sandstone, clay shale, and siltstone yielding trilobite *Ectenoglossa*

sp., *Lochodomas aff. yohi*, *Ceraurinus* sp., Than Sa Formation ($\epsilon_3 ts$), and shows tectonic contact with the Song Cau Group (D1 sc). 200-225 m thick overlies conformably the

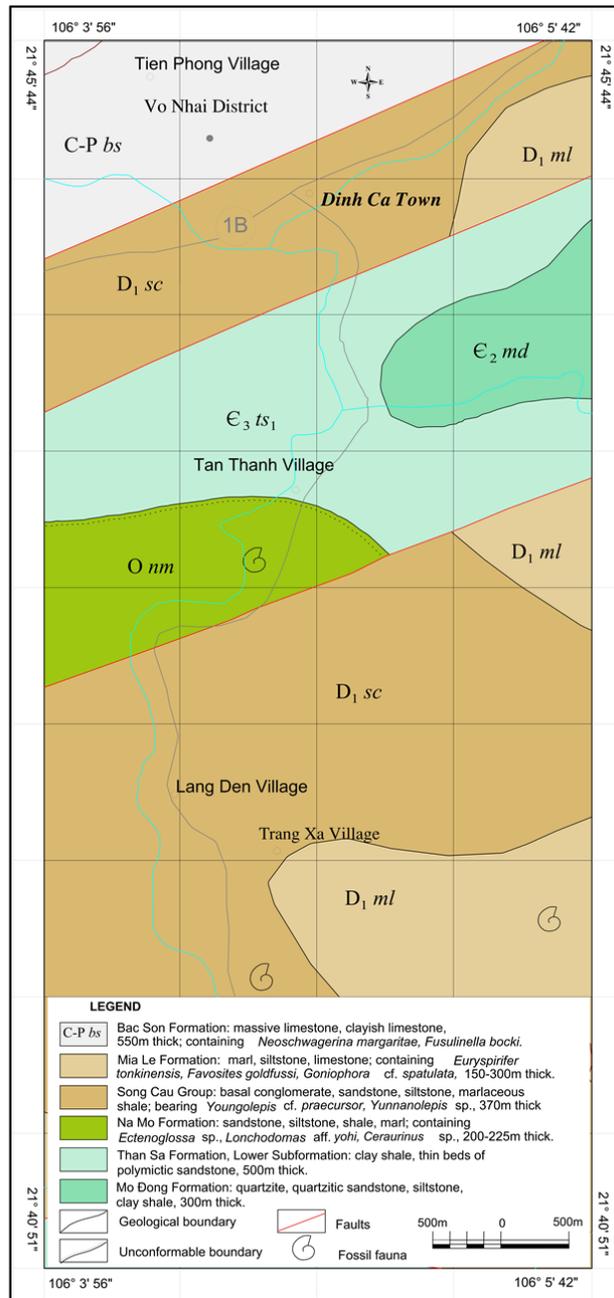


Figure 2. The Dinh Ca - Trang Xa area shown in Lang Son geological and mineral resources Sheet map at 1:200,000 scale (Doan Ky Thuy et al., 2000)

The Song Cau Group (D1 *sc*) comprising basal conglomerate, gritstone, sandstone, siltstone, marlaceous shale bearing fish *Yungolepis cf. praecursor*, *Yungolepis* sp., 370 m thick has a tectonic contact with the Than Sa Formation (ϵ_3 *ts*), Na Mo Formation (O *nm*), Bac Son Formation (C-P *bs*), and underlies conformity the Mia Le Formation (D1 *ml*).

The Mia Le Formation (D1 *ml*) composed of marl, siltstone, and limestone containing brachiopod *Euryspirifer tonkinensis*, *tabulate Favosites goldfussi*, bivalve *Goniopora cf. spatulata*, 150-300 m thick overlies conformably the Song Cau Group (D1 *sc*), and shows tectonic contact with the Than Sa Formation (ϵ_3 *ts*).

The Bac Son Formation (C-P *bs*) is composed of massive limestone, oolitic limestone, clayish limestone, yielding foramiferan *Nesoschwagerina margaritae*, *Fusulinella bocki*, 550 m thick. It has a tectonic contact with the Song Cau Group (D1 *sc*).

3. Materials and methods

Five hundred paleontological samples were collected from this area. Among these two hundred specimens are graptolite fossils, some were determined by Xu Chen (Laboratory of Palaeontology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences; 39 East Beijing Road, Nanjing 210008, China). The brachiopod, poriferan, cnidarian, mollusc, echinoderm, bryozoan and chordata (fish fossils) data cited in this study were determined by Kobayashi T. (1960), Sokolov B. S. (1965); Tong Duy Thanh (1967), Tong Duy Thanh, Janvier Ph. (1994), Duong Xuan Hao, Pham Kim Ngan, Luong Hong Huoc, Dang Tran Huyen (1980), Le Hung (1977, 1980), Nguyen Van Liem (1978), Nguyen Huu Hung (1982) and this study.

The section bearing graptolite faunas of late Early Ordovician is exposed along the road, in south-southwestern direction from Dinh Ca Market to Dong Bo-Na Mo cross section (Figure 1 and Figure 4). In general, this section reveals an anticlinorium structure, which consists mainly of sandstone, siltstone, calcareous shale and siliceous shale rhythmically intercalated with thick-bedded sandstone. In the previous studies, this stratigraphic sequence was confusingly described by Dovjikov et al. (1965) as of the Mo Dong Formation (ϵ_3 *md*) and showed on the North Vietnam geological map at 1:500,000 scale; or listed to the Than Sa Formation (ϵ_3 *ts*) and shown on the Lang Son geological map at 1:200,000 scale (F-48-XXIII) by Doan Ky Thuy et al. (1976, 2000).

Member 1: Containing medium-grained sandstone, light-colored, 4-5 cm bedded; yielding some crinoid stems, not well preservation, interbeds are light-colored siltstone, and black-grayish shale, thin-bedded yielded graptolite faunas. The total thickness is about 150m

Member 2: 50 m thick. The medium-grained sandstone, greenish-grey, thick-bedded; no fossils found.

Member 3: Including greenish-grey micaceous siltstone, with interbeds of brownish shale; no fossils found. The total thickness is about 150 m

Member 4: Being named as Ba Nhat Member (new name) for the sediments yielding graptolite faunas. The base is characterized by fine-grained sandstone, 1-2 cm bedded. Directly overlying is grey siliceous shale intercalated with light-colored siltstone, and black-grey calcareous shale, 1-2 mm bedded with abundant graptolite faunas (Figure 3). This member is isolated with

Member 3 by minor fault. The total thickness is about 20 m.

Member 5: Comprising brownish quartzitic sandstone, thick-bedded of the total thickness about 50 m, no fossils found.

Member 6: Including grey-greenish siltstone, thin-bedded with the total thickness about 8 m, no fossils found.

Member 7: Containing brownish sandstone, medium-bedded, having a

thickness of about 10 m; no fossils found.

Member 8: Containing greenish-grey siltstone, thin-bedded with the total thickness about 8 m no fossils found.

Member 9: Comprising brownish sandstone, thick-bedded with the total thickness about 80 m, no fossils found.

Member 10: Including white-grey, greenish-grey siltstone, thin-bedded, intercalated with fine-grained sandstone with the total thickness about 60 m, no fossils found.

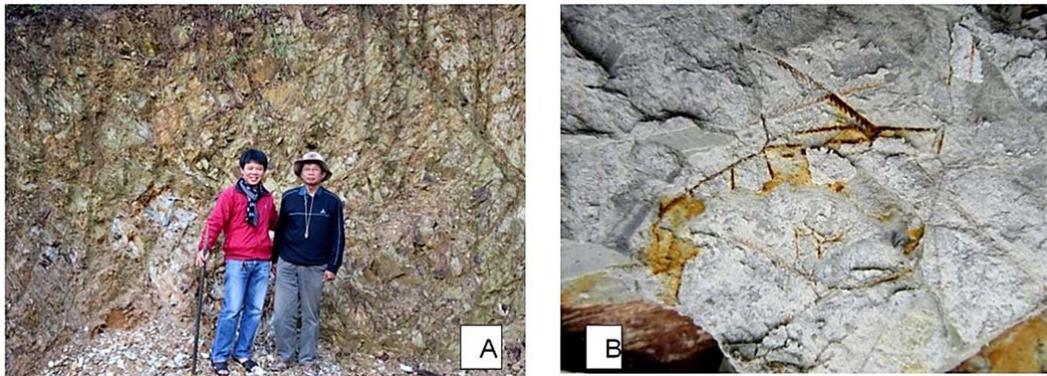


Figure 3. A. Outcrop containing late Early Ordovician graptolite faunas at the Ba Nhat Village; B. Light-colored siltstone including graptolite faunas *Tetragraptus quadribrachiatius* Biozone

In summary, 200 graptolite specimens were collected in the Ba Nhat Member. Some of the samples have recently been identified by Xu Chen as *Expansograptus urbanus* (Monsen) (Figure 5A), *E. abnormis* (Hsu) (Figure 5B), *Tetragraptus quadribrachiatius* (Hall) (Figure 5D-C), *Tetragraptus. approxi-*

matus Nicholson (Figure 5E-F), *Tetragraptus. pacificus* Ruedemann (Figure 6A-C), *T. decipiens* T.S. Hall (Figure 6D), *Schizograptus* sp. (Figure 6E), belonging to the *quadribrachiatius* Biozone. This graptolite biozone is completely disappeared at the top of the Ba Nhat Member.

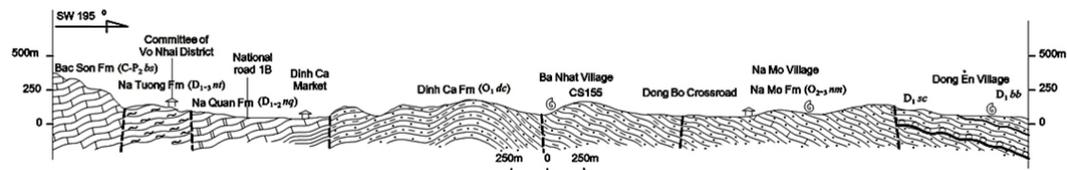


Figure 4. The Dinh Ca Market - Na Mo - Dong Bo cross section

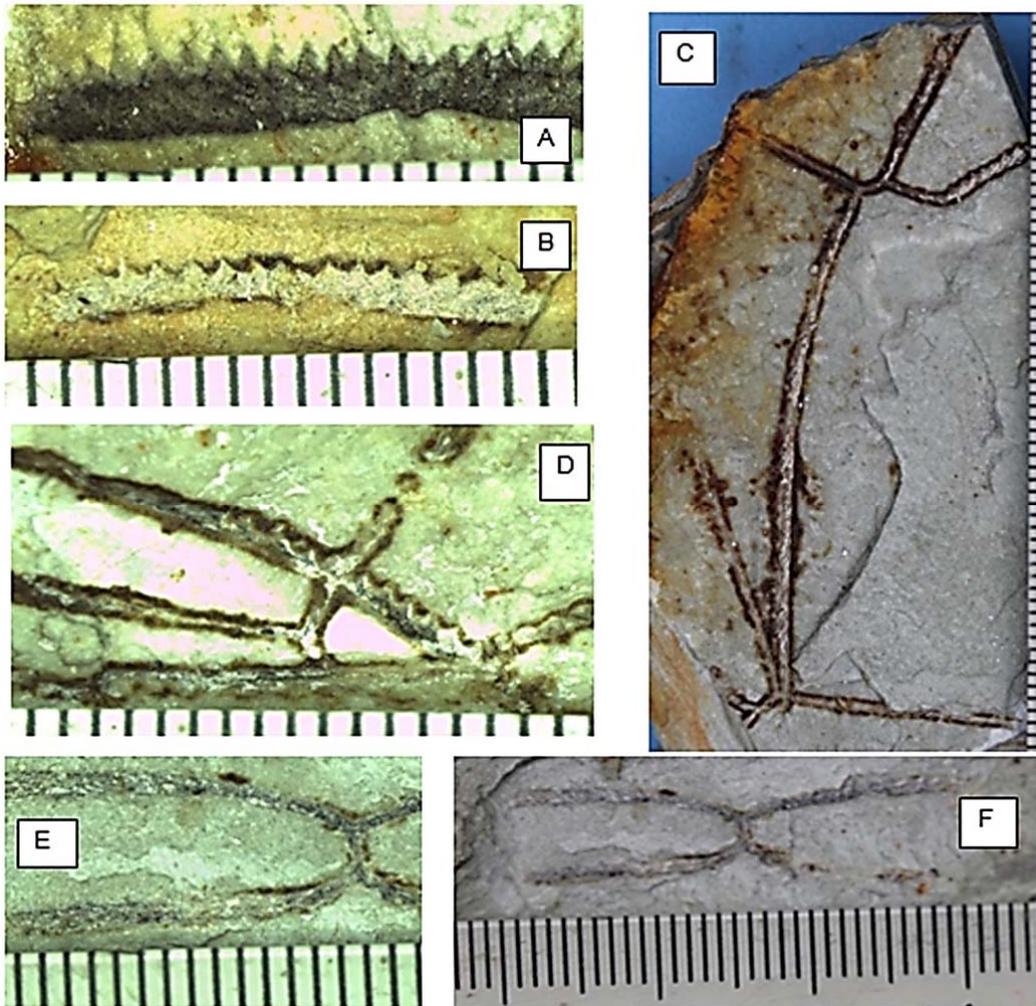


Figure 5. A. *Expansograptus urbanus* (Monsen), specimen no.CS155.3.1; B. *Expansograptusabnormis* (Hsu), specimen no.CS155.3.9; C-D. *Tetragraptus quadibrachiatus* (Hall) C-specimen no.CS155.3.2, D-specimen no.CS155.3.10.; E-F. *Tetragraptus approximatus* (Nicholson); E-specimen no.CS155.3.3; F-specimen no.CS155.2.2.The all specimens are housed in the Vietnam National Museum of Nature, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet Street, Cau Giay District, Ha Noi Capital

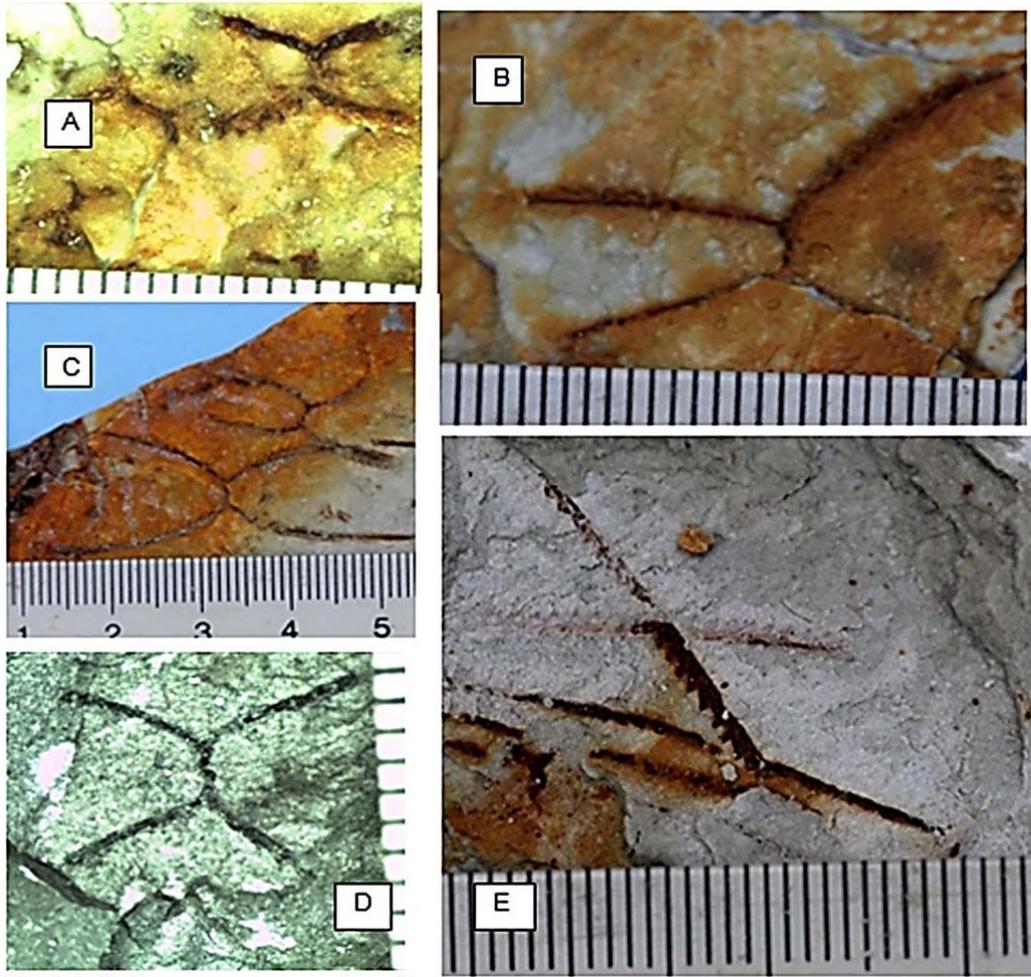


Figure 6. A-C. *Tetragraptus pacificus* Ruedemann; A - specimen no.CS155.2.3; B-specimen no.CS155.2.4; C - specimen no.CS155.2.5; D. *Tetragraptus decipiens* T.S. Hall, specimen no.CS155.1.1; E. *Schizograptus* sp., specimen no. CS155.2.6. The specimens are housed at the Vietnam National Museum of Nature, VAST, 18 Hoang Quoc Viet Street, Cau Giay District, Ha Noi

4. Stratigraphic sequence in the Dinh Ca-Trang Xa area

The stratigraphic sequence of Paleozoic sediments in the Dinh Ca - Trang Xa area is shown in Figure 8.

4.1. Late Early Ordovician sediments in the Dinh Ca Formation (newly defined)

The late Early Ordovician graptolite

faunas newly found from the Dinh Ca - Trang Xa stratigraphic section have provided important information relative to the Ordovician graptolite faunas and regional stratigraphy of the Lower Paleozoic sediments in Viet Nam. The stratigraphical and biogeographical significances of graptolite biozone are described as follows:

- *Tetragraptus quadribrachiatum* (Hall) is geographically widespread in the world. It

was reported in the works of Hall (1858), Elles and Wood (1901), Ruedemann (1904, 1947), Berry (1960), Cooper (1979), Cooper and Fortey (1982), Tsai (1974), and Carter (1988). It was found in Alaska, Western Canada, New Zealand, Spitsbergen and Soviet Union. Recently in the Ordovician biochemostratigraphic chart (International Sub-commission on Ordovician Stratigraphy, 2009) (Bergstöm 2008, Xu Chen et al. 2009), the graptolite *Tetragraptus approximatus* Zone is considered as the base of stage slice F11. Above it is the conodont *Oepikodus evae* Zone, belonging to F12. This interval corresponds to the lower part of Floian Stage or late Early Ordovician.

- *Tetragraptus approximatus* Nicholson is considered as the global graptolite *Tetragraptus approximatus* Biozone, that is the base for the global Florian Stage (Bergstöm, 2008). In Southwest Sweden, *Tetragraptus approximatus* Nicholson appeared at the lower half of the Second Stage of Lower Ordovician, including *Tetragraptus phyllograptoides*, *Didymograptus balticus* (Bergstöm, 2004).

- *Expansograptus abnormis* (Hsu) appears at the base of the Hentang Member corresponding to the late Early Ordovician, and completely disappears at the Upper Member of the Ningkuo Formation, corresponding to the Middle Ordovician in Zhejiang Province, South China. The other forms are *Tetragraptus pacificus* Ruedemann, *T. decipiens* T.S. Hall, *Expansograptus urbanus* (Monsen), *Schizograptus* sp., generally known in the Lower-Middle Ordovician stratigraphy of North America, Europe and China. In summary, most of the graptolite faunas from Ba Nhat Member showed closest relationships to the Floian (late Early Ordovician) graptolite species in the world. At present, there are a number of fossil-free gaps (or not yet found) at the section of Dinh Ca Formation; but hopefully the fossils will be found in both the lower and upper parts so that age of the Dinh Ca Formation will be completely defined.

The sediments yielded late Early Ordovician graptolites cited above may not be viewed as Upper Cambrian or of the Mo Dong Formation ($\epsilon_3 md$) as in the geologic map of northern Vietnam at 1:500,000 scale by Dovjikov et al. or the Than Sa Formation ($\epsilon_3 ts$) as in the Lang Son geologic sheet at 1:200,000 by Doan Ky Thuy et al. (1976, 2000). Therefore, we propose new lithostratigraphic units for terrigenous sediments of the Lower Paleozoic stratigraphy. The Dinh Ca Formation (newly named) named after Dinh Ca Town, and the Ba Nhat Member (newly named) named after Ba Nhat Village, where graptolite faunas found. They are characterized by rhythmic sediments, including sandstone with intercalations of siltstone, cherty shale, and calcareous shale yielded graptolite faunas of late Early Ordovician age. The stratigraphic section from the Dinh Ca Market (21°45'08''N, 106°04'42''E) to the Dong Bo-Na Mo cross section (21°43'47''N, 106°04'18''E) is chosen as the stratotype for the Dinh Ca Formation (Figure 4). The Ba Nhat Member is characterized by thin beds of sandstone, siltstone intercalated with siliceous shale and calcareous shale yielding abundant graptolite faunas of late Early Ordovician age. In the Song Hien Structure-facial Zone of Dovjikov et al. (1965) in Northeast Viet Nam, the Dinh Ca Formation ($O_1 dc$) is distinguished from the Than Sa Formation ($\epsilon_3 ts$), which was established by Tran Van Tri et al. (1964) in Than Sa area, Vo Nhai District, Thai Nguyen Province by the presence of graptolite biozones of late Early Ordovician age. It is also distinguished from the Phu Ngu Formation of Late Ordovician-Early Silurian age, which was established by Pham Dinh Long (1968) in the Phu Ngu area, Dinh Hoa District, Thai Nguyen Province by its sediments, which are free of acidic effusives but containing older graptolite biozones. The detailed sedimentary distributions in the Dinh Ca Formation in the Song Hien Structure-facial

Zone, also elsewhere in Northeast Viet Nam should be studied in future.

4.2. Middle-Late Ordovician sediments of the Na Mo Formation ($O_{2-3 nm}$)

Sediments of the Na Mo Formation widely exposed in the southern side of the Dinh Ca-Na Mo section (see Figure 4) are composed of thick-bedded quartz sandstone with interbeds of sandstone, siltstone containing trilobite, brachiopod faunas of Middle Ordovician age.

In the upper part of the formation are interbeds of light-colored limestone (Figure 7A, B) which in the E. D. Vaxilevskaja's original description (Dovjikov et al., 1965), these limestones yielded heliolitoid coral *Plasmoporella* of Late Ordovician age. Presently, limestone beds are well exposed along the local road, to the left hillside, about 300m southwest of the Dong Bo-Na Mo cross section. The contact with the underlying Dinh Ca Formation is cut by minor faults running in east-west direction.

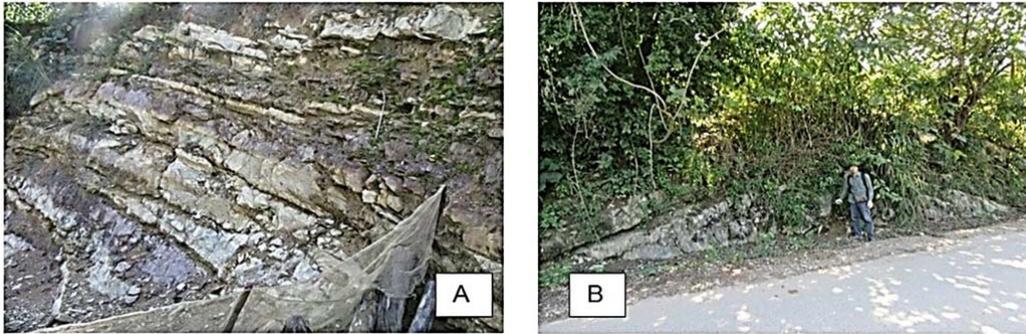


Figure 7. A. Light-colored limestone, thick-bedded at left hillside; B. Light-colored limestone of the Na Mo Formation widely exposed to the left of the road, km 3.7 toward Trang Xa

4.3. Devonian sediments

The Devonian sediments are largely spread. Five lithostratigraphic units are being proposed here. At the southern side of the section in the Dong En Village exposed cropped out are red conglomeratic sandstone beds yielding some fish remains, assigned to the Si Ka Formation ($D_1 sk$). It lies unconformably on the Na Mo Formation, but locally, some of the beds are cut by small-scaled faults. The Early Lochkovian age of the Si Ka Formation is based on the correlation with stratotype of the formation bearing fish, crutacean, plant fossils in the Dong Van area, Ha Giang Province. Directly above are calcareous siltstone yielded abundant brachiopod *Howellella mercuri*, *Howittia wangi*; fish *Yunnanolepis* cf. *praecursor*, *Y. meemannae*, *Chuchinolepis* cf. *dongmoensis*, *Zeaspis* sp., *Nostolepis* sp., *Langdenia campylognathus*; tabulate *Favosites* aff. *intricatus*, *Squameofavosites ko-*

lymaensis, *Thamnopora incerta* showing Late Lochkovian-Early Pragian age, being assigned to the Bac Bun Formation. Overlying conformably the Bac Bun Formation are marble and dark-grey calcareous shale of the Mia Le Formation ($D_1 ml$), including abundant brachiopod, coral, bivalve, stromatoporoid, crinoid faunas belonging to the *Euryspirifer tonkinensis* assemblage of the Late Pragian-Early Emsian age. Overlying conformably the Mia Le Formation are mainly limestones bearing abundant coral and stromatoporoid faunas suggesting the Late Emsian-Early Eifelian age, and assigned to the Na Quan Formation ($D_{1-2 nq}$). Found in the northeastern side of the section, at the Dinh Ca bridge is a tectonic fault of NE-SW direction, which spreads along a stream of north flank of the terrigenous mountain range of the Dinh Ca Formation ($O_1 dc$). On the valley from the Dinh Ca Town to the Ve Bridge exposed are light-colored limestones yielding poriferan *Amphi-*

pora, *Stachyodes*, *Trupetostroma*, *Chaetetes* and coral, brachiopod fossils belonging to the Na Quan Formation ($D_{1-2}ng$). Directly above, on the hills around the Dinh Ca Town outcropped are siliceous shale bearing tentaculitid *Stiatostyliolina* sp., *Viriatellina* sp., *Styliolina* sp. showing the Late Emsian-Frasnian age, and assigned to the Na Tuong Formation ($D_{1-3}nt$).

4.4. Carboniferous-Permian sediments

Along the northwestern direction near the Committee Building of Vo Nhai District, above the Na Tuong Formation cropped out are mainly thick-bedded limestones of the Bac Son Formation ($C-P_2 bs$) bearing abundant foraminifers of zones *Dainella*, *Endothy*

anopsis, *Millerella*, *Profusulinella*, *Fusulinella*, *Obsoletes*, *Triticites*, *Schwagerina*, *Robustoschwagerina*, *Misellina* and *Neoschwagerina*. The Bac Son Formation ranges from the Lower Carboniferous (Visean stage) to the upper Middle Permian (Capitanian stage), and has the tectonic contact with the Na Tuong Formation.

In general, the structure of the stratigraphic section from the Committee Building of Vo Nhai District, northsouthern direction passing by the Dinh Ca Market to Trang Xa Village (Fig. 8) is an anticlinorium, whose core is filled by sediments of the Dinh Ca Formation, bearing global *Tetragraptus quadribrachiatatus* graptolite Biozone of late Early Ordovician age.

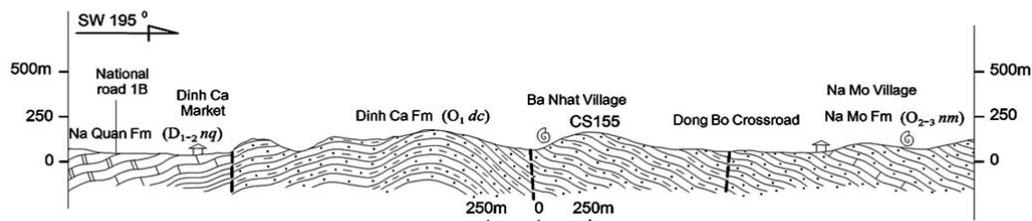


Figure 8. Geologic section from the Committee Building of Vo Nhai District passing by the Dinh Ca Market to the Trang Xa Village

5. Conclusion

The discovery of Early Ordovician graptolithina plays an important role for stratigraphic correlation of Lower Paleozoic sediments in Northern Vietnam. It serves as the basic data for establishing new lithostratigraphic unit termed as the Dinh Ca Formation in the north-eastern region of Vietnam.

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