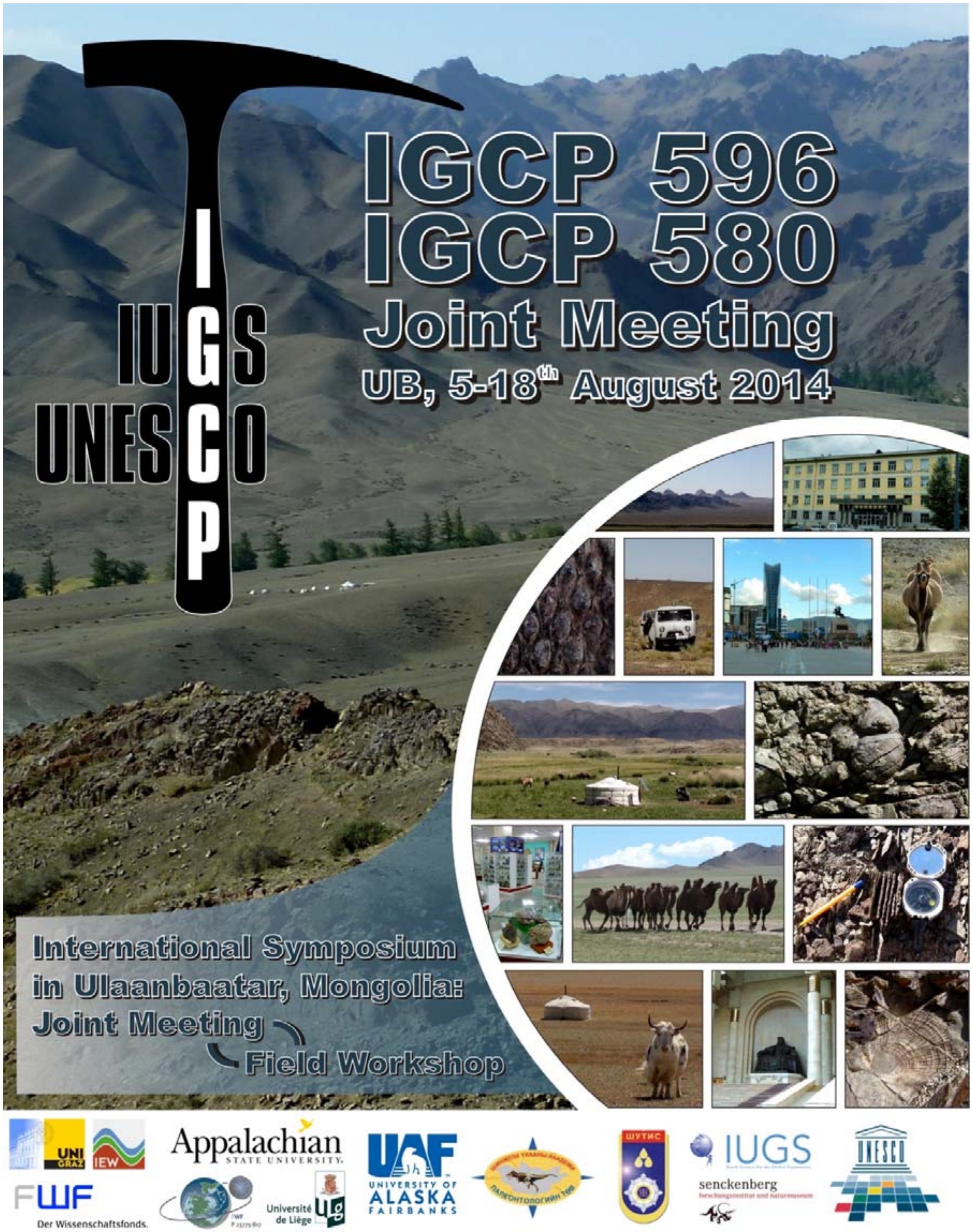
IUGS
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IGCP 596
IGCP 580
Joint Meeting
UB, 5-18th August 2014
International Symposium
in Ulaanbaatar, Mongolia:
Joint Meeting
Field Workshop
UNI GRAZ
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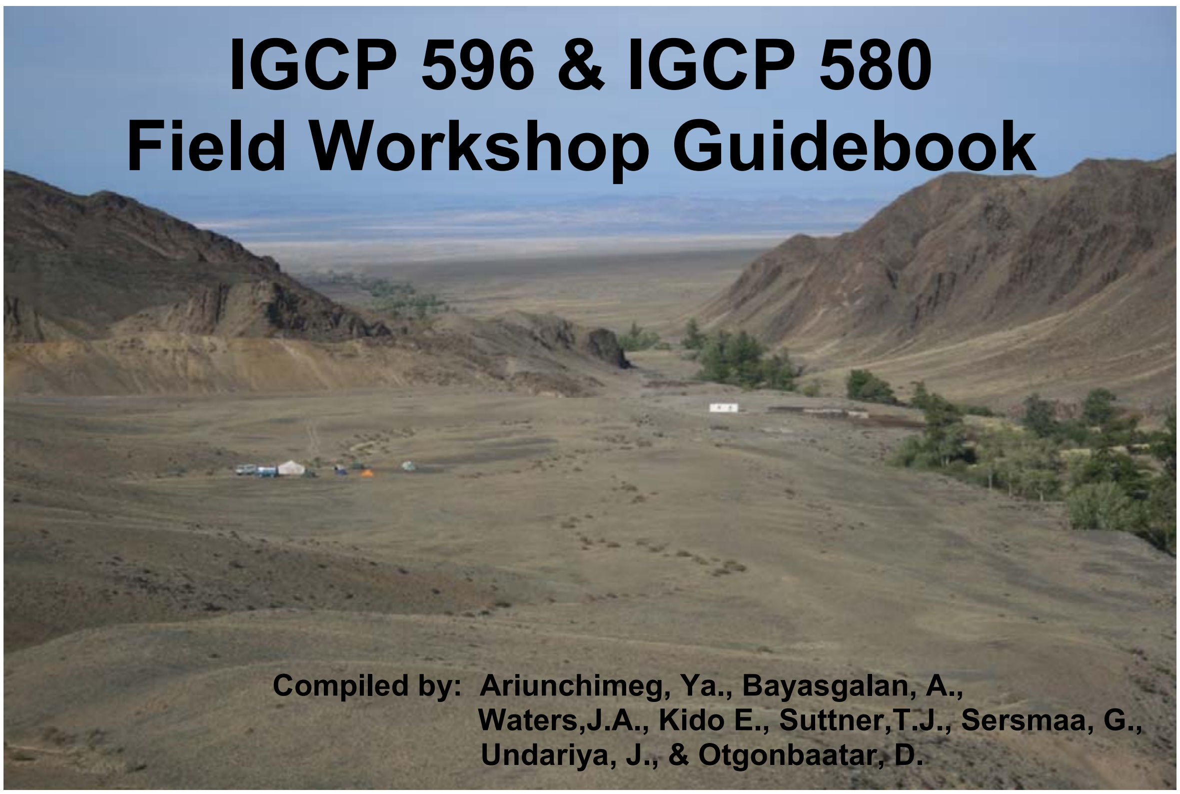


8-18 August, 2014, Ulaanbaatar, Mongolia

Introduction

IGCP 596 has a primary focus on climate change and biodiversity patterns in the Mid-Paleozoic (Early Devonian to Late Carboniferous). The Mid-Paleozoic was a time of dynamic long-term climate change accompanied by significant changes in biodiversity. The preliminary goal of this project is to increase the record of biodiversity and clarify links between specific biodiversity patterns and climate. In order to reach the goal, we would like to enhance the discussion within the project with multidisciplinary approaches such as geochemistry and geophysics as well as paleoclimate modeling. Therefore the International Symposium in Mongolia will take place jointly with the IGCP 580 (Application of Magnetic Susceptibility on Palaeozoic Sedimentary Rocks).

As a part of IGCP 596, we conducted a field workshop in western Mongolia in the summer of 2012. The goal was to locate fossiliferous sections that expose the stage boundaries from the Eifelian / Givetian boundary (Middle Devonian) to the Devonian / Carboniferous boundary to expand our knowledge of the key Devonian biotic and geochemical events such as the Frasnian / Famennian extinction event and the Kačák, Kellwasser and Hangenberg oceanographic events.

The Frasnian / Famennian event is one of the Big Five extinction events. Subsequent work has shown that a number of biodiversity crises occurred in the Middle and Late Devonian including the Givetian / Frasnian event, the Frasnian / Famennian event and the Devonian / Carboniferous event. All the analyses conclude that the Middle and Late Devonian was a time of biotic crisis that spanned many millions of years. Middle Devonian events may not have reached the ecological severity of the F/F event, but the G/F event was a significant extinction event for echinoderms and bryozoans and for the replacement of endemic marine faunas by more cosmopolitan ones. The Middle Devonian was the time of rapidly increasing diversification of tree-like vegetation on land, the development of root-systems and the formation of soil, which dramatically changed atmospheric CO_2 and climates. Although many Devonian-Carboniferous sections contain evidence of these extinction and anoxic events, we have been conducting fieldwork in northwestern China and now Mongolia not only to expand the global scale of such studies, but also to examine stratigraphic sections deposited on volcanic island arc systems.

We wish you fruitful discussions during the field work and hope it will provide an important step towards the final project year of IGCP 596.

FIELD EXCURSION PROGRAMME

Day 1 (8 August)
Flight from Ulaanbaatar to Khovd (1500 km). Drive towards south to the campsite. Stay in the field for night.

Day 2 (9 August)
Arrive to Camp side.

Day 3 (10 August)
Visit the Samnuuruul section near the monument (Point no. 3).

Day 4 (11 August)
Visit the Samnuuruul section near the monument (Point no.3)

Day 5 (12 August)
Visit the Samnuuruul section near the monument (Point no.3)

Day 6 (13 August)
Drive to the outcrop (10 km) of Samnuuruul section near the Hushoot shiveetiin gol (Point no.4).

Day 7 (14 August)
Drive to the outcrop (60 km) of Samnuuruul section at Shiveet uul (Point no.5).

Day 8 (15 August)
Drive to the “bentonite” (70 km) section (Point no.6, Nuhniinuruu Formation).

Day 9 (16 August)
Drive to Hovd. Camping at Hoshoot coal mine.

Day 10 (17 August)
Return to Hovd city.

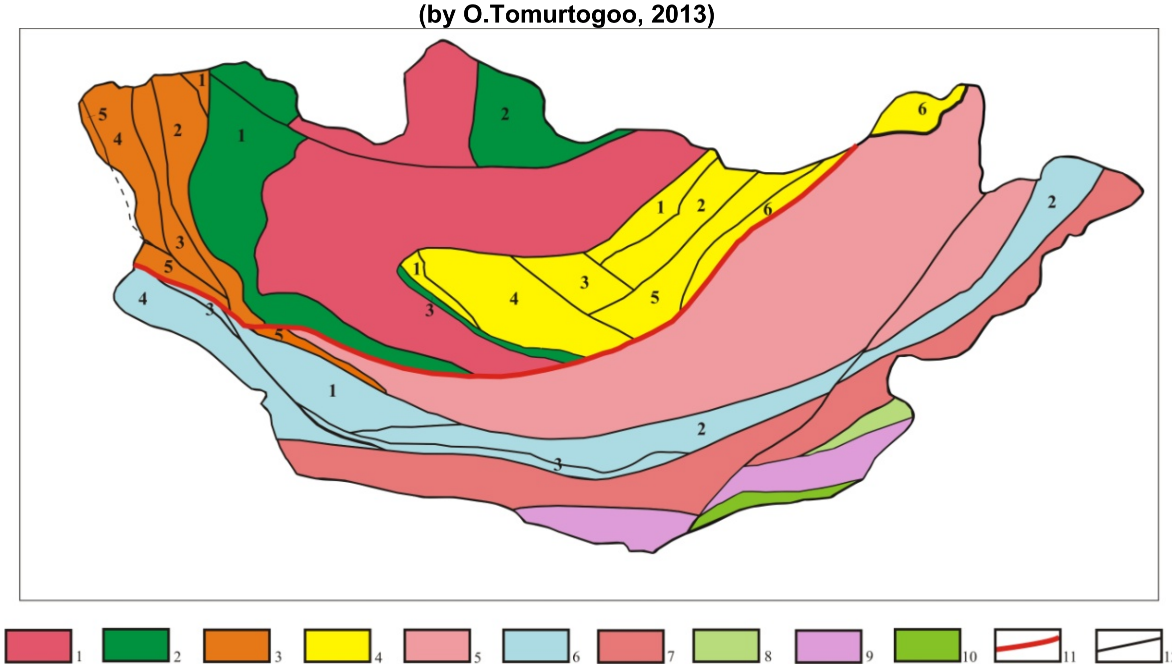
Day 11 (18 August)
Flight from Hovd to Ulaanbaatar.

Fig. 1. The road map from Hovd to studied localities.

1-Nariinhar Formation; 2-Baruunhuurai Formation, 3-main locality of Samnuuruul Formation near the monument, 4-Samnuuruul Formation near Hushoot Shiveetiin gol, 5-Samnuuruul Formation at Shunhat uul, 6-Nuhniihuruu Formation, “bentonite” locality.

The Paleozoic fold belts of Central Asia, situated between the Siberian platform and Cathaysia are ordinally regarded as a part of the Central Asian Orogenic Belt. The following folded regions are identified within Mongolia (Fig.2).

Fig.2. Tectonic scheme of the Folded domains in Mongolia (by O.Tomurtogoo, 2013)



1-4 – North Mongolian Folded domain: 1 – Central Mongolian massif, 2 –Lake (1), Eastern Pre-Hovsgol (2) and Bayanhongor (3) fold megazones, 3- Mongolian Altay fold megazone (1-5 terranes), 4-Hangay-Hentey fold megazone (1-6 terranes); 5-10 South Mongolian Folded domain: 5- Herlen massif, 6 – Gobi fold megazone (1-4 terranes), 7 – South gobi massif, 8 – Zamyn-Uud suture zone, 9 – Hatanbulag massif, 10 – Sulinheer fold megazone, 11-12 – faults: 11-Mid Mongolian Tectonic Line, 12 – other faults.

THE BARUUNHUURAI TERRANE

In recent years, according to the O.Tomurtogoo (2013) the Baruunhuurai terrane is the south west end of the Gobi fold megazone (Fig.2, 6/4). An attempt at subdivision of Baruunhuurai into several zones were undertaken by Ruzhentsev et al., (1992) and Ruzhentsev (2001, Fig.3), who named this zone as East Dzungaria and recognized five tectonic zones (from north to south): the Bidzi, North Barunkhurai, Olonbulag, Ulanus and South Barunkhurai zones. In the Baruunhuurai region Ruzhentsev et al., see pinchout of a number of principal tectonic elements of eastern Kazakhstan and Xinjiang (Ob-Zaisan folded system, Chingiz-Tarbagatai system, Junggar-Balkhash system) and their replacement by structures of southern Mongolia. The south Baruunhuurai zone (Baitag and Ulaanus subterranes) is viewed as the eastern termination of the Junggar-Balkhash Variscan folded system; the Olonbulag and north Baruunhuurai (Baaran subterrane) zones are an analog of the Central Kazakhstan volcanic belt. The Bij zone (Fig.2, terrane 3 of Gobi fold megazone) is the connecting link between the Varizcan Ob-Zaisan and South Mongolian systems. The following paleotectonic model of the Mongolian part of East Dzungaria were suggested by Ruzhentsev: the upper sheet of Baitag subterrane - a pre-arc paleo-oceanic trough; the lower sheet -the fore arc zone of the Baitag ensimatic island arc; southern part of the Ulaan us subterrane - the back arc zone, the Ulaanus subterrane - back arc basin, the Baaran volcanic belt (an Andean type continental margin) formed on the eastern continuation of the Caledonian Chingis Tarbagatai continent; the Bij paleooceanic basin, probably representing the eastern continuation of the ob Zaisan Variscian paleo-ocean.

All of the above mentioned structures probably died out in middle Carboniferous time, due to a collision between the Caledonian continent and the Baitag island arc. The obduction of palaeo-oceanic elements on to the continent, with firstly the deposits of the back arc basin and then those of the islanbd arc and the pre-arc trough being overtrust on the continental margin, is well esteablished. The neoautochthonousd orogenic complex there is a late Palaeozoic in age.

In the tectonic map of Mongolia published in 2003 the scheme of subdivision by them is basically adopted with a few modifications.

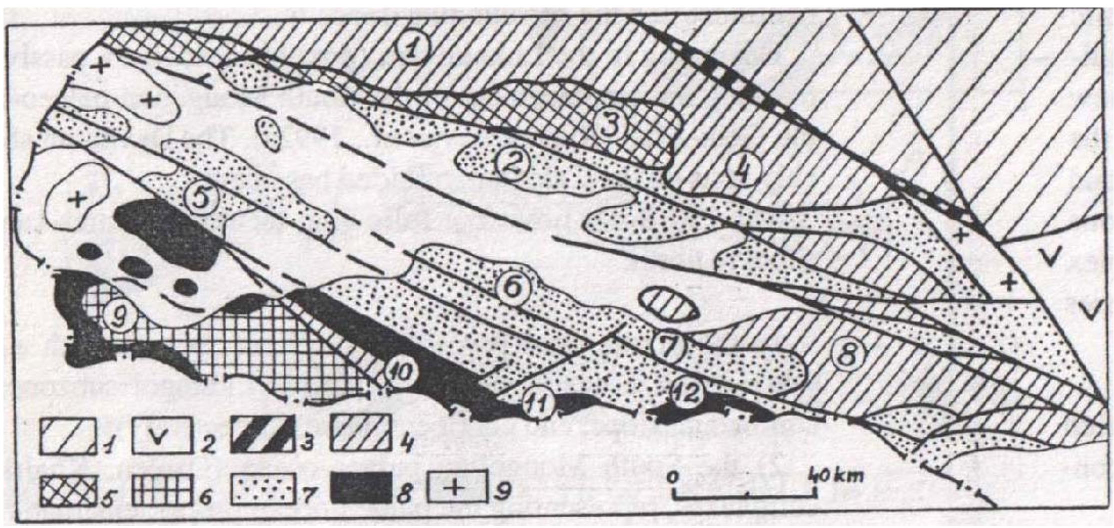


Fig.3. Tectonic zonation of the Baruunhuurai terrane (East Dzungaria)
1-Caledonids of Mongolian Altai; 2-Variscides of South Mongolia; 3-9 – Variscides of Baruunhuurai: 3 –Bidzi zone, 4 and 5 – North Baruhkhurai (Baaran) (4-Argalant and 5-Khaistyn zubzones), 6-Olonbulag, 7-Ulaanus, 8-South Barunkhurai (Baitag), 9 –granitoids. Numbers on the map: 1-Seeriin nuruu, 2-Sertengiin nuruu, 3-Khaistyn uul, 4-Argalant uul, 5-Maikhan har, 6-Indrengiin nuruu, 7-Ulaan us well, 8-Khairkhan uul, 9-Baitag, 10-Sukhaityn ovgor har, 11-Ikh Havtag, 12-Huh Undriin nuruu.

The Variscan folded structure of the Baruunhuurai depression developed at the location of the Devonian accretionary system, which included an oceanic fore-arc trough, an ensimatic island arc, back-arc basin (South Baruunhuurai zone) and an active continental margin of the Andean type (Olonbulag and Nortth Baruunhurai zones). The latter formed within the Caledonian continental block. A southern polarity has been established for the subduction zones. The nappe structure of the region formed in the middle Carboniferous as a result of obduction of oceanic and island arc complexes onto the deposits of the continental margin.

Fig.4 shows a geologic map at scale 1:200 000 published by regional geological survey teams. As you can see from the geologfical map the Devonian and Carboniferous are well developed in the area of Baruunhuurai.

Devonian subdivided into the following formations: Nariinhar, Baitag, Hurendush, Baaran, Havtag, Baruunhuurai and Samnuuruul (Fig. 6) and lithostratigraphical correlation of Devonian formations of the Baruunhuurai terrane are shown on the Fig.8.

Carboniferous subdivided into the following formations: Barlaggol, Borhavtsal, Inder, Olonbulag, Nuhniinuruu, Tsahirynnuruu, Tavanovoo, and Uushgiinulaan (Fig.7).

During the Field workshop upper Devonian Samnuuruul and lower Carboniferous Nuhniinuruu and Olonbulag Formations will be studied. These sections are geographically located between sections exposed in the Junggar Basin in northwestern Xinjiang (Ma et al. 2009) and exposures in the Santanghu Basin in eastern Xinjiang (Chen & Archbold 2002).

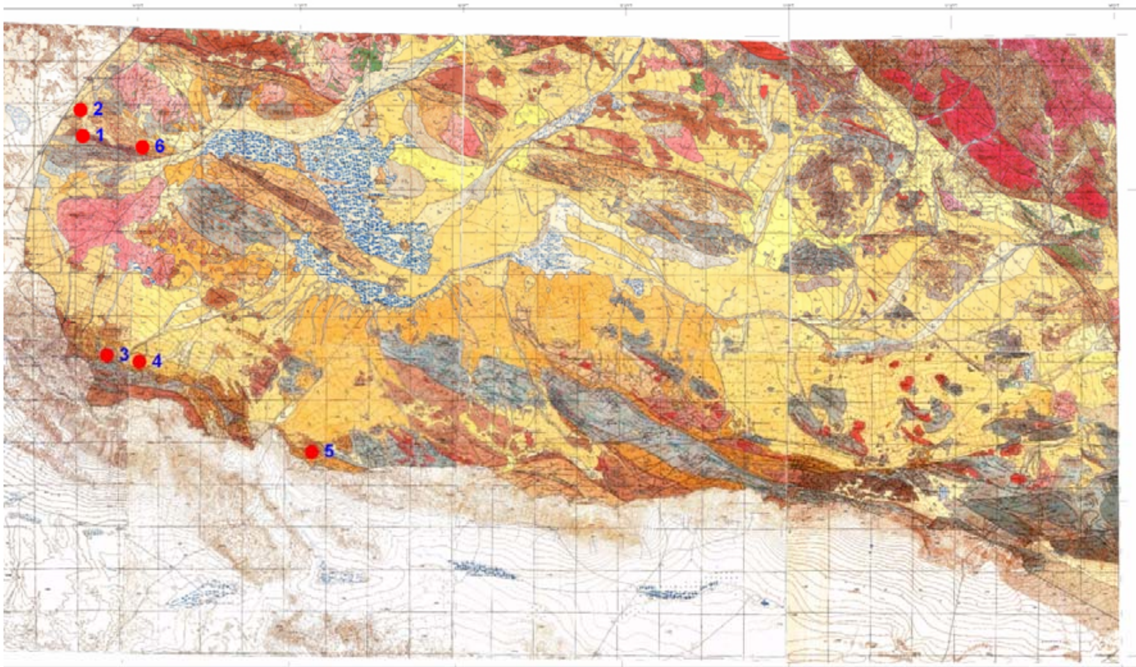


Fig.4. Geological map of the Baruunhuurai region.

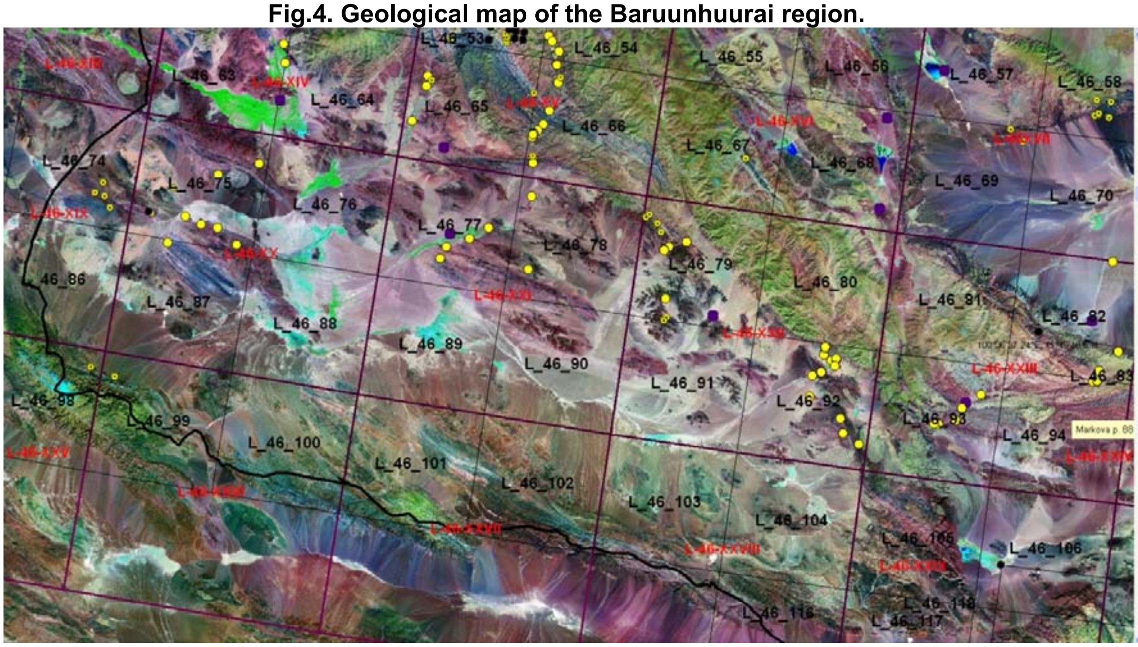


Fig.5. Satellite image of the Baruunhuurai region.

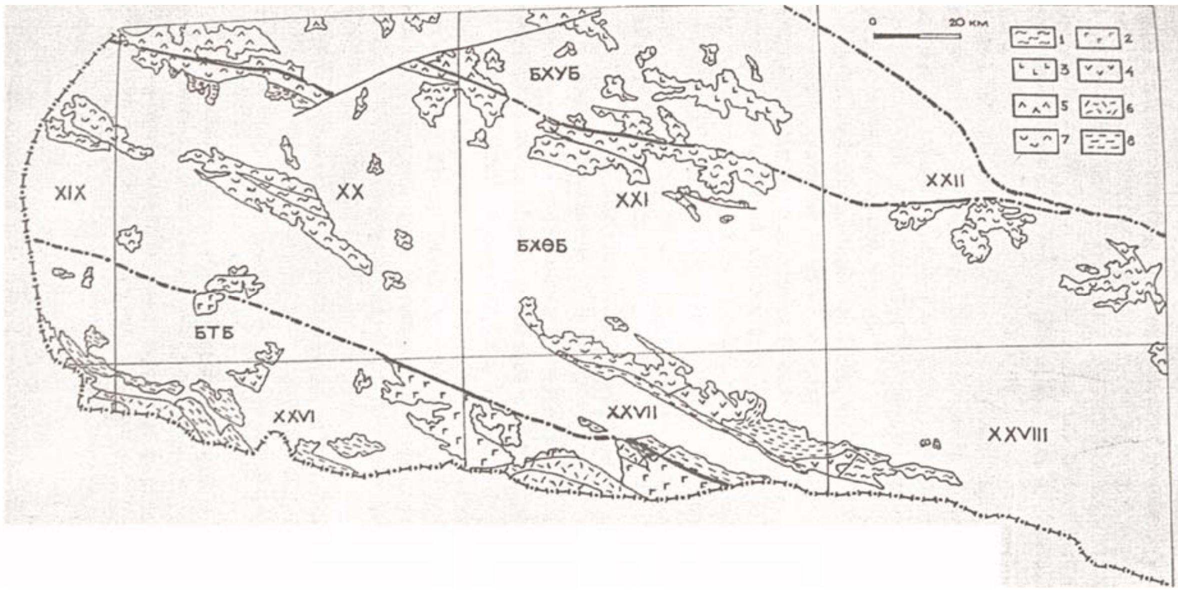


Fig. 6. Devonian outcrops in the Baruunhuurai region:
1-Nariinhar, 2-Baitag, 3-Lower-midle Devonian undifferentiated, 4-Hurendush, 5-Baaran, 6-Havtag, 7-Baruunhurai, 8-Samnuuruul

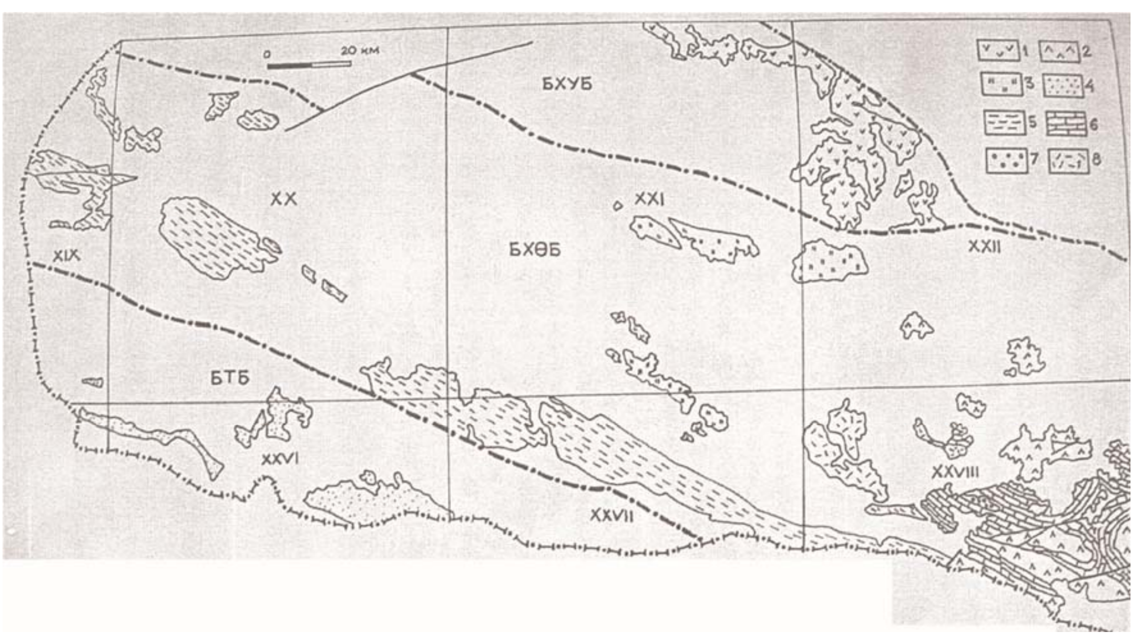


Fig.7. Carboniferous outcrops in the Baruunhuurai region.
1-Barlaggol, 2-Borhavtsal, 3- Inder, 4- Olonbulag, 5-Nuhniinuruu, 6-Tsahiryn nuruu, 7-Tavan ovoo, 8-Uushgiinulaan.

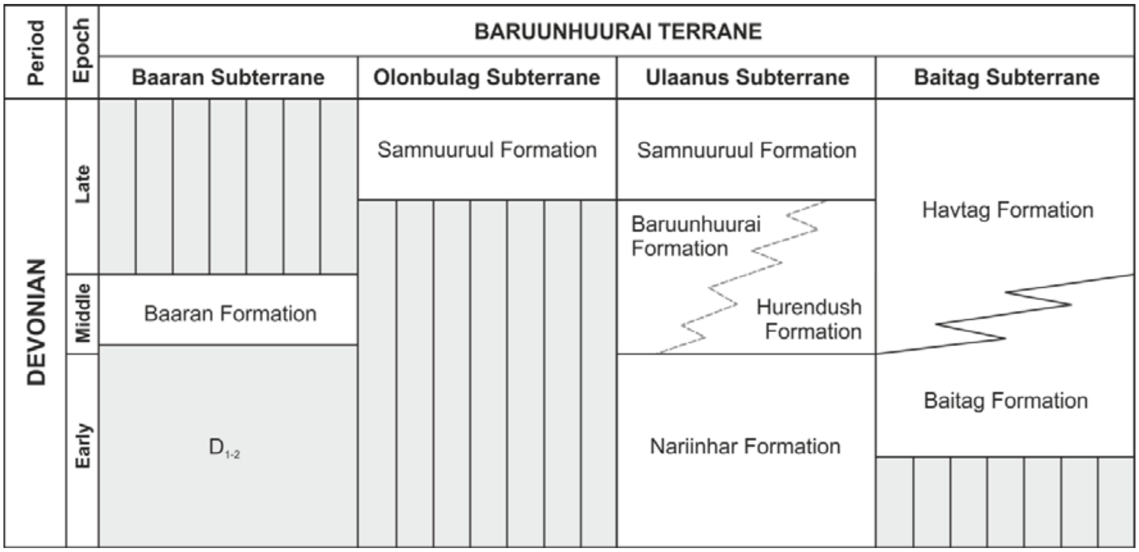


Fig.8. Lithostratigraphical correlation of Devonian formations of the Baruunhuurai terrane

In 2012, members of the Western Mongolia Devonian Working Group conducted a field workshop in the Baruunhuurai Terrane and investigated several localities. Description of five, and discussion based on these study are introduced here (Kido et al., 2013). Lithology, fossil content and depositional environment for each subterrane are discussed below based on the study of Ruzhentsev et al., (1992), Ruzhentsev (2001), Alekseeva et al. (2006), Ulitina, (2001), Kuzina & Lazarev (1994), Ariunchimeg (2000,2010), Bol'shakova et al., (2003), also unpublished dates of the results of geological mapping projects are used.

The Baaran Subterrane

The Baaran subterrane considered as a middle Paleozoic volcanic belt, formed on preeifelian sialic basement and can be regarded as an Andean-type continental margin with a subduction zone with a southern polarity. Baaran subterrane is made up of volcanic, varying in facies from basalts to rhyodacites, with all of them showing high alkalinity and includes four structural-formational complexes: Baaran, Khaistyn, Khairhan and Gurvan-Khairhan. Description of all this complexes are given in Ruzhentsev et al. (1992).

The Baaran Formation (D_2br). The Baaran Formation exposed in the northern part of the Baruunhuurai terrane and subdivided into three members with total thickness of 2600-3700m. No key section is described, besides two partial sections are described at the mountain Suhain Har uul and Suhait Tolgoi.

The first member is characterized by siliceous-terrigenous sediments green-grey, grey, thin bedded siliceous tuffite, chert with radiolarians, ash flow tuffs, silicate, tuffaceous sandstone and siltstone, and clastic, coarse grained shoshonite tuff. Rare dacite, latite, trachybasalt, trachiandesite lavas are seen. Sandstone and siltstone yielding bad preserved crinoids and plant remnants were found. Thickness is 600-800m.

The second member is porphyritic and composed of green, greenish-grey slightly acid porphiryte, shoshinite, latite, lavabrechia, red-brown chert, and mafic tuffs. Thickness is 1200-1500m.

The third member is mafic to intermediate tuffitic and consists mainly from tuffaceous sandstone, gravelites, thin bedded tuffite, siltstone with rare basaltic and andesitic flows in the upper part. Thickness is 1000-1200m.

In the Sukhaityn Ovgor nuruu (Fig. 2, 10) a section of limestone band, enclosed in porphyries, has yielded the remains of the brachiopods *Leptaena* sp., *Xystostrophia umbraculum* (Schl.), *Plicostropheodata* sp. indet., and *Euryspirifer* sp.

The Baaran Formation has tectonic contact with Baruunhuurai Formation and intruded by late Carboniferous granites. To the north-west, sediments of Baaran Formation is continued to China and middle Devonian brachiopods and corals were identified there and based on this information O.Davaa et al. (1995, 4865ф) established a new formation during the geological mapping.

The Barlaggol Formation (C_1bg). In 1960 T.P.Gridasova and V.A.Fedorovskii described the middle-late Devonian Barlaggol Formation in the valleys of Bodonch and Barlag river in a limited areas from west to east Khar Uzuur, Elsen Khutul, Ulaan Khairkhan, Uvur, and Udgan Uul. However, S.V.Ruzhentsev and G.Badarch (1992) identified this formation as a Lower Carboniferous. The key section is located near the Talyn Bulag in the valley of Barlag river.

Barlaggol Formation mainly consists of red-brown, brown, green, green-gray and dark-gray basalt and andesitic basalt, trachyandesites, trachydacites, rhyolites, rhyodacites, lava breccia and their tuffs, tuffconglomerate, gravellite, sandstone, tuffite, jasper and siltstone. In he section from bottom to top andesite-basaltic, siliceous, andesite-dacitic, spheroidal lavas and quartzite sequences are distinguished.

At the section described in the western edge of the Khar Boom hills, brachiopod relicts *Torynifer* sp. indet., *Streptorhynchus tomskiensis* (Janisch.), *Syringothyris hannibalensis* (Swallow), *Schuehertella cf. globas* Tolm. were identified by Sh.Suurisuren and M.V.Martynova and defined the age of sediments as lower Carboniferous Tournasion.

Later S.V.Ruzhentsev et al., (1992) has reported brachiopods *Schizophoria* sp., *Orthotetes* sp. indet., *Spirifer bukhtarmensis* Gretch., F.Tungalag has identified crinoids *Kasachstanocrinus* sp., and Ya.Ariunchimeg (2010) has identified bryozoans, *Nematopora afgana*, *Pseudonemathopora turkestanica*, *Nemacanthopora costatiformis*, *Streblotrypella major, Nikiforovella* sp., *Primorella* sp., *Alternifenestella* sp., *Fenestella* sp., *Penniretepora* sp. and all confirmed the Lower Carboniferous age.

Fig.9. Barlaggol Formation , Argalant uul. (fig.3, 4).

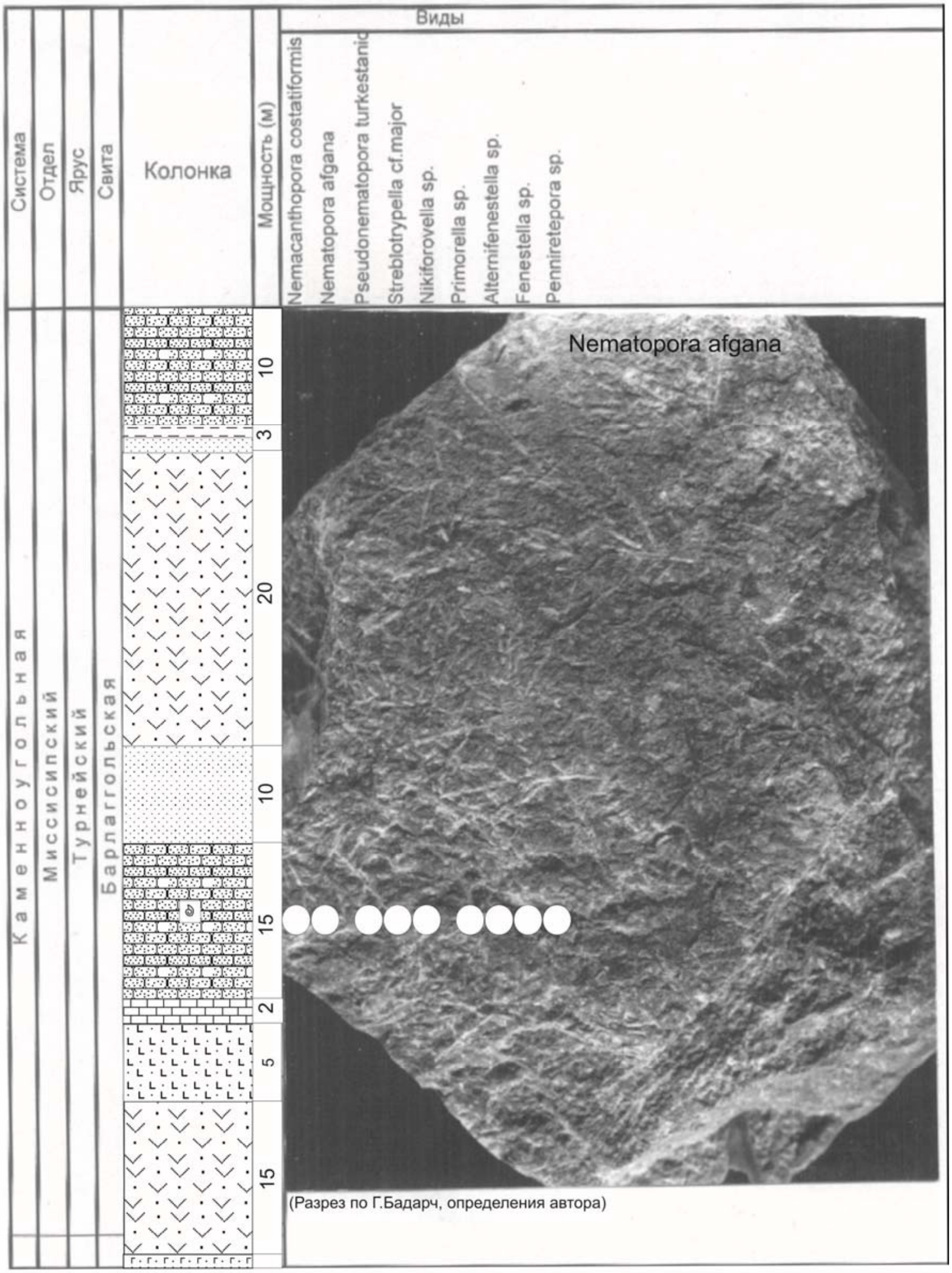


Fig.10. Distribution of Bryozoans in the key section of Barlaggol Formation

Fig.11. Fossils from the Barlaggol Formation

The Olonbulag subterrane

This zone is characterized by the presence of carbonaceous rocks. As regards it is a mixed sequence up to 2 km thick. Acid epiclastics, rhyolitic tuff, and numerous subvolcanic bodies of rhyolite and dacite occur at the base of the exposed section. In places there are red beds, and locally grey beds containing lenses of coal.

The middle section is made up of ash tuff, lithic acid tuff, and tuffite.

The upper section consists of calcareous sandstone, and rarer limestone. The lower, middle, and upper sections yields Famennian, Tournaisian and Visean brachiopods respectively. There is an abundant assemblage of lepidofites.

The deposits of Olonbulag subterrane are unique. They represent a carbonaceous molasse, formed in coastal conditions. In some of their features they resemble the deposits of the volcanic belt (an abundance of rhyolites and dacites, epiclastics, and lower Carboniferous brachiopod limestones), these allow Ruzhentsev (2001) to consider the subterrane as being part of a volcanic belt.

The Samnuuruul Formation (D_3su). Badarch G. (Davaa et al., 1995F) first described the Samnuuruul Formation during 1:200000 scale geological mapping based on the studies of Lazarev S.S and Suur'suren (1991,1992) and named after mountain Samnuur. The Samnuuruul Formation is distributed in the Olonbulag and Ulaanus subterranes and occur in a tectonic blocks from northern part of the Baitag Bogd range to south-east through Baga Havtag range, Huh Undur, Tsahir and Huren Bogd mountain.

The Samnuuruul Formation underlies conformably the middle Devonian Hurendush and Baruunhuurai Formations and is overlain by the lower Carboniferous Olonbulag Formation.

The sediments of the Samnuuruul Formation consists mainly of reddish brown conglomerate, gravelstone with limestone beds, greenish grey, grey small-middle grained sandstone, siltstone and tuffite. Thickness is 250-450m. In the lower part of the section tuffite, siliceous sediments and in the upper part fossiliferous limestones observed.

The age of the Samnuuruul Formation is assigned to the Famennian based on brachiopod-*Cyrtospirifer ivanovae* Besn., *Sphenspira* sp., bryozoan-*Cyclotrypa laminata* Nekh., rugose coral - *Amplexus echinatus* (Bol'shakova et al., 2003), and conodonts- *Polygnathus communis* Br. et Mehl., *Bispatothodus stablilis* (Br. et Mehl.).

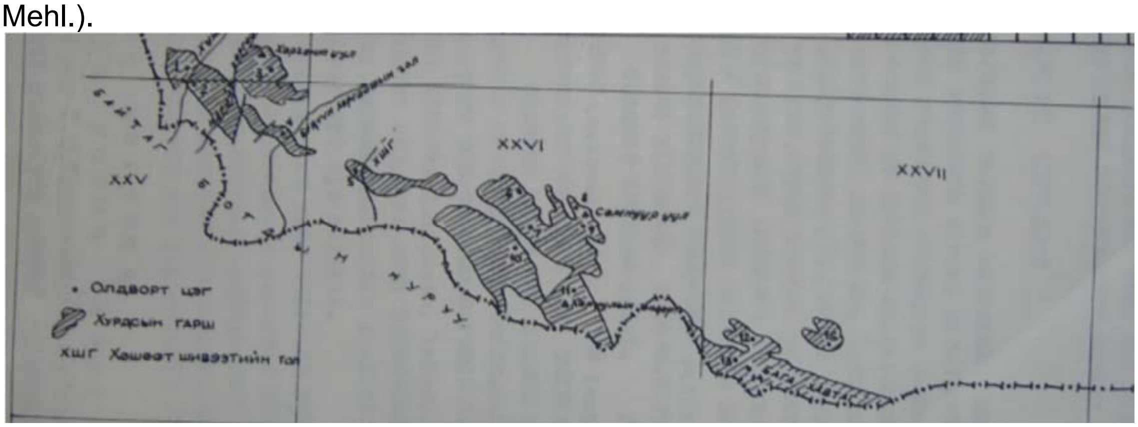


Fig.12. Outcrops of the Samnuuruul Formation in the Olonbulag subterrane.

We measured a section (Erica Kido et al., 2013) in the Samnuuruul Formation located at 45°17'06''; 90°57'31'' (Fig. 1, loc. 3; Fig. 13). This was the section from which Ariunchimeg (2000) first reported Famennian bryozoans from Mongolia. The bryozoans were correlative with the Simorinskii horizon in Kazakhstan, the Upper Famennian in the Rudny Altai, the Middle *crepida* Biozone in northwestern China and the Etroeungtian of Japan. Ariunchimeg (2000) also reported the presence of foraminifera *Quasiendothyra dentata*, an index fossil of the Etroeungtian of Europe and the brachiopod *Cyrtospirifer ivanovae*, a fossil characteristic of upper Famennian in the Kuznetsk basin. These fossils support the late Famennian age of the Samnuuruul Formation. In addition, many of the bryozoans have close affinity with bryozoans reported by Xia (1997) from the Hongguleleng Formation in Xinjiang.

The Samnuuruul Formation outcrops in an area that has been subjected to folding, faulting, and extensive fracturing from joint sets. This tectonic overprint has hampered our ability to completely characterize the stratigraphy and biota of the formation.

This is especially true in the lower 330 m of units 1 and 1a (Fig. 13). All units were measured bed-by-bed, but due to the problematic stratigraphic relations in the field, only lithological columns of the units 2, 3 and 4 are figured here (Figs. 19 and 27). A small, but significant collection of brachiopods, gastropods and cephalopods was collected from a siltstone cliff about 30 m above the base of the section (Fig. 14). The cephalopods indicate a late Famennian age (R. T. Becker, personal communication, 2012).

A second fossil-bearing interval rich in brachiopods, rugose corals and crinoid ossicles was found about 60 m below the top of unit 1a (Fig. 15, "x" indicates fossil horizon).

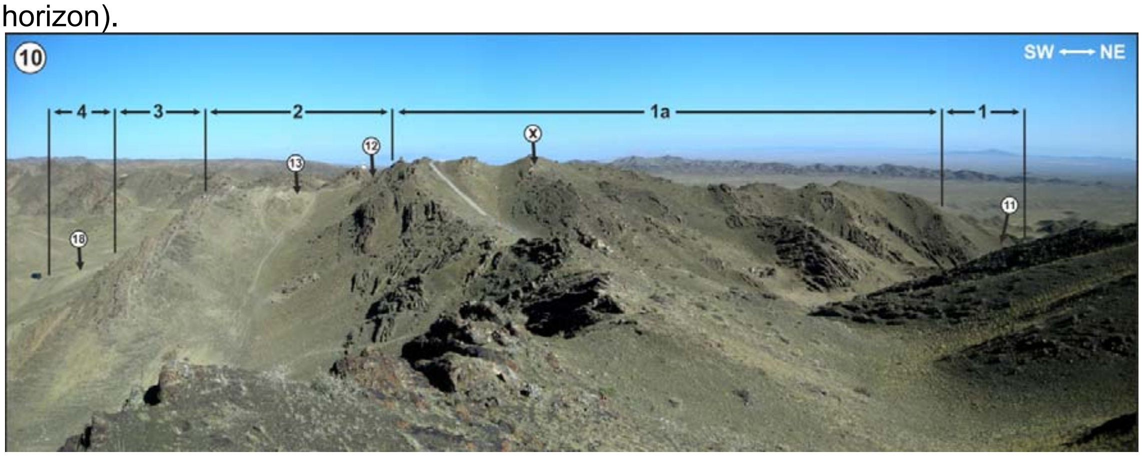


Fig.13. Samnuuruul formation (SAM). Panoramic view of the outcrop in the main Samnuuruul Formation, divided into 4 units (indicated as Loc.3 in Fig. 1).

Fig.14. Fossils from SAM section, unit 1. (11)

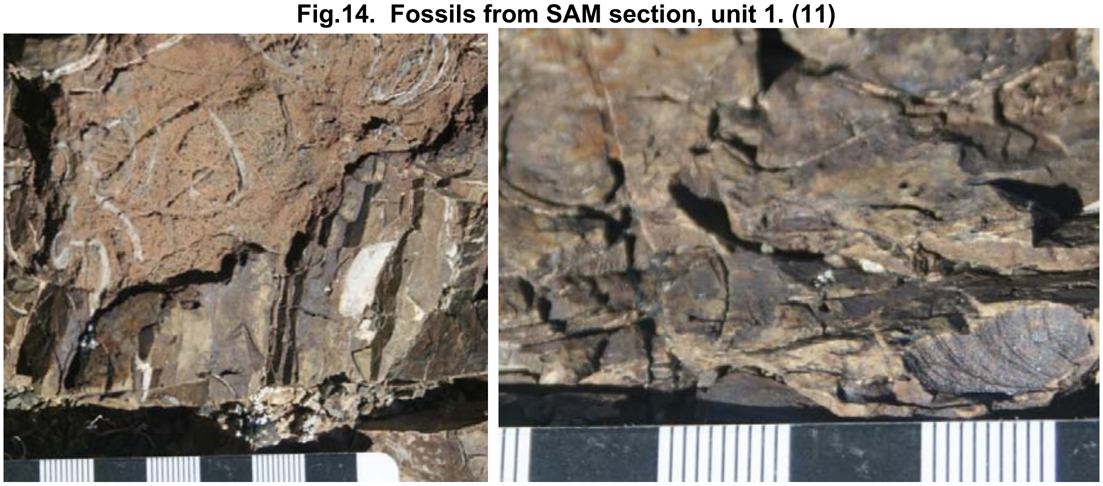


Fig.15. Fossils from SAM section,unit 1a (X)

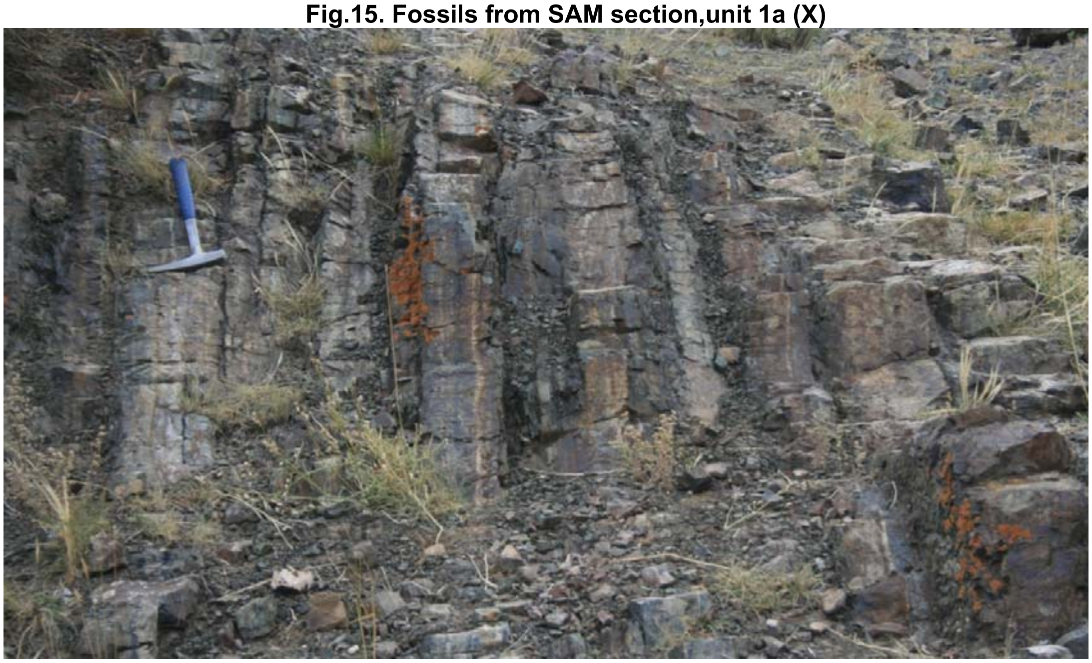


Fig.16. Siliceous beds of the SAM section, unit 1a.

Units 2 and 3 include an interval of approximately 74 meters, and consist of dark greenish gray siltstones and shales interbedded with thin, but laterally continuous, limestones. Some siltstone beds in the lower part of unit 2 have pillow-shaped structures of unknown affinity (Fig. 18). Initial consideration of these beds as volcanic pillow structures has been replaced with hypotheses of a microbial origin. Stratigraphically above this siltstone interval is a 4 meter interval of fossiliferous green fissile shale with thin discontinuous limestone beds (Figs. 17,20). This is the primary interval yielding the fossils described by Ariunchimeg (Fig. 22). Higher in the section are a series of vertical siltstone beds with very abundant macrofossils including brachiopods, solitary rugose corals, branching tabulate corals and phacopid trilobites (Figs. 22-25).

Fig.17. Terrigenous beds of the SAM section, unit 2.

Fig.18. Volcanic beds of the SAM section, unit 2 .

Fig.19. Bioturbation in SAM section, unit 3.

The top of the Samnuuruul Formation (unit 4) is characterized by a series of coarsening upward sandstones and conglomerates, with interbedded siltstones and shales often containing macroscopic plant debris (Fig.23). This sequence grades upwards into a weathered shale culminating in a series of ?soil horizons, carbonaceous shales, and coal which likely cross the Devonian / Carboniferous boundary (Fig. 26). Within this transition is a 0.5 meter black shale, which appears to be correlative with the Hangenberg Event. We conducted a detailed sampling scheme through this interval, and are awaiting the results of geochemical and palynological studies to further elucidate the events contained within this interval.

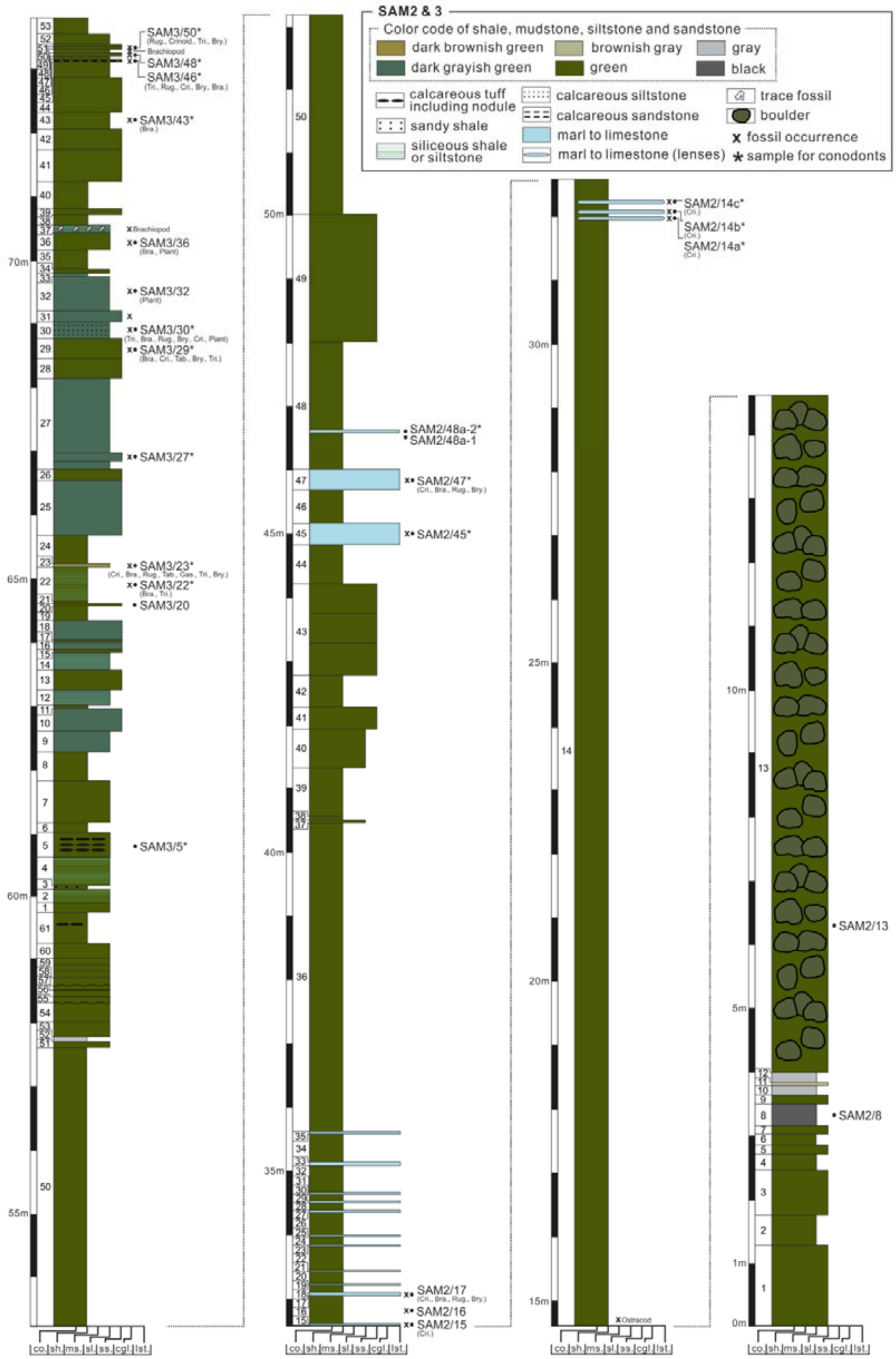


Fig. 20. Measured columnar sections of SAM, units 2 and 3.
Sections provide details on the lithological content and show the stratigraphic position of collected samples for geochemistry and fossils.

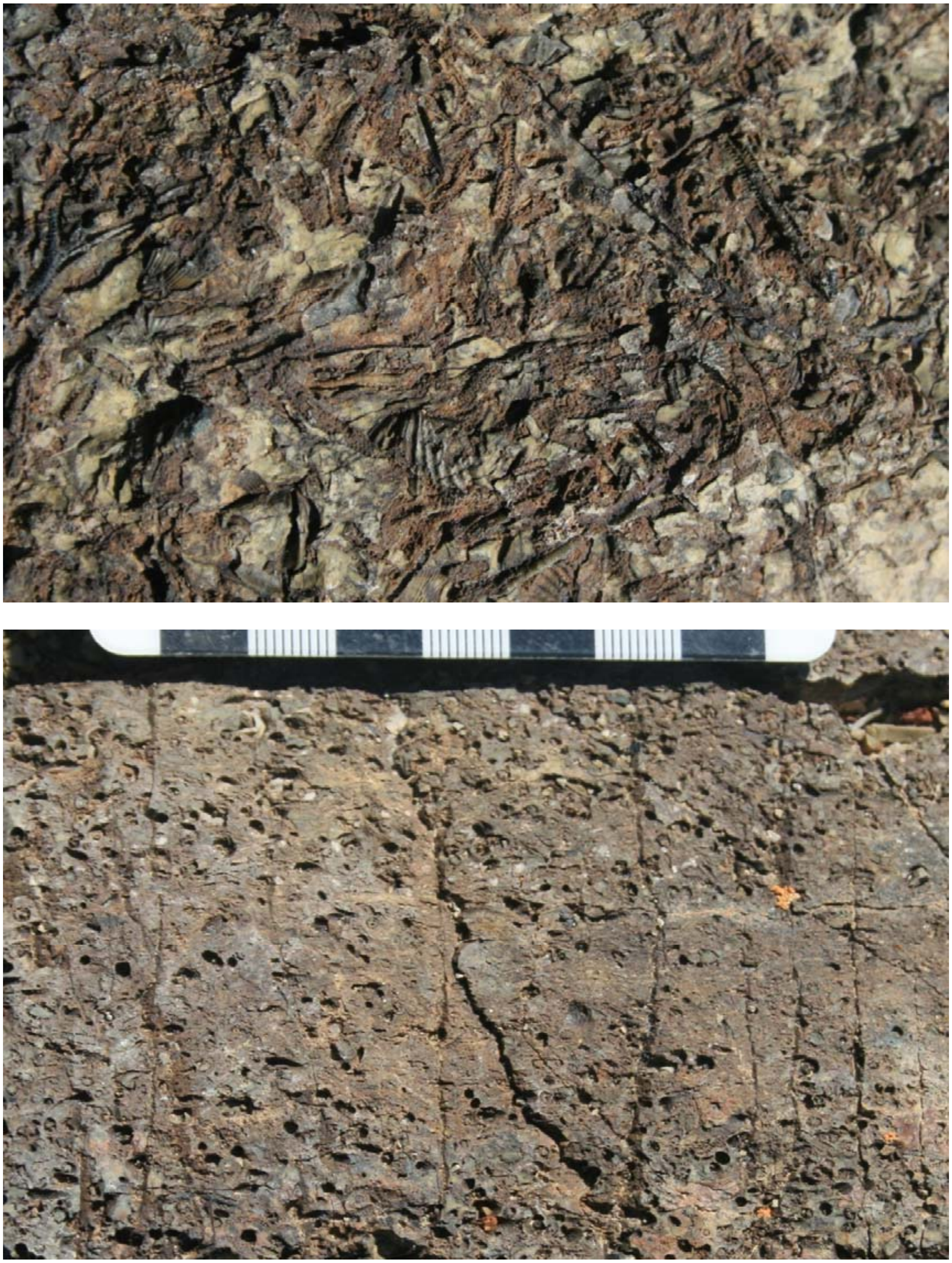


Fig.21. Limestone beds in SAM section, unit 2 (surface and cross beds)

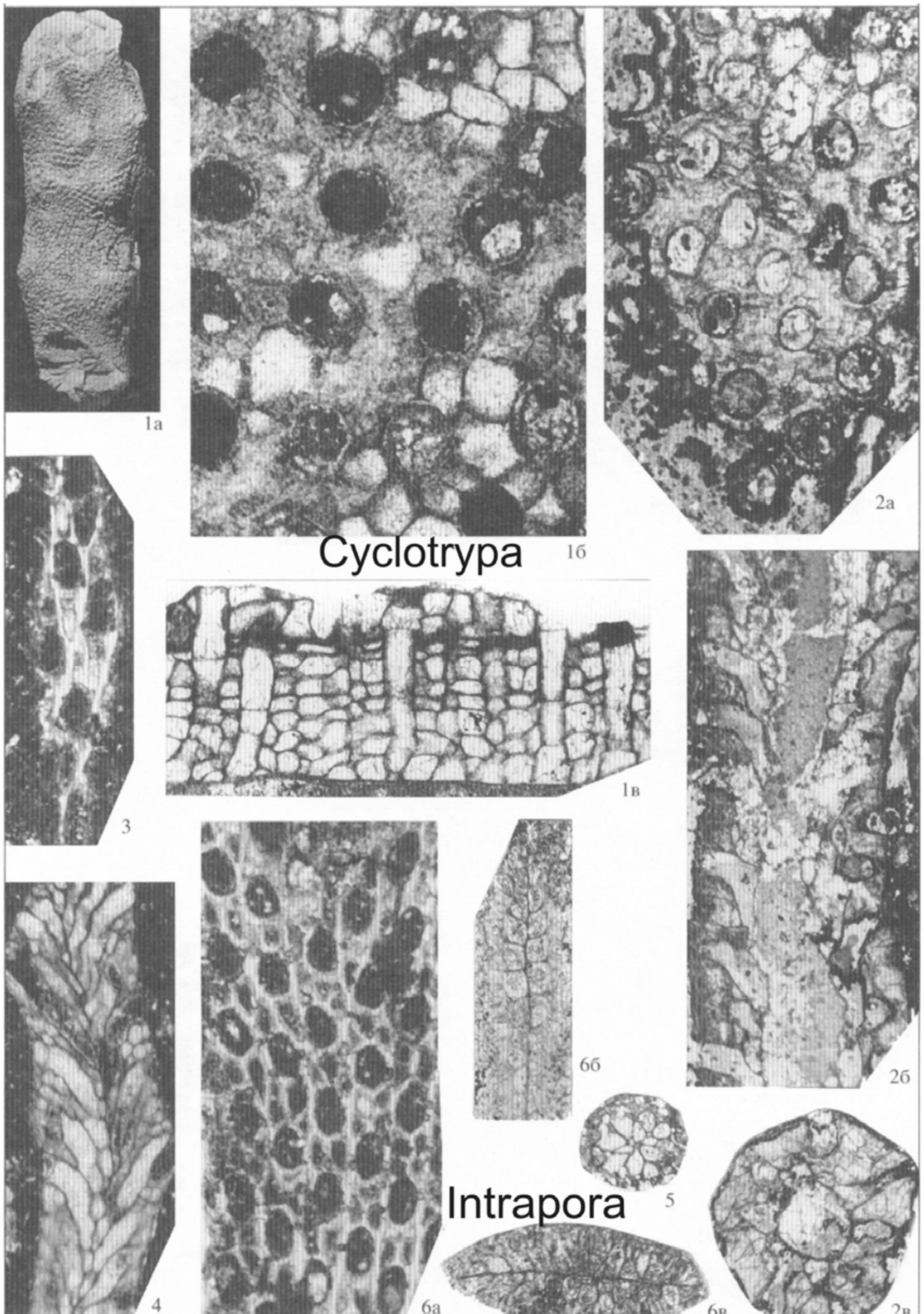


Fig. 22. Bryozoans described from the unit 2. (Ariunchimeg, 2000)

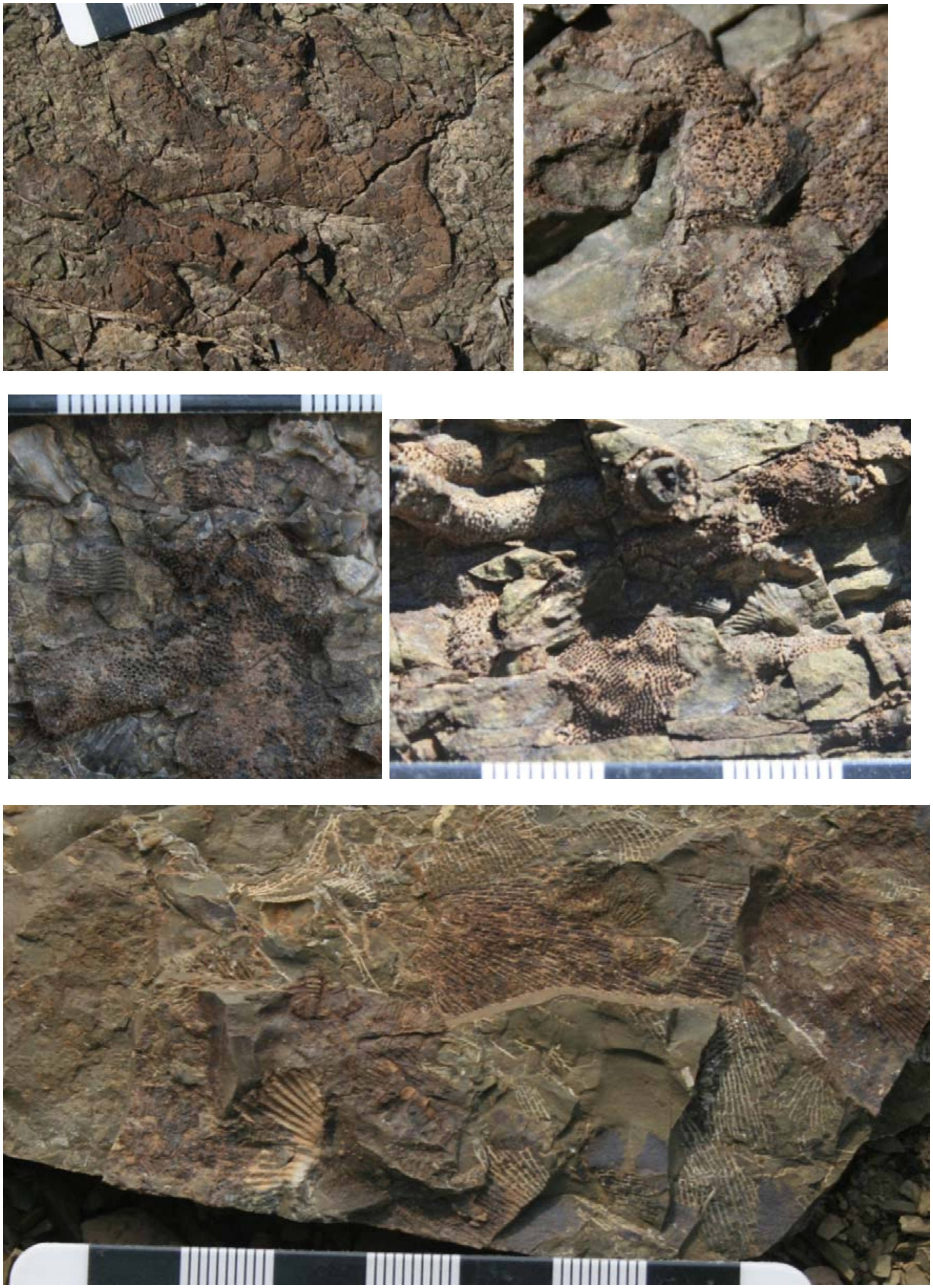


Fig.23. Bryozoans from the SAM section, unit 3

Fig.24. Tabulate coral and plant from SAM section, units 3,4.

Fig.25. Brachiopods, trilobites, gastropods and rugosa corals from SAM section, unit 3.

Fig.26. Black shale of unit 4 hypothesized to represent the Hangenberg event. Soil horizon and carbonaceous shale at the D/C boundary.

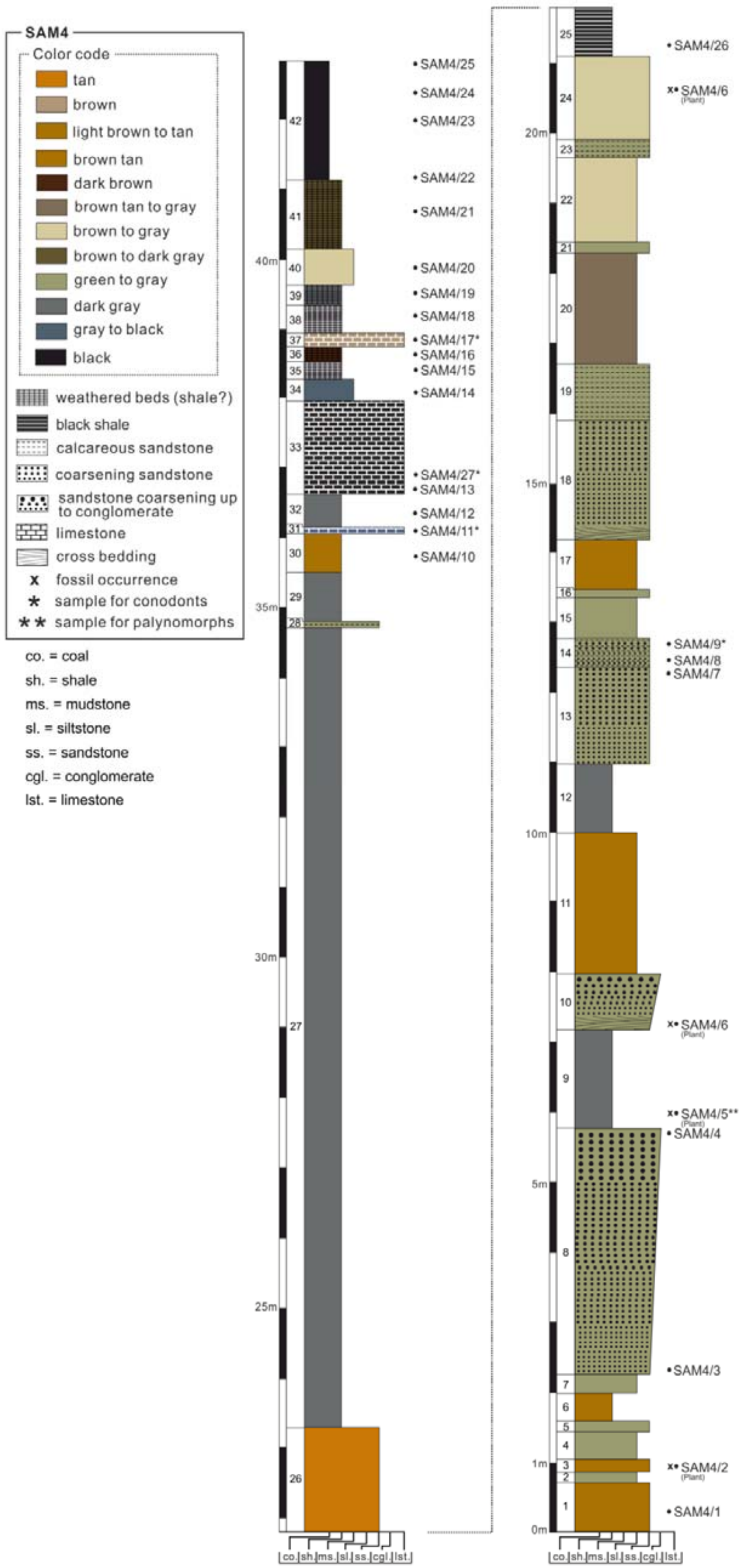


Fig.27. Measured columnar sections of SAM, unit 4 (stratigraphic continuity of Fig. 20).

Fig.28. View of locality near Hushoot Shiveetiin gol exposing deposits of the fossil-rich unit 3 of the Samnuuruul Formation (indicated as Loc. 4 in Fig. 1).

Additional two localities within the Samnuuruul Formation are Loc. 4 (45°16’18’’; 91°03’20’’; Fig.28) and Loc. 5 (45°05’02’’; 91°34’13’’; Fig.30), which were observed in the eastern outcrop belt of the formation to assess lateral facies changes. The first outcrop near Hushoot Shiveetiin gol (Loc. 4) is located 7.5 km east of the main Samnuuruul section. It consists of fossil-rich siltstones, which can be correlated with unit 3 in the measured section. We collected a well preserved fauna of complete trilobite specimens, several cm-large domal bryozoan colonies, large rugose corals and numerous articulated brachiopod shells here. Ulitina reported the rugose coral *Amplexus echinatus* (Fig.29) from the left bank of Hushoot Shiveetiin gol, in 4.5 km northwest from the mountain Orgot in the Samnuuruul Formation (Bol'shakova et al. 2003).

Fig.29. Rugosa coral Amplexus echinatus Ulitina, 1975 occur in Samnuuruul Formation (Hushoot Shiveetiin gol section).

The second outcrop (Loc. 5) is located 53 km east of the Samnuuruul section directly at the Mongolian-Chinese border, Mt.Shunhat uul. There deposits have undergone low grade metamorphism, but contain a thick interval of well bedded highly fossiliferous slates (Fig.31). On bedding planes large bivalves, accumulations of spiriferid brachiopods (Fig.31), rugose corals, trilobites, bryozoan colonies, and even one articulated crinoid crown (Fig.32) are found. Downhill, the sequence changes from a marine paleoenvironment (Devonian) into terrestrial deposits (Carboniferous, Olonbulag Formation) bearing megaplant fossils several meters long (Fig. 36).

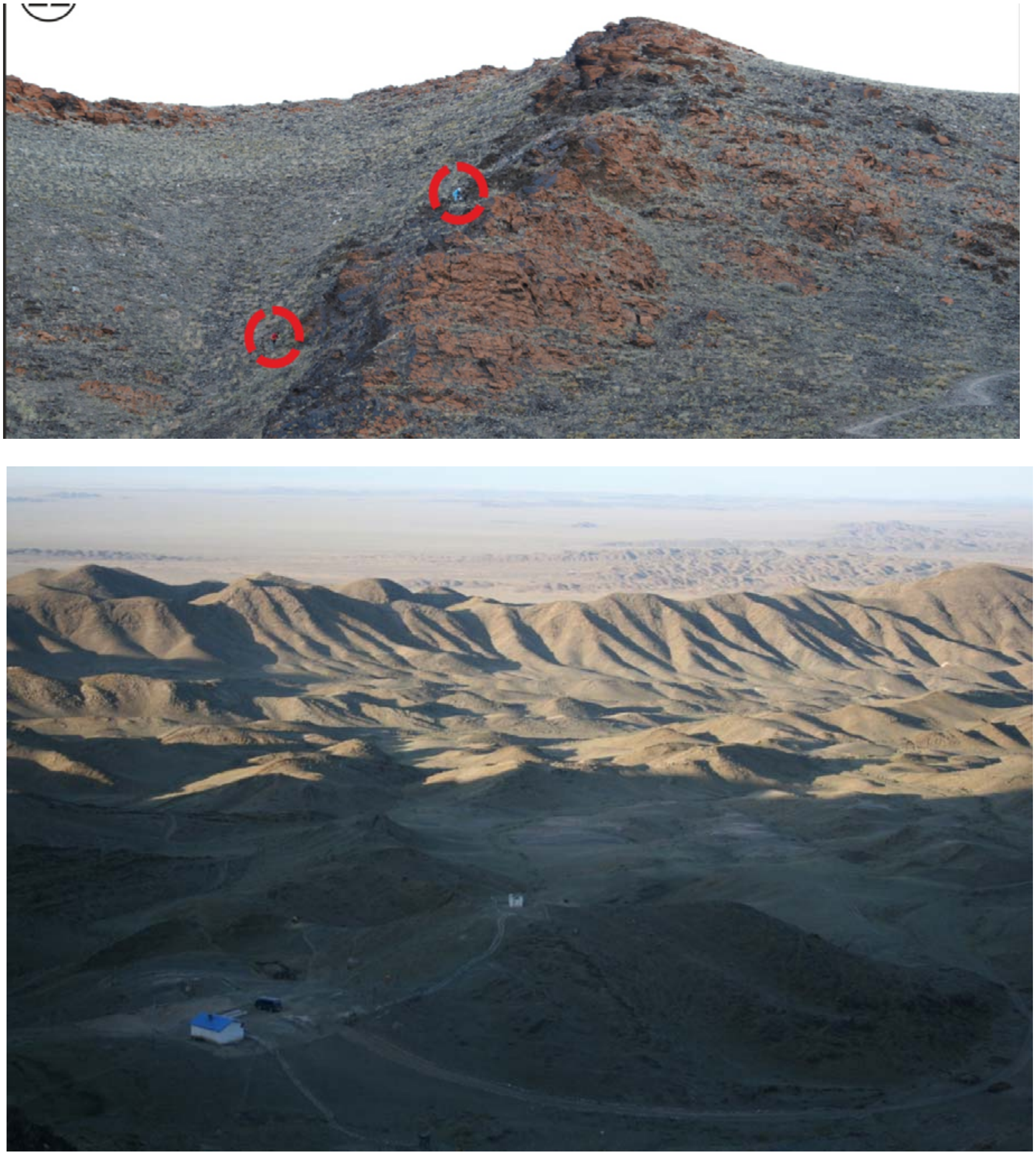


Fig.30. Photo from the Samnuuruul Formation outcropping at the Mongolian-Chinese border, Shunhat uul (indicated as Loc. 5 in Fig. 1). Red circles indicate two colleagues who stood for scale near the fossil-rich horizons.

Fig.31. Brachiopods and dense accumulation of fossils on the rock surface, such as spiriferid brachiopods, bivalves, crinoid ossicles and trilobite.

The Olonbulag Formation (C_1ob). Suetenko O.D. et al. (1990) first recorded the Olonbulag Formation in the south-western part of Baitag zone and described kye section near the Olon Bulag well (Figs.33,34). This formation is distributed at tne northern slope of Baitag Bogd range, south-eastern part of Maikhan Har mountain and eastern part of Baga Havtag mountain.

The Olonbulag Formation consists mainly of dark green, greenish gray, dark gray, brownish, gray colored limestones, siliceous and carbonaceous shale, fine-middle grain conglomerate with coal beds, gravelstone, middle-coarse grain sandstone, and siliceous siltsones. Total thickness of Olonbulag Formation is 500-600m.

On the left bank of the Buduun khargaitn gol along the goniatites of the genus *Bollandoceras* (two complete shells) and a shell fragment of *Dzhaprakoceras* with a well preserved septum were found several complete shells and numerous fragments of *Michiganites*, one of the early representatives of the order Prolecanitida (Fig.35).

Fig.32. Crinoids from the Shunhat uul.

Sandstone sequence, with various gastropods and with brachiopods of the genus Tolmatchoffia, whose early representatives are close to its ancestral Scissicosta. Since true Tolmatchoffia specimens are not known from below the analogs of the Osagean stage of the Mississippian, Lazarev considered the corresponding deposits to be close to the boundary between the Osagean and the underlying Kinderhookian. A few species of Kazakhstania are known from the Kassin beds in Kazakhstan, the Kinderhookian of North America, and the Tournasian of China.

Near the Olon bulag well ammonoids such as *Kazakhstania mongolica* of Tournaisian have been found together with brachiopods remnants. Uranbileg L. has assigned it to the Tournaisian-Visean age based on the plant-*Lepidodendropsis concinna* Radcz. previously not found in Mongolia.

Fig.33. Olonbulag Formation near the Olon Bulag well.

Fig. 34. Fossiliferous lasyer of the Olonbulag Formation near the Olonbulag outpost.

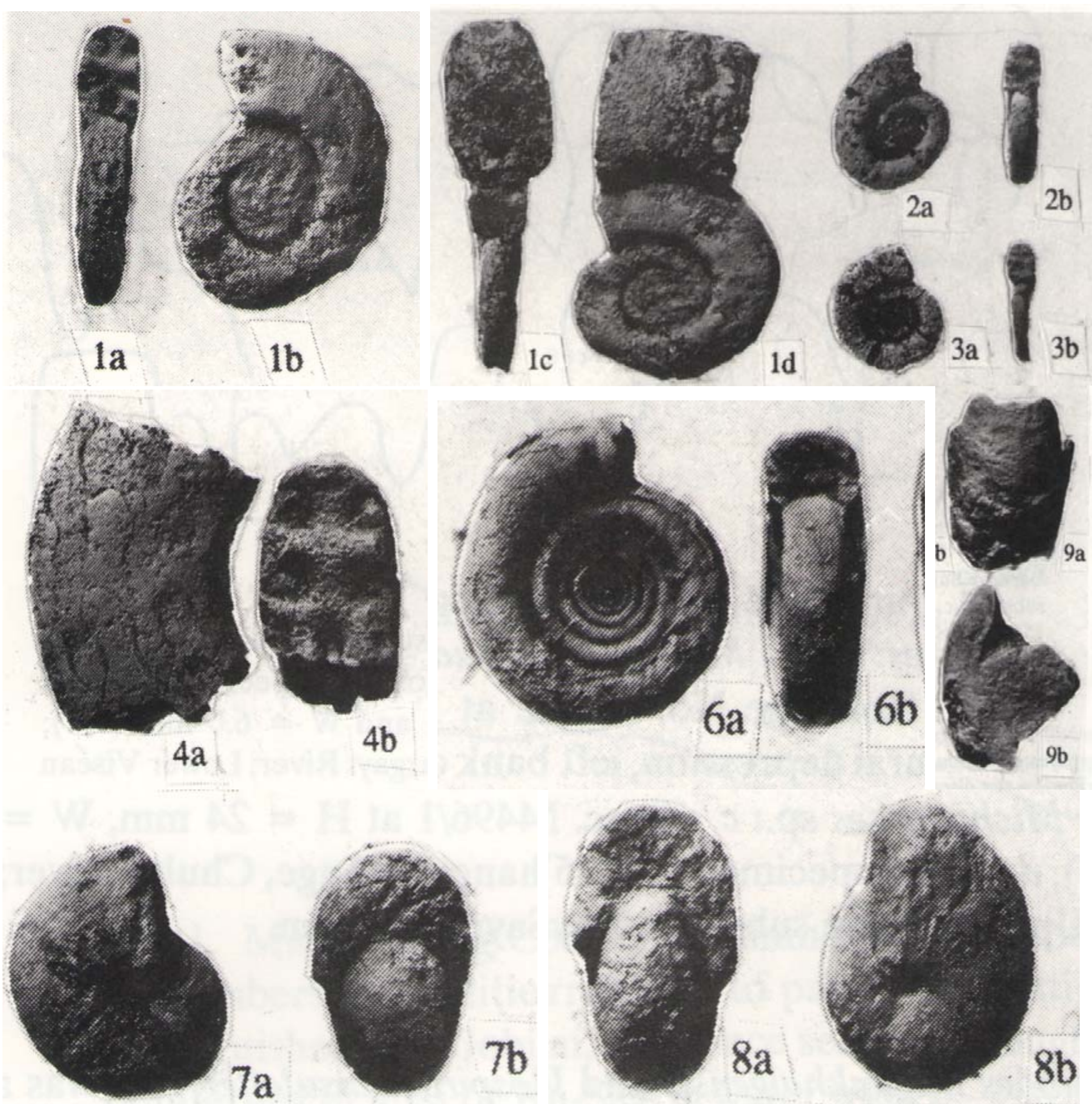


Fig.35. Ammonoids occur in the Olonbulag Formation.
6 – Kazakhstania mongolica Kuzina, area of Olonbulag outpost, Tournaisian; 1-4 – Michiganites budunensis Kuzina, 7 – Bollandoceras parvum Kuzina; 8 – Bollandoceras suursureni Kuzina, 9 – Dzhaprasakoceras sp., left bank of Buduun Khargaityn gol, lower Visean

Fig.36.Plant fossils from the Olonbulag Formation near the Shunhat mountains.

The Ulaanus subterrane

The deposits were chiefly represented by epiclastics and tuffs in Devonian time and greywaske flysch in lower Carboniferous times. In the axial part of the section the flysch units appear at the Devonian level. In the Devonian section the clastic deposits show a zonal differentiated com[position, grain size and stratification. An overall deepening of the basin was accompanied by the mixing and reworking of clastic material, this suggests that the source areas were remote from the sedimentary basin. The occurrence of massive volumes of the products of granite erosion, making the composition of sediments more polymictic, is also significant.

In the southern part of the Ulaanus subterrane, volcanic and coarse clastics which mark the southern side of the trough and its transition to an island arc dome, again increased in importance in Devonian time.

Ulaanus subterrane is a system of allochthonous sheets, each of which has its own formational characteristics. The age of the series is defined in the range Eifelian-Frasnian.

The Nariinhar Formation (D_1nh). The sediments now belonging to this formation was assigned by B.A.Amantov (1953F) to Silurian. However, Yu.A.Borzakovskii et al. (1990) determined these sediments as middle-upper Devonian Baruunhuurai Formation. Later O.Davaa et al. (1995F) has defined a separate formation and named this formation as Nariinhar after the name of Nariin Har mountain. During the geological mapping D.Ganshukh et al., (2003F) accepted this formation.

Sediments of this formation distributed in the region of Nariin Har range, Nariin Har mountain, in the Baitag zone Yangirt Ulaan of Huvchiin nuruu, in the northern part of Zuulun Bogd mountain. The Nariinhar Formation underlies unconformably middle-upper Devonian Baruunhuurai and lower Carboniferous Borhavtsal formations. Also is overlying with an erosional surface by upper Devonian Samnuuruul Formation. From west to the east the facies change from volcanic rocks to terrigenic sediments are observed. Near the Altai sum of Gobi-Altai province brachiopods are found in the sediments mapped as Nariinhar Formation (Fig. 49).

The Nariinhar Formation is subdivided into two members. The lower member is intermediate volcanic rocks composed mainly of greenish grey, green, blue grey, white grey metamorphed basalt, schistose basalt, andesibasalt, tuff, tuffaceous sandstone, siltstone, andesitedacite and dacite. The thicnees is 500-600 m.

The upper member is terrigenous and is composed of whitish green, greenish grey, blue grey siltstone, sandstone, tuff, shale, mudstone, limestone, marbleized limestone interbedded thin beds of calcareous sandstone, limestone and siltstone with brachiopods, corals and crinoids.

The outcrop of the Nariinhar Formation (Loc. 1; fig.1, GPS coordinates 45°45’16’’; 90°53’30’’) is located in an intensely deformed zone and continues laterally for approximately 2 km until major fault zones displace the unit in the East. The formation in this area is traceable for 13 km laterally. The Nariinhar Formation is 50-60 m thick and consists of decametric scale bedded bright gray marble beds (dipping: 025/75) bounded by green to brownish tuffaceous deposits at the base and top. Fossil-rich levels yield abundant articulated crinoid stems reaching a length of 15 to 20 cm with a diameter of about 1.5 cm. As far as preserved, the Nariinhar Formation reflects deposition on an ephemeral carbonate platform in a volcanically active terrane. Based on the crinoid species *Pentagonocyclicus glaber* and *Pandocrinus* aff. *plicatus* the age of Nariinhar Formation was determined as Early Devonian in the map (scale 1:200 000) reported by O. Davaa et al. in 1995. They correlated the Nariinhar Formation with the Asushan Formation of Xinjiang. In 2008-2009 N. Batbayar et al. produced a map (1:50 000) of this area and suggested Middle Devonian age of the formation. However, an Early Devonian age is proposed by latest investigations of regional mapping geologist.

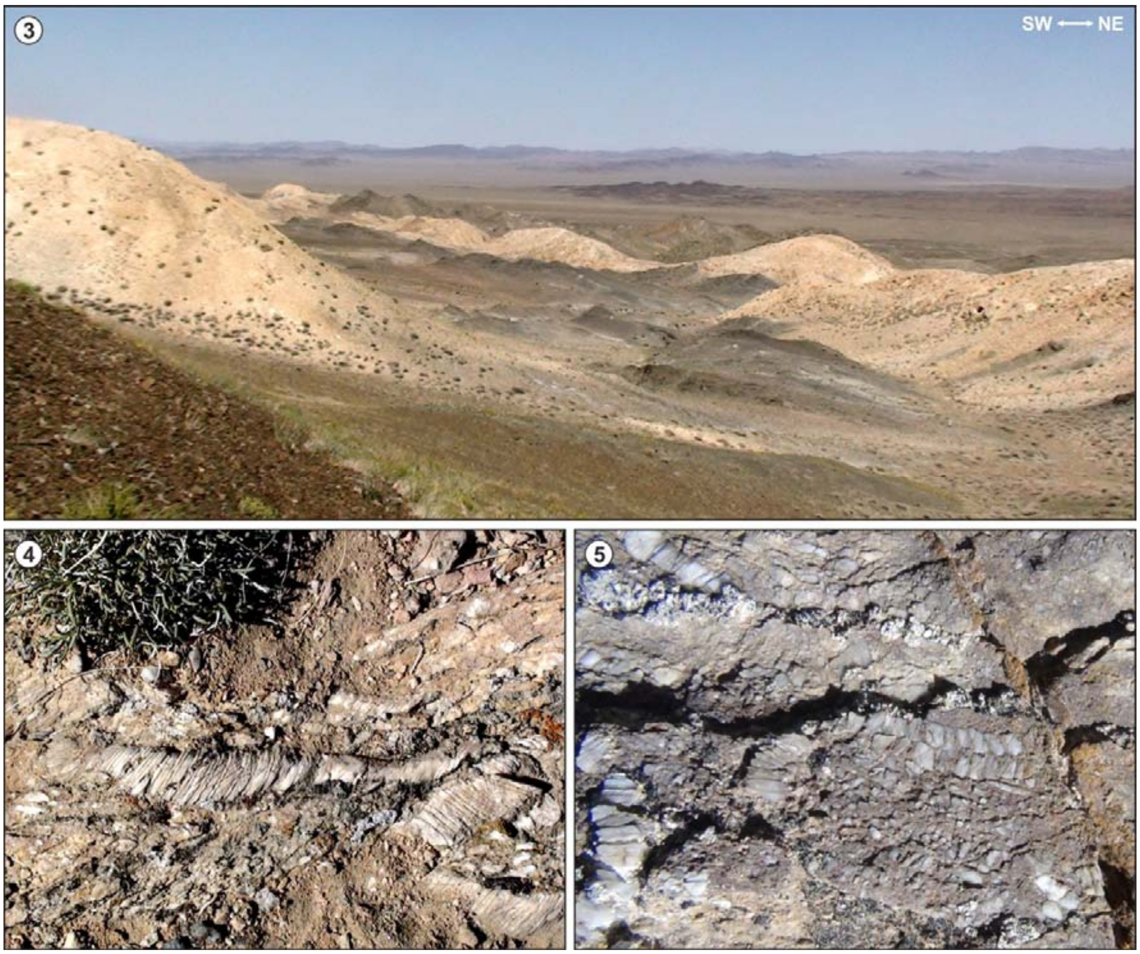


Fig.37. Panoramic view of the folded outcrop in the Nariinhar Formation (indicated as Loc. 1 in Fig. 1). 4, 5: articulated crinoid ossicles of different stratigraphic levels within the sedimentary sequence.

The Baruunhuurai Formation ($D_{2\text{-}3}$bh). The terigenous volcanic sediments distributed to the south from Bulgan fault were described by O.Davaa et al. (1995F) as a middle-upper Devonian Baruunhuurai Formation. M.Batbayar et al. (2009) are subdivided this formation into 3 members based on lithology during 1:50000 scale's mapping progect. Devonian Working group (Erika Kido et al, 2013) of IGCP596 project detailed the studies of the section of Baruunhuurai Formation in the western part of terrane.

The Baruunhuurai Formation is widely distributed in the Baruunhuurai terrane from boundary with China to south-east and separated by a tectonic boundary from the other rocks. The Baruunhuurai formation comformably is overlying by lower Carboniferous sediments and intruded by upper Carboniferous granite. The key section of Baruunhuurai Formation is located in southern side of Baarangiin Har nuruu, and consists of volcanic-sedimentary rocks such as andesite, dacite, tuff, tuffaceous siliciclastics, jasper type rocks, conglomerate layer with quartzite boulders (40-100m), upward dacite, andesitic tuff, silicified limestone beds, shale, siliceous shale, siltstone and sandstone (1000-1200m).

In the Baruunhuurai valley near the Huren uul this formation is consisits of dark blue, purple, gray green color dacite, gydesite, tuff, yellow color silicified, fossiliferous limestone with corals, brachiopods and bryozoans (400-700m), to upwards brigth variegate, green, pink, purple, silicified tuff, silt sandstone, tuffaceous sandstone and thin beds of pelitic limestone (800m). The total thickness is 2800-3500m.

The Baruunhuurai Formation outcrops on several hills (Fig. 38) at GPS coordinates 45°48'36''; 90°53'10''. The strata are steeply dipping to vertical southwest to northeast in outcrop. At least two levels of igneous rocks (intrusions ?) are recognized parallel to bedding. We measured 4 sections (A-A' to D-D'; Fig. B) to document the lateral and vertical continuity of the sequence in the outcrop and to determine the relationships of fossil-rich levels observed in each of the small hills. The dominant deposits of the sequence are tuffaceous siliciclastics, which show a successive change in color from green to yellow across the section. We divided the formation into three units according to the dominant facies.

The lower unit is composed primarily of shale, siltstone, and sandstone (spanning the interval of section A-A'). The facies and thickness of the beds vary laterally between the two levels of igneous rocks and include calcareous shale and a few limestone layers restricted to the vicinity of section B-B'. The middle unit (starting above bed 58, the second level of igneous rocks, and continuing to the top of bed 62 in section C_1-C_1') is characterized by shale deposition intercalated by thin beds of limestone. The upper part of the section C_1-C_1' is more calcareous corresponding to the limestone beds in section D-D', where a change of facies and an increase in limestone thickness is observed laterally. The upper unit (= section C_2-C_2') consists of shale with intercalations of thin sandy unfossiliferous limestone lenses, silty shale to siltstone, and are overlain by a thick interval of yellowish to brown shale.

Fig.38. Panoramic view of the outcrop in the Baruunhuurai Formation (indicated as Loc. 2 in Fig. 1). The numbers (1-8) show small hills where the fossils were collected from.

Fossils are found in slightly elevated hills and are represented by rugose and tabulate corals (Fig.43), trilobites, bivalves, brachiopods (Figs.42,44), bryozoans (Fig.41), crinoids and fish dermal plates (Fig. 42). Fossils occur in the lower and middle units of the section and are preserved as molds and casts. A large collection of crinoid stems was obtained from the section D-D'. In the section C_1-C_1', rugose corals were collected from four levels (BAK3/48, 3/62e, rubble of 3/62j and 3/62o),

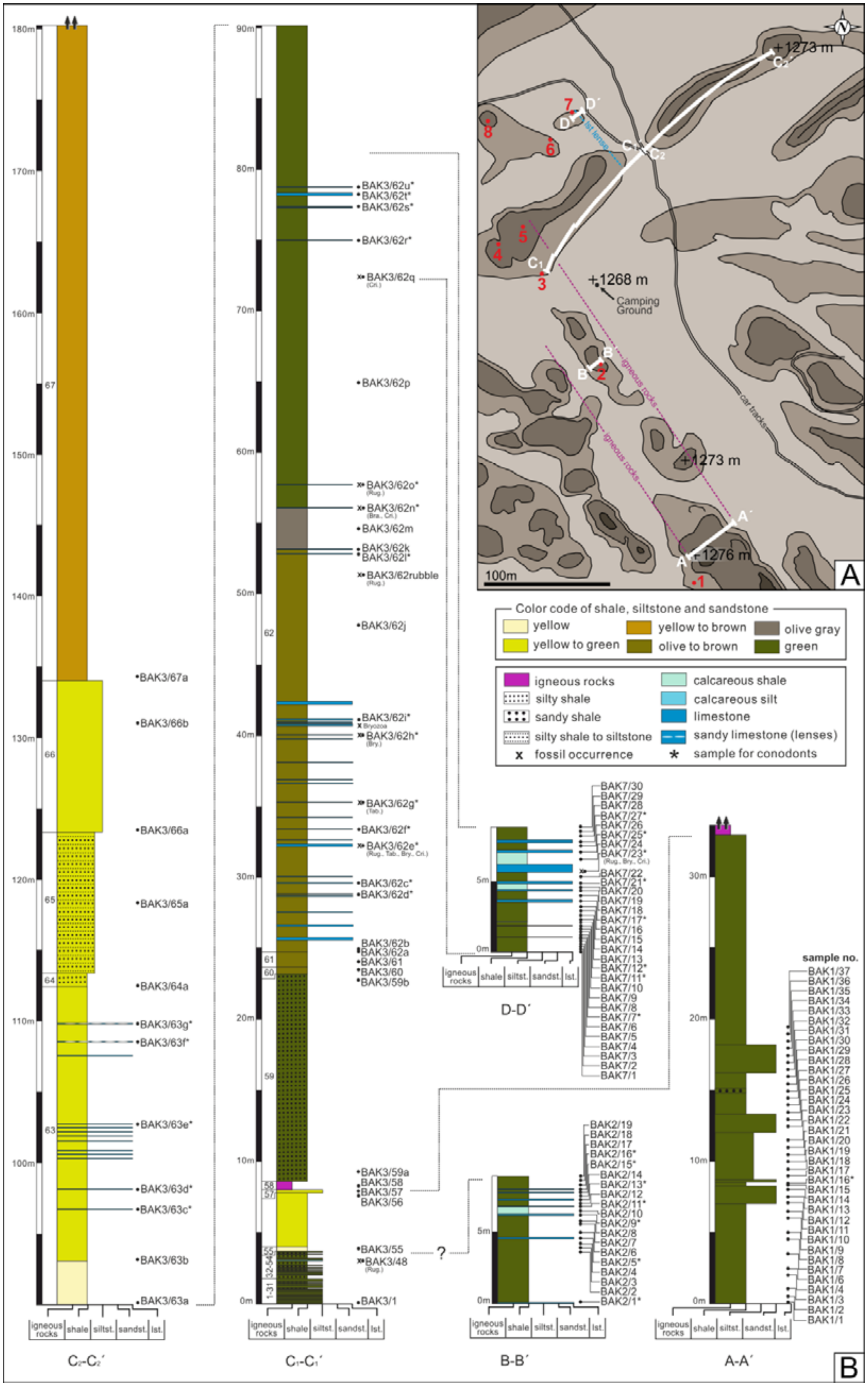


Fig.39. A: Rough topographic map showing the numbers of hills. B: Measured columnar sections (A-A' to D-D')

whereas tabulate corals are found only in two beds (BAK3/62e and 3/62g). The rugose corals are characterized by trochoid to conical solitary corallia one to seven cm in length. Specimens with the largest corallia were found in the scree the shale-interval of bed BAK3/62j. Bryozoan colonies, corals and crinoid ossicles occur in all four sections, whereas the bivalves and fish remains were found only at the hill 2 (=section B-B') and hill 8, respectively.

Based on the fossils obtained and the preliminary lithofacies analysis, the Baruunhuurai Formation in this area was deposited in a shallow marine nearshore setting with regionally dispersed limestone lenses produced by locally restricted fossil communities and intermittent volcanically derived sediment. In Ruzhenzhev (2001), brachiopods (*Stropheodonta* cf. *interstrialis*, *S. asella*, *Cariniferella tioga*, *Productella jubaculeata*, *Atrypa* sp., *Cyrtospirifer shelonicus*), conodonts (*Polygnathus costatus patulus*, *P. communis communis*, *Pelekysgnathus* sp., *Icriodus* ex gr. *corniger*, *Bispathodus stabilis*) and tabulate corals (*Cladopora kokscharskaje*, *Thamnopora nicholsoni*, *T. cervicornis*) have been reported from the Baruunhuurai Formation. Based on these fossils the formation was referred to range from the Eifelian to the Frasnian. Ulitina (2001) reported rugose corals from the same formation cropping out in the vicinity of the Zagiin-Hara-Uul Mountains, west of Ih-Shovgor Mountain, and on the southern slope of the Indrengiin-Nuruu Range. They are *Nicholsoniella hurenensis*, *N. golovtshenkoae*, *Aulacophyllum exiguum* and *Temnophyllum ruzhentsevi* (Fig.46). Based on the rugose corals and on brachiopods (*Cariniferella ulitinae*, *Streptorhynchus* sp., *Protoleptostrophia* sp., *Desquamatia* (*Seratrypa*) *pectinata*, *D.* (*Independatrypa*) sp., *Adolfia loriger*, *Cyrtiopsis* sp. and *Cyrtospirifer* sp.) (Alekseeva et.al., 2006; Fig.47) she suggested a Frasnian age for the deposits of the Baruunhuurai Formation. Erlanger (1994) also described Frasnian brachiopods (*Bulgania mongolica*) from the Zagiin-Hara-Uul Mountains. Goryunova and Ariunchimeg reported frashnian assamblages of Bryozoans (Fig.45). All these fossils come from the sections in the eastern part of Ulaanus subterrane near the Indrengiin mouintain. From the upper part of section late Famennian brachiopods are described (Fig.40).

Fig.40. Barunkhuraya indrengynensis, Upper Famennian, Indrengiin nuruu mountain

Fig.41. Bryozoans from the Baruunhuurai Formation.

Fig.42. Brachiopods, crinoids and fish (?) from the Baruunhuurai Formation.

Fig.43. Rugose corals from the Baruunhuurai Formation.

Fig.44. Brachiopods from the Baruunhuurai Formation.

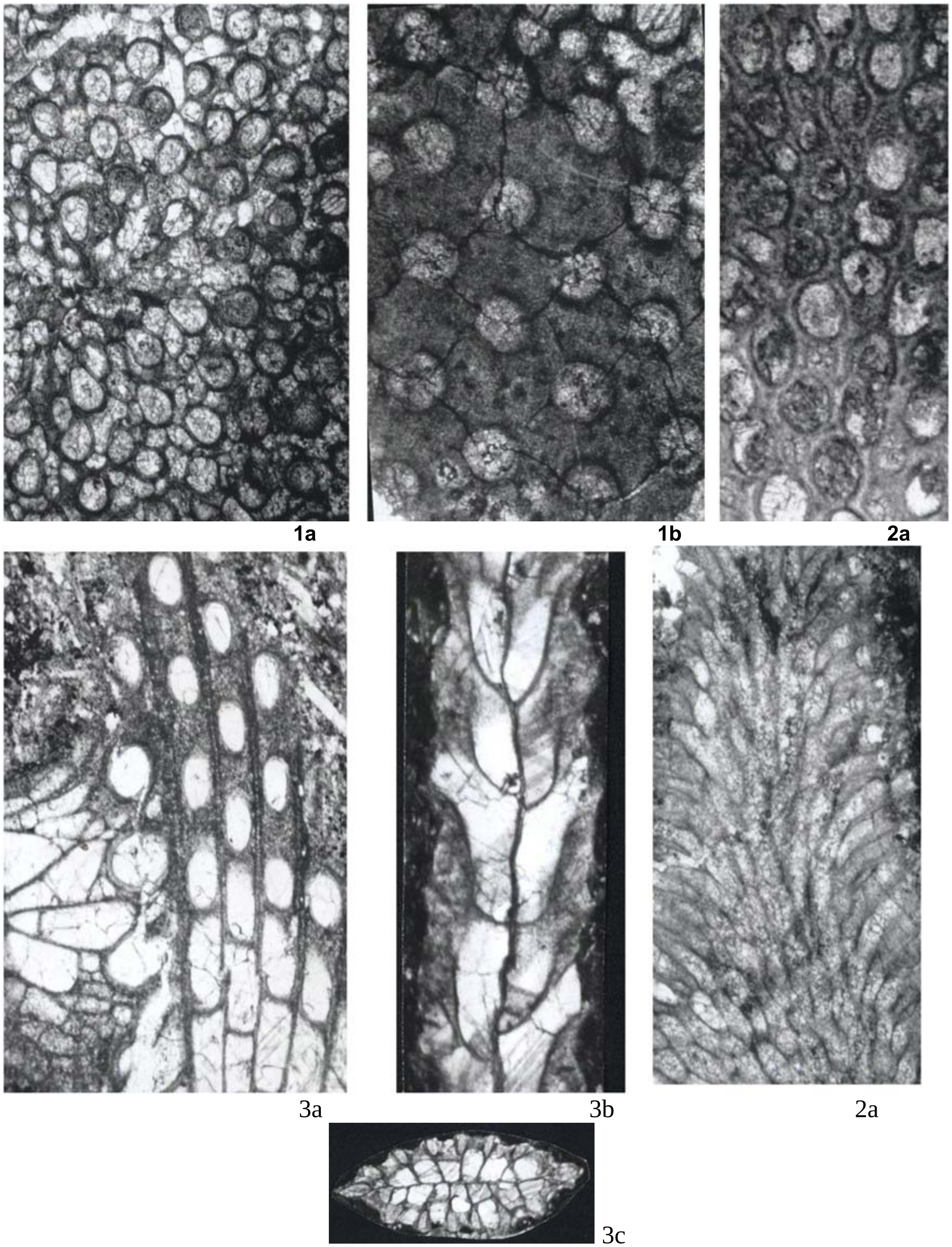


Fig.45. Frasnian bryozoans, Baruunhuurai Formation, Indrengiin huruu area.
1-Pileotrypella lautissima, 2-Boardmanella richardi, 3-Sulcoretepora consona.

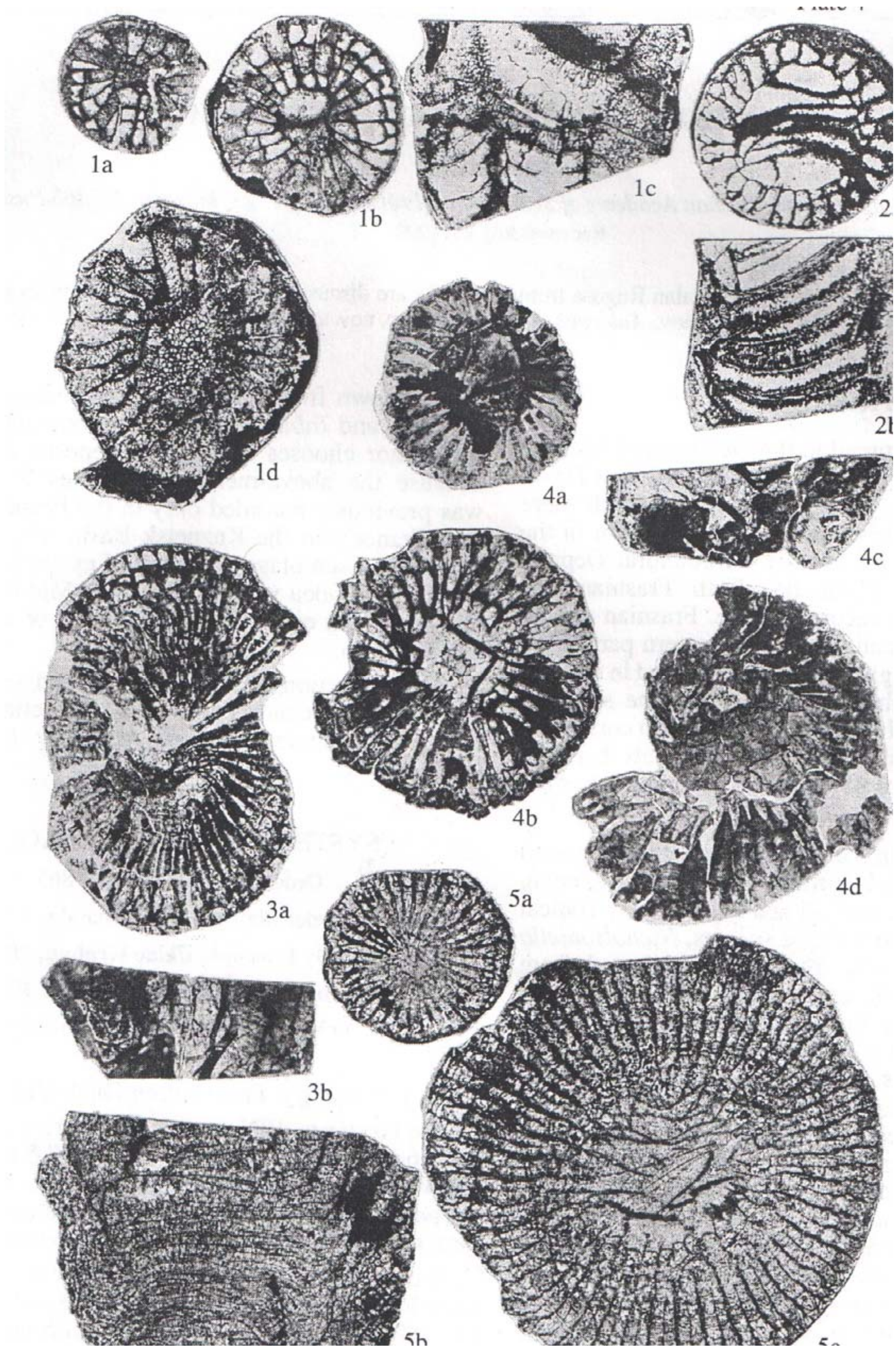


Fig.46. Frasnian corals, Baruunhuurai Formation, Indrengiin nuruu area.
1- Nicholsoniella hurenensis; 2- Nicholsonella golovtshenkoae; 3-4 Aulacophyllum exiguum; 5-Temnophyllum ruzhentsevi,

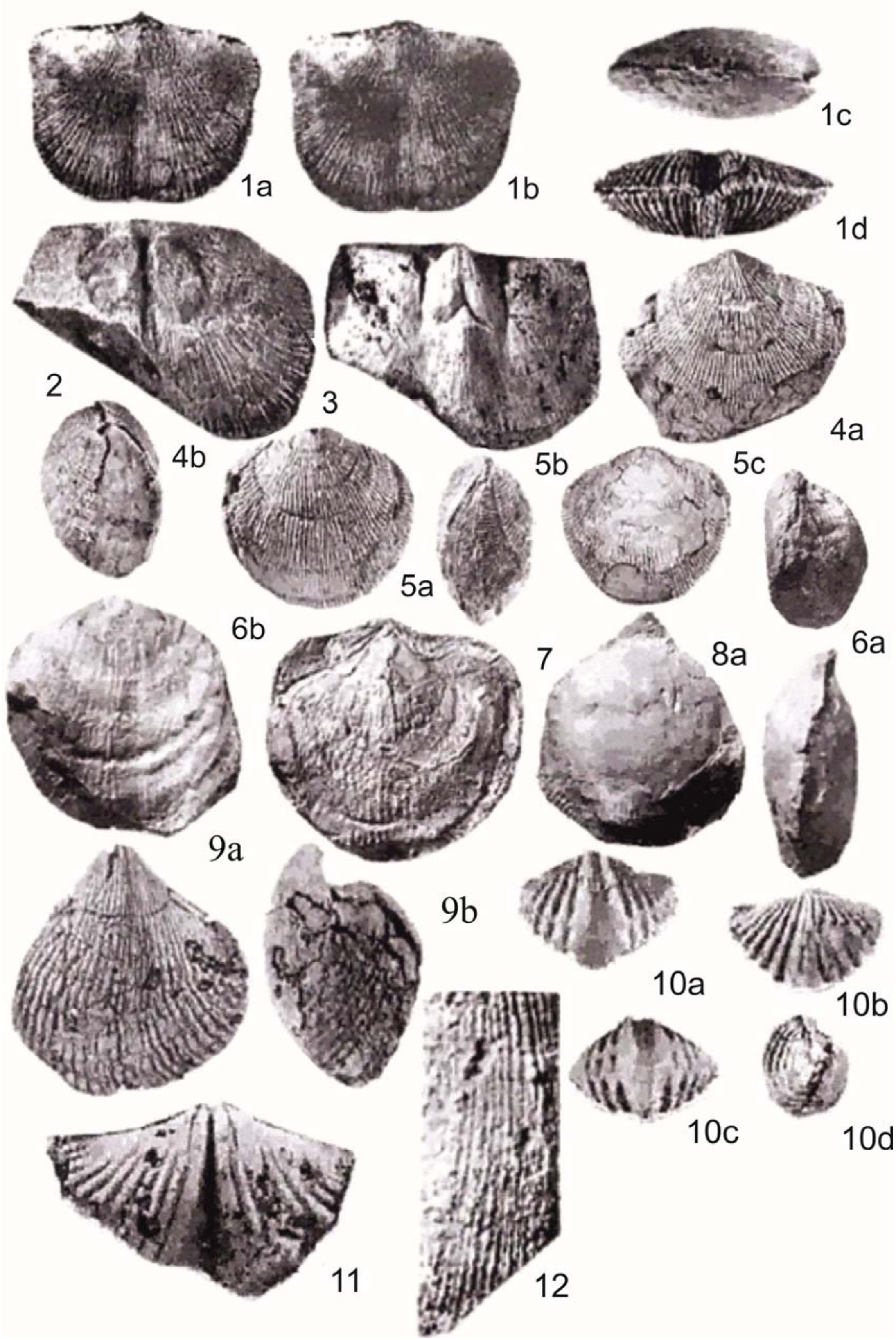


Fig.47. Frasnian brachiopods, Baruunhuurai Formation, Indrengiin nuruu area.
1-3 -Cariniferella ulitinae, 4-5 – Desquamatia (Desquamatia) alticoliformis; 6-7 – Variatrypa sp.; 8 – Radiatrypa maanshanensis; 9- Platyspirifer sp.; 10-12 – Adolfia loriger.

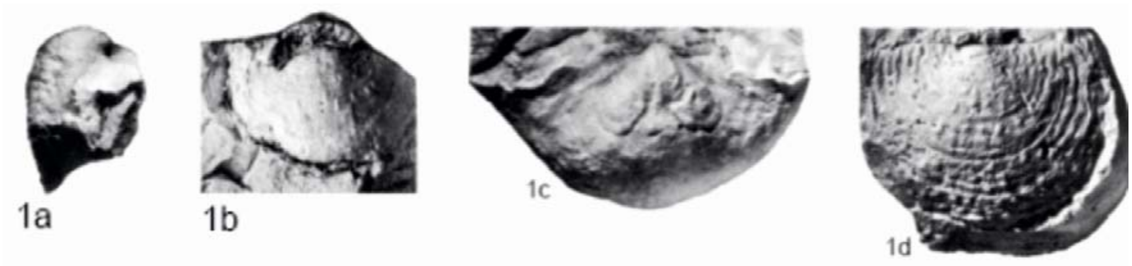


Fig.48. Onavia barunkhurensis, Lower Carboniferous, Tournaisian, Huren uul Mountains.

Fig. 49. Nariinhar Formation (?), to the south from Altai sum (Gobi-Altai)

Further taxonomic and stratigraphic works of the faunas collected from the studied area of the Baruunhuurai Formation are ongoing.

The Hurendush Formation (D_2hd). In 1956-1959 V.A.Ajipa and B.A.Fedorovskii assigned lower-middle Devonian undifferentiated sediments to middle Devonian Taigankhudag formation. Later Yu.A.Borzakovskii classified as middle-upper Devonian Baruunhuurai formation. Recently O.Davaa et al., (1995 F) based on thematic studies during regional mapping established a new formation called Hurendush with key section located 3.0 km to south-east of Khurendush mountain. Thickness ranges between 480-720 m.

This formation are locally distributed in Baitag and south Baruunhuurai area and occupies Hurendush, Maikhan Khar, Teregtiin khuren, Zuun tergen, Khuren Bogd, Tsakhiryn, and Chomodjai khoron mountains and low hills forming rocky outcrops.

The Hurendush Formation overlies lower Devonian Nariinkhar Formation unconformably and conformably undelies the upper Devonian Samnuuruul Formation and has a tectonic contact with lower Carboniferous sediments. The rocks of this formation consists of purple-brown, brown, green-grey, light grey trachybasalt, andesitbasalt, andesite, dacite, rhyodacite, rhyolite, their tuff, tuffbreccia, tuffsandstone and siltstones, tuffite and sometimes limestone.

In the Mergen hutuliin huruu range in the region of Khuren dush mountains remains of the lower Eifelian conodonts *Polygnathus costatus patulus* Klap.*, P.costatus partitas* Klap.*, P.* sp.*, Pelekysgrathus* sp., *Icriodus ex gr. corniger* Witt (V.A.Aristov) were obtained from the limestones among the volcanomictic sandstones and tuffs.

In the Bandzain Khuren range in the region of the 1722.0 level remains of middle Devonian tabulate corals *Thamnopora nicholsoni* (Frech.), *Cladopora kokscharskaje* Dub., (T.T.Sharkova) were collected in the limestones among the volcanomictic sandstones.

On the southern slope of the Idrengiin nuruu mountains remains of middle Devonian tabulate corals *Thamnopora cervicornis* (Blainv.), *Emmonsia talteinsis* Janer., are present in the calcareous sandstones. Upwards along the profile remains of Frasnian brachiopods *Stropheodonta cf. interstrialis* (Phill.), *S.asella* Vern., *Cariniferella tioga* (Hall)., *Productella subaculeata* (Murch*.), Atrypa* sp., *Cyrtospirifer shelonicus* Nal., and others were collected here.

The Inder Formation (C_1in). The sediments distributed in the Indert mountain predominantly consists of green-grey, blue-grey, grey and brown conglomerate, coarse to medium grained calcareous sandstone, stratified tuffite and siltstones with lenses of limestone were described by V.A.Fedorovskii and V.A.Ajipa as a middle Devonian Taigankhudag Formation, then Yu.A.Borzakovskii et al., assigned it to the middle-upper Devonian Baruunhuurai Formation.

During the geological and paleontological investigations conducted over the last few years Carboniferous fossils were found from this sediments and a new formation Inder was accepted. The rocks of this formation are distributed in southern part of the Argalant Serten and Huh Del mountains with a total thickness of 800-1300m. Near the Huren uul mountains the Inder formation comformably overlies upper Devonian Samnuuruul Formation. The calcareous sandstone of this formation contains gastropods, crinoid, rugose corals, brachiopods (Fig.48) and bryozoans.

Based on brachiopods *Dictyoclostus* sp*.,* and *Torynifer* sp., are identified by V.M. Martynova and crinoids *Rhyocamax grandes* M.et.J., and *Unilineatocrinus unilinealus* identified by F.Tungalag the the age of sediments accepted as Tournaisian.

The Nuhniinuruu Formation (C_1nn). The sedimentary rocks distributed southwards from village Altai to Nuhniinuruu Range initially was classified as Nuhniinuruu formation by V.A.Fedorovskii et al., (1960). The formation predominantly consist of black, black-grey, green-grey, grey and brownish fine to middle grained sandstone, siltstone, mudstone, clay-schist, and rarely gravelites, coarse graned sandstone as well as crinoids bearing limestone.

The formation widespread in NW-SE trending Nariin Har Range, Mergen Uul, south foothills of Mt. Nariin Har (Figs.50,51), north side of Talyn Har Range, Nuhnii Nuruu Range, through Seer Hudagiin depression to Tahiin Shar Range in the east. The thickness varies from 1600 to 1700m.

The formation was firstly assigned to middle-upper Devonian, then N.G.Markova (1975) described it as lower Carboniferous at Mergen Uul area, and E.V.Golovchenko et al., (1992), S.V.Ruzhentsev et al., (1992), O. Davaa et al., (1996) collected crinoids, conodonts and flora such as *Lepidodendron aff. pseudokirghizcum* Radcz., *Calamites cf. suchovii* Brond. (Fig.52) and defined as Visean-Serpukhovian. Nuhniinuruu Formation is conformably overlain the Samnuuruul formation, and laterally changes to Borhavtsal Formation.

Fig.50. Nuhniinuruu Formation (indicated as Loc. 6 in Fig. 1).

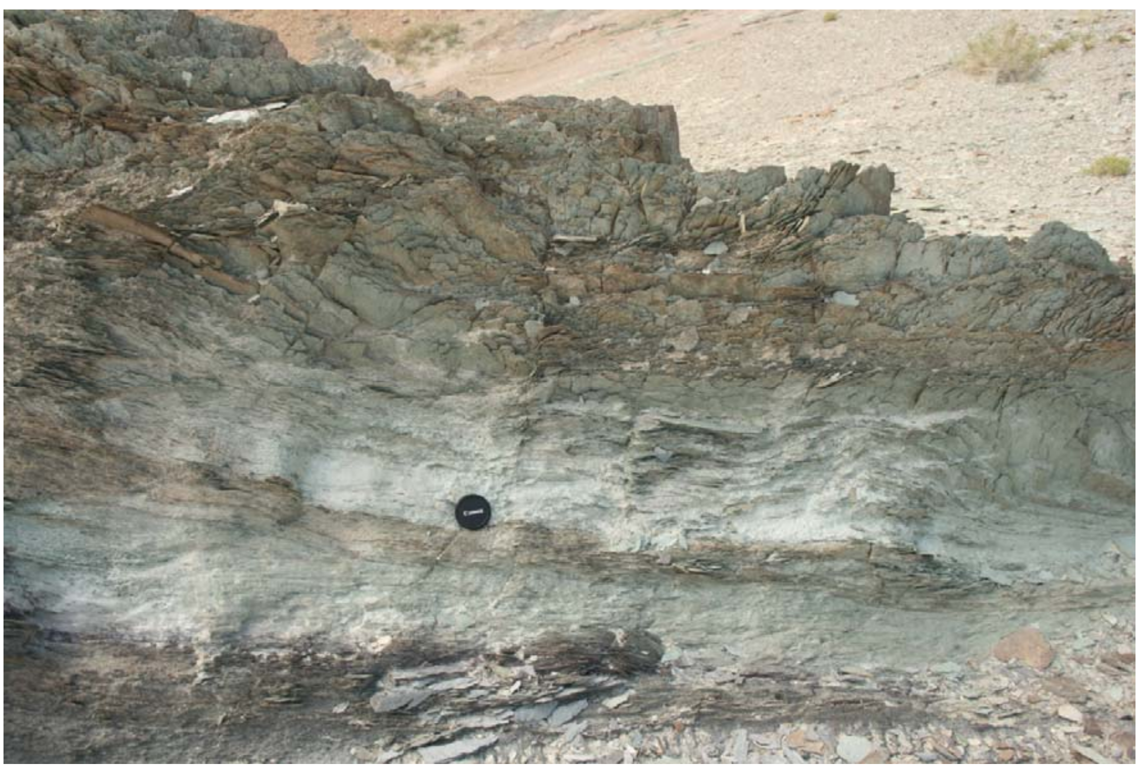


Fig.51. The same as 50. “Bentonite locality”

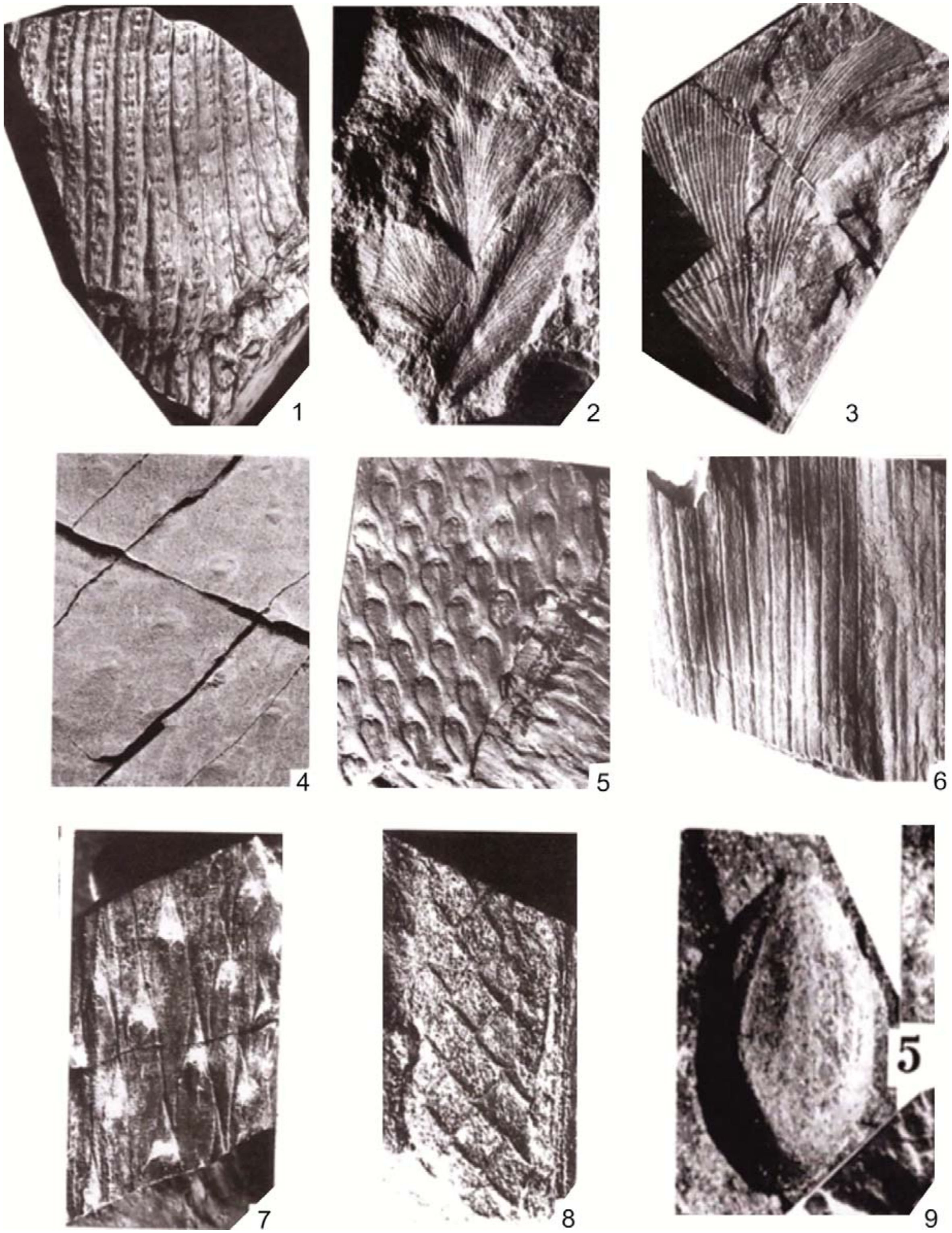


Fig.52. Plant fossils from the Nuhniihuruu Formation.
1-Syringodendron sp., 8-Leptophloeum cf. rhombicum Dawson, 1862, Baga Havtag,
2-Cardioneura sp., 3- Angaropteridium (?); 4-Caenodendron (?) sp., 6- Archaeocalamites ex gr. Radiates (Ad.Brongniart) Stur, 1875; 9- Carpolithes sp., Mergen uul;
5-Lepidodendron sp., Baitag, 7-Lepidodentron ex gr. Kirghizicum Zalessky, 1932, Haltar uul.

The Borhavtsal Formation (C_1bh). The Borhavtsal Formation was defined during the geological mapping by V.A.Fedorovskii et al., (1959), then was studied in detail by B.Luvsandanzan (1970) and V.V.Yarmolyuk. Yu.A.Borzakovskii et al., (1990) divided these sediments into two units. The lower unit was defined as middle-upper Devonian Borhavtsal Formation, which is composed of intermediate, acidic volcanic rocks with few beds of organic limestone and conformably overlied by carbonate-tuffaceous unit represented by acidic to intermediate volcanics with rare layers of fossiliferous limestone and named Tsahirynnuruu formation which is upper Devonian-lower Carboniferousin in age.

During the geological mapping O. Davaa et al., (1996) reported stratigraphic conformable contact between Borhavtsal and Tsahiriinnuruu formations at the Shantsav mountains to the north-east from Tahiin Shar Range. In the lower part of section mafic, intermediate volcanic rocks, tuffs and in the upper part of section sandstone, mudstone, tuffite and flysh-like sediments are observed.

From the upper part of section V.V.Yarmolyuk collected brachiopods such as *Megachonetes zimmermanni* (Paesk.), *Avonia* sp., *Tolmatchoffia* sp., *Rhynchonellidae, Productidae, Chonetidae, Spiriferidae,* and accoding to the R.T.Gratsianova identification they are middle-upper Tournaisian. The Borhavtsal formation laterally changes to the Carboniferous Nuhniinuruu formation, and are conformably overlapped by Tsahirynnuruu formation. Thickness of Borhavtsal formation is 1500-2500m.

The Tsahirynnuruu Formation (C_1cn). Southward from village Bugat of the Gobi-Altay aimag to Mongolia-Chinese border, tuffaceous-terrigenous-carbonate sequence is classified as the Tsahirynnuruu formation by Fedorovskii et al., (1959), which widespreads in south slope of Mt. Yamaat, Tsahir Range, from northern margin of Mt. Jargalan to the east continuing in Bor Havtsal valley, southeastwards from Erdene Chuluut, Tsahir Us. The key section is described in valley of Bor Havtsal (Fig.53)

The formation is predominantly composed of sedimentary rocks, mainly carbonite rocks. At bottom of section near the Bor Havtsal tuff-sandstone, tuffconglomerate with thin layer of green-grey tuffs (150m), upwards in some places tuffeceous rocks and massive and bedded limestones with thin beds of green stratified tuffs (850m). At the top of the section dark-grey, green-grey tuffaceous siltstone, tuffs and tuffites (350m) are described. The elsewhere the section is rich of fauna (Figs.54,55), and Fedorovskii et al., (1959), Luvsandansan, (1970), Golovchenko, Suetenko et al., (1990), Davaa et al., (1995) collected plentiful brachiopods, which were determined as Visean-Serpukhovian by Pavlova, E.E., Lazarev, S.S., Afanas'eva G.A., and Suur'suren, Sh.

At Baitag Bogd, Baaran, Nariin Har Ranges, and Bor havtsal areas of the Baruunhuurai depression, a thick Tournaisian fauna bearing sedimentary-volcanogeneous rocks are widespread, which was assigned to Lower Carboniferous by Luvsandansan (1970). This sedimentary-volcanogeneous sequence is divided into two units: volcanogenic and siliceous-terrigenic. The age of lower volcanogenic unit is under the hot debate, researchers cannot approach any decision for the age. V.M. Sinitsin (1956) assigned it to upper Devonian porphyric sequence, P.S.Matrosov (1960) assigned to middle-upper Devonian Baitag Formation, but Luvsandansan (1970) assigned it to Tournaisian stage based on fauna, and showed that sedimentary-volcanogeneous thickness has one succession. M.V.Durante (1980) analyzed Luvsandansans' (1970) section, and concluded that volcanic rocks in eastern part of the Baruunhuurai depression are Devonian in age, tuffaceous-sedimentary rocks gradually continuous from Devonian to Lower Carboniferous and the terrigenous-siliceous rocks in the upper part of the section is Tournaisian.

Fig.53. The Tsahirynnuruu Formation, valley of Bor Havtsal.

Fig.54. The Tsahirynnuruu Formation

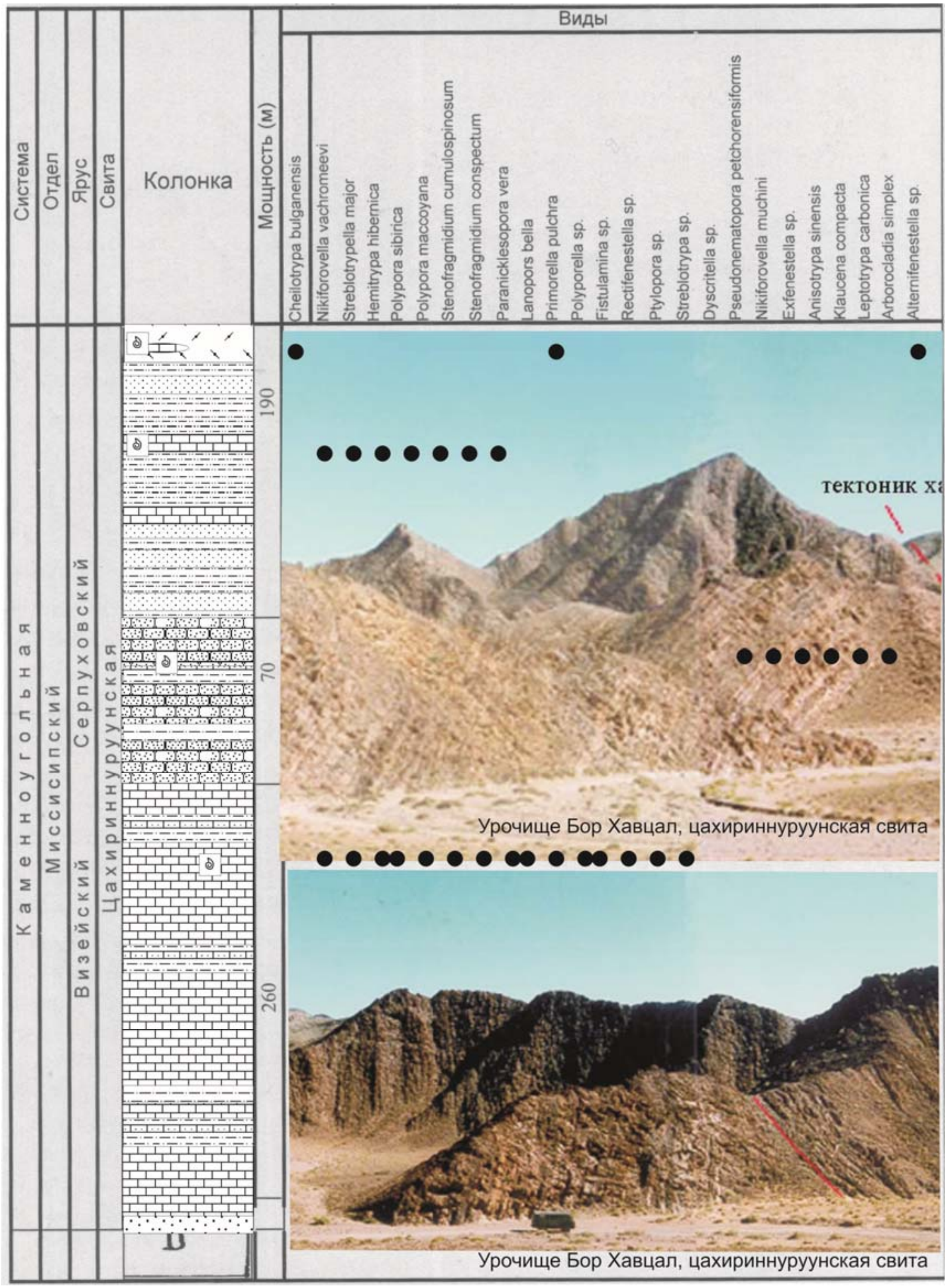


Fig.55. Distribution of bryozoans in the Tsahirynnuruu Formation in section Toodgiin us.

The Tavan-Ovoo Formation ($C_{1-2}$to). In previous studies the sediments of Tavan-Ovoo and Uushgiinulaan formation were drawn as Tsahirynnuruu Formation. Badarch et al., (1992) defined the Tavan-Ovoo and Uushgiin-Ulaan Formations. The Tavan-Ovoo Formation distributed in limited area near the Tavan-Ovoo well and unconformably with erosional surface overlies the Tsahirynnuruu formation. The sediments in the lower part are represented by conglomerates composed of well-rounded, small medium pebble acidic volcanic rocks, tuffecous rocks and quartz; in the upper part cross bedded middle-coarse sandstone, black siltstone and coal bearing mudstone alteration are seen. The Tavan-Ovoo Formation assigned to visean-upper Carboniferous based on flora and petrified wood such as *Knorria* sp*.,* *Tomiodendron mongolicum* Durante and *Paracalamites* sp*.* by Uranbileg.

The Uushgiin-Ulaan Formation(C_2 uu). Volcanogenic sediments with total thickness of 350-400m could be assigned to the new late Carboniferous formation named Uushgiinulaan. This formation is drawn eastward from Mt. Yastiin Hurgad to Mt. Huren Del in central part of Baitag zone. It is predominantly characterized by green, greenish-grey, violet-grey, light-grey, grey dacite, rhyodacite, trachyrhyolite, their tuffs, tuff-lava, tuff-breccia, tuff-conglomerite, sometimes which contains andesite, andesite-tuff, sandstone and siltstone layers.

The Baitag subterrane

The Baitag subterrane was represented by a sequence of differentiated tholeiites in Devonian times. In their chemistry and structure the dewposits are here regarded as rocks from fore-arc zone of the Baitag island arc. A change in the character of ther volcanism (the replacement of calc-alcaline volcanic by tholeiites to the south) suggests that saubduction zone had a southern polarity. The Baitag arc died out in early Carboniferous times. An extensive single basin, infilled with greywaske flysh, was formed.

This includes the Baitag and Ikh Khavtag ridges which extend into China and is also made up of volcanic and terrigenous deposits.Ther Devonian is represented by Baitag formation, is chiefly represented by volcanic which make up two tectonic sheets. The lower sheet is made up of aphyric basalts pyroxene-porphyrites, plagioporphyry, their tuffs, and epiclastics, up to 1 km thick. The volcanic of the upper sheet are represented by basalts. They are massive flows: pillow lavas up to 400 m in apparent thickness. The lower carboniferous deposits of both sheets are represented by flysch which is similar to that in the Ulanus zone.

Baitag Formation (D_{1-2} bt). Initially Matrosov P.S. (1966) has assigned the volcano-terrigenic rocks to formation by name Baitag Bogd mountain. The key section is situated near the Ichkesu spring on the northern slope of Baitag Bogd mountain.

The Baitag Formation is widespread in the north of the Tumurtiin Har and Baitag Bogd, west and east edge of Talyn Har, Ikh Har, Baga Har, Zeeg, Huh Undur, and near the Takhiin Shar range. These sediments are black, dark gray, green, greenish gray, brown gray colored and contains lower volcanogenic and upper effusive -tuffaceous beds.

The lower volcanogenus bed consists mainly low grade metamorphosed amygdaloidal, spherical and columnar basalt, andesite-basalt, tuffs with different size clast, tuff conglomerate. This bed contains rare lenses of red jasper, thin beds of clay siltstone and siliceous shale . Thickness is 1000-1300m.

The upper effusive-tuffaceous bed is characterized by greenish-gray mafic to felsic lava, green tuffs, blue perple stratified graywaske and tufficeous siltstone, sandstones, sandy limestone and red, red brown colored jasper lenses with radiolarians. Thickness is 1500m.

Baitag Formation underlies unconformibly the lower Devonian rocks and with erosional surface structurally conformably is overlying by middle-upper Devionian Baruunhuurai Formation.

In adjasent China the tuffaceous-terigenous sediments contains lower-middle Devionian brachiopods and bryozoans (Ajipa 1966, Matrosov 1960). Sharkova T.T described Givetian corals-*Alveolites cf. edwardis* Les., *Thamnopora nicholsoni* (Erench), *Favosites* sp., near the Har Morit well, Martynova M.V. indicated lower-middle Devoinian brachiopods- *Euryspirifer cheehia* (Koninck) from section of Zeeg mountain. Further Suetenko O.D. found from these sediments the Eifelian plant, lower Devonian crinoids and Emsian brachiopods.

The Havtag Formation (D_{2-3} hb). Initially V.P.Ajipa has described the lower-middle Devonian rocks in the region. Further Ö.Davaa et al., (1995, 4865 f) has carried 1:200000 scale geological mapping in the Gobi-Altai and Khovd province and identified a significant difference from Baitag formation and established a new Havtag formation based on the G.Badarch and S.V.Ruzhentsev thematic studies.

The sediments of the Havtag Formation widely spread in southern Baruun Huurai belt along the border, and patchy outcrops along the northern slopes of Baitag mountain, Buduun mountain, around Damjingiin Huren-Undur mountain and the Ikh Havtag Nuruu. As an assemblage with Devonian and Carboniferous sediments being in tectonic contact the outcrops mostly create rocky mountain tops and slopes.

The formation is divided into two members - intermediate volcanic rocks dominated lower and acidic volcanic rocks dominated upper members and smooth transition seen between them. The formation is mainly composed of green, black, dark gray, basalt, andesite, dacite, rhyolite, their tuffaceou lavas, breccia, tuff, tuff sandstone, siltstones and occasionally gravellite, sandy limestone lenses containes.

Lower member consists of the dark gray, gray, gray-green andesite and andesite-dacite, their tuff, tufflavas, breccia, tufficeous sandstone, siltstones, rare rhyolite, riodacite and limestone layers. Upper member consists of the light gray, greenish gray, brown schistose dacite, rhyolite, their tufbreccia, tuffsandstone and siltstone. The thickness is 700-1000m. There is no key section of this formation.

Several sections described at 5 and 6 km southeast from Emgeljin Khashaat Undur mountain and to the east from Tamtyn Undur mountain. They contain brachiopods *Cyrtospirifer* sp., *Cyrtospirifer ivanovae* Bes., *Lejtagniu ex gr. analoga.*

Discussion

The Baruuhuurai Terrane is covering big area with complicated geological structure, and during this field work we could visit just western part of it. The Devonian deposits of the Baruunhuurai Terrane in western Mongolia are characterized by volcaniclastic rocks with intercalated fossil-rich marl to limestone lenses. These units were deposited on an island arc complex of the same tectonic terrane as similar Devonian units in the western and eastern Junggar in northwestern-China.

Lithostratigraphically, the Middle to Late Devonian sediments of the western Junggar region are represented by the Hefen Formation (Eifelian; tuffaceous sandstone yielding brachiopods and corals, siltstone and tuffaceous conglomerate levels), Hujierste and Zhulumute formations (Givetian to Frasnian; tuffaceous siliciclastic rocks yielding abundant plant fossils), and the Hongguleleng Formation (Frasnian to Famennian; shallow water carbonates intercalated with siltstones with a diverse fauna succeeded by a unit of radiolarian rich shale and chert) in ascending order.

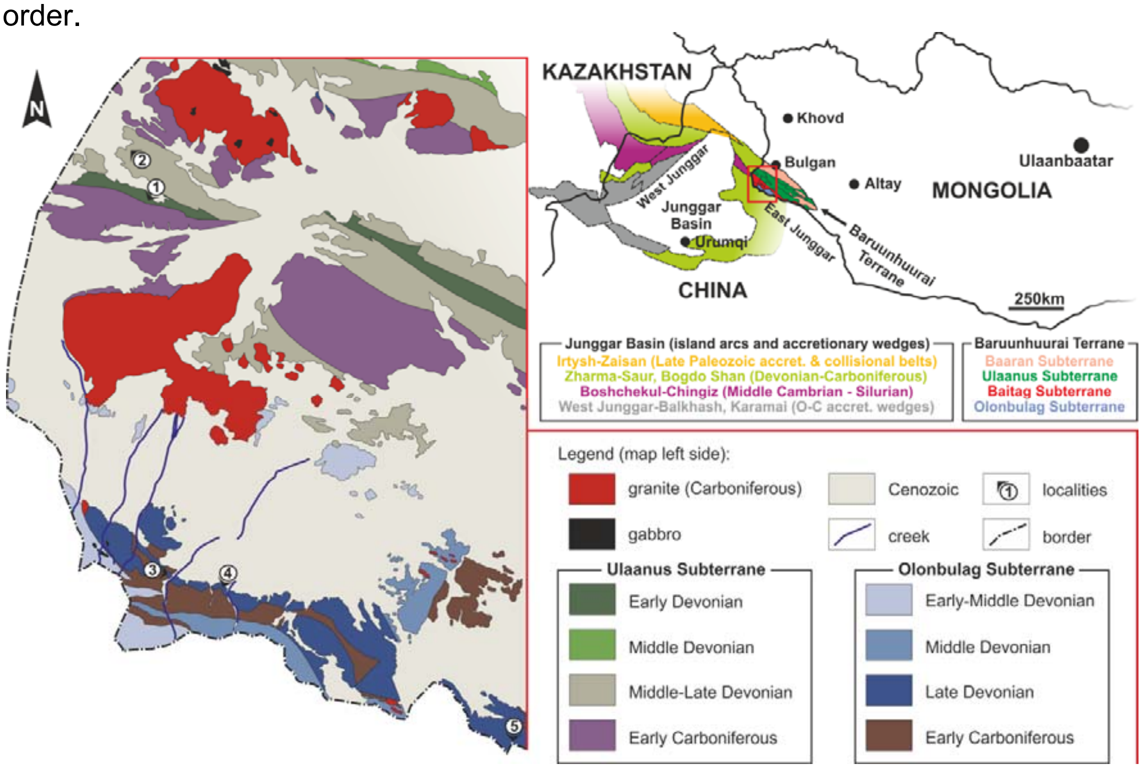


Fig.56. Locality map showing the subdivision of the Baruunhuurai Terrane, western Mongolia and its relation to the Junggar Basin, northwestern China (based on Ma et al. 2009 and Xiao et al. 2010). A geological map of the observed area is illustrated on the left side

According to Wang et al. (2005) and Ma et al. (2009), the Middle to Upper Devonian in the eastern Junggar region is represented by the Ulusubasite Formation (Eifelian; sandstone, tuff and tuffaceous sandstone with plant fossils, and coral bearing limestone in the uppermost part), Zhifang Formation (Givetian; conglomerate levels at the base, tuffaceous sandstone and siliciclastic rocks with limestone nodules; fossils including plants, brachiopods and corals) and the Ke'ankuduk

Formation (Frasnian to Famennian; lower unit: tuffaceous siliciclastics with plants, intercalated by radiolarian-chert; upper unit: tuffaceous sandstone intercalated with tuffaceous conglomerate).

Our preliminary data indicate that the Eifelian to Frasnian Baruunhuurai Formation in the study area was deposited in a shallow marine nearshore setting with regionally dispersed limestone lenses produced by locally restricted fossil communities and intermittent volcanically derived sediment. The lithological content of the sequence shows characteristics of both areas in NW-China during the Eifelian, but seems to have a closer relation to the eastern Junggar region during the Givetian.

The Late Famennian Samnuuruul Formation is dominated by volcanically derived fine grained clastic deposition on a shallow shelf interspersed with sporadic deposition of limestone in the lower and middle part. The upper part of the formation consists of a series of sandstones perhaps deposited as a series of offshore bars or coastal barrier bars that grade upwards into a terrestrial coal producing sequence. The Samnuuruul Formation shares many biotic elements with the Hongguleleng Formation in western Junggar region of China, but seems to occupy a somewhat different sedimentary regime. We visited outcrops of the Samnuuruul formation just in one subterrane. Several hundred kilometers farther southeast, an abundant marine Frasnian fauna is reported. In the future we have to analisy the sections in the eastern part of terrane and compare them with sections in adjacent areas.

The Samnuuruul Formation contains a black shale interval in a stratigraphic position consistent with the Hangenberg Event. In contrast, the Late Famennian interval of the Ke’ankuduk Formation in eastern Junggar region consists of a non-carbonatic terrestrial development. As a result finding similar aged formations with strikingly different patterns of sedimentation between the sections in western and eastern Junggar regions and the Samnuuruul Formation in western Mongolia is not surprising, but the resulting geographic isolation provided the proper conditions to support ecological refugia, particularly in the aftermath of the Frasnian / Famennian event.