2010 AAPG EUROPEAN REGION CONFERENCE & EXHIBITION

FIELD TRIP GUIDEBOOK

Trip # 1

Geology of the Crimean Mountains in the context of petroleum exploration in the Black Sea

15 – 16 October 2010

Leaders:
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HISTORICAL PAST
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Guidebook to fieldtrip No. 1
Ukraine, Crimea, October 15-16, 2010

GEOLOGY OF THE CRIMEAN MOUNTAINS IN THE CONTEXT OF PETROLEUM EXPLORATION IN THE BLACK SEA

by Igor Popadyuk, Oxana Khriachtchevskaia, Sergiy Stovba

Reference to the guidebook

It is recommended that reference to all or parts of this guidebook should be made in the following way.

Popadyuk I., Khriachtchevskaia O., Stovba S., 2010. Geology of the Crimean Mountains in the context of petroleum exploration in the Black Sea. AAPG European Region Conference and Exhibition, Kyiv, Ukraine, Guidebook to field trip No. 1, Ukraine, 50 p.

Acknowledgment to prof. A.Nikishin for numerous discussions of Crimean geology and providing some photographs and section descriptions.

CONTENT

Pages

INTRODUCTION

"What we have in the surface is exactly we have in the subsurface. So, understanding of the surface geology is a key issue."

Hussein Seddiq, 2007

The field trip involves twelve visits over two packed days (see next page with a time schedule and **Figs. 1, 2**).

The stops were selected to offer a good coverage of stratigraphy of the Tertiary and the Mesozoic outcropping in Crimea (**Figs. 3, 4**).

Emphasis is also placed on the formations which are proven and/or probable reservoir, seal and source in the adjacent areas, either offshore (e.g. the Odessa Shelf, **Fig. 5**) or onshore (e.g. Kerch Peninsula, Plain Crimea).

Date: 15 – 16 October 2010

Location: Originates and ends in Simferopol with one night in Yalta (Crimea, Ukraine).

Leaders:

During the pre-field trip in Crimea, 5-6 September 2010

Sergiy	Oxana	Igor
Stovba	Khriachtchevskaia	Popadyuk

TIME SCHEDULE

Date	Program
14th, October, Thursday	Arrival of attendees to Simferopol. Overnight rest in the hotel "TES-hotel" in Simferopol city
15th, October, Friday	07.00 – 07.30 Breakfast. 07.45 – 08.00 The first meeting at the lobby of the hotel. 08.10 – 17.00 Field trip in western Crimea. 08.10 – 08.40 A relocation from Simferopol to Prohladnoe. 08.40 – 10.00 **Stop 1-1. Prohladnoe outcrop** – Up.Triassic-L.Jurassic (Tavric) flysch 10.00 – 10.30 A relocation from Prohladnoe to Bakhchisaray 10.30 – 11.10 **Stop 1-2. Bakhchisaray outcrops** – Maastrichtian, L.Paleocene 11.10 – 11.30 A relocation from Bakhchisaray to Verhnesadovoe 11.30 – 12.00 **Stop 1-3. Verhnesadovoe area** – Up.Eocene, Middle-Upper Miocene 12.20 – 12.40 A relocation from Verhnesadovoe to Inkerman 12.40 – 12.50 **Stop 1-4. Inkerman outcrop** – Maastrichtian / Paleocene *(overview)* 12.50 – 14.30 Lunch and relocation to Balaklava 14.30 – 15.00 **Stop 1-5. Balaklava area** – Upper Jurassic *(overview)*, Albian 15.00 – 15.20 A relocation from Balaklava to Laspy Bay 15.20 – 16.20 **Stop 1-6. Laspi Harbor** – Upper Jurassic 16.20 – 17.00 Hotel-coming to Yalta city. 19.00 – 20.30 Dinner in the hotel. Overnight rest in the hotel "Yalta-Intourist" in Yalta city.
16th, October, Sunday	07.00 – 07.30 Breakfast. 08.10 – 17.00 Field trip in southern Crimea. 08.10 – 08.50 A relocation from Yalta to Kutuzovka area. 08.50 – 09.20 **Stop 2-1. Lavanda area** – Upper Jurassic of Demerdji, Chatyr-Dag *(overview)*, Tavric flysch 09.50 – 10.05 A relocation from Lavanda area to Krasnopeschernoe 10.05 – 10.30 **Stop 2-2. Krasnopeschernoe** – Upper Jurassic, Albian 10.30 – 11.00 A relocation from Krasnopeschernoe to Mazanka 11.00 – 11.30 **Stop 2-3. Mazanka** – Hauterivian-Barremian (?) 11.30 – 12.00 A relocation from Mazanka to Belogorsk. 12.00 – 13.30 **Stop 2-4. Belogorsk outcrop** – Albian, Cenomanian 13.30 – 14.30 Lunch in Belogorsk city 14.30 – 15.00 A relocation from Belogorsk to Ak Kaya mountain. 15.00 – 15.30 **Stop 2-5. Ak Kaya outcrop** – Up.Cretaceous-Oligocene succession 15.30 – 16.00 A relocation from Belogorsk to Ulyanovka quarries. 16.00 – 16.30 **Stop 2-6. Ulyanovka quarries** – Up.Jurassic 16.30 – 17.00 Hotel-coming to Simferopol city. 19.00 – 20.30 dinner in a hotel. Overnight rest in the hotel "TES-hotel" in Simferopol or evening departure to Kyiv.
17th, October, Sunday	07.00 – 07.30 Breakfast. A morning departure of attendees to Kyiv.

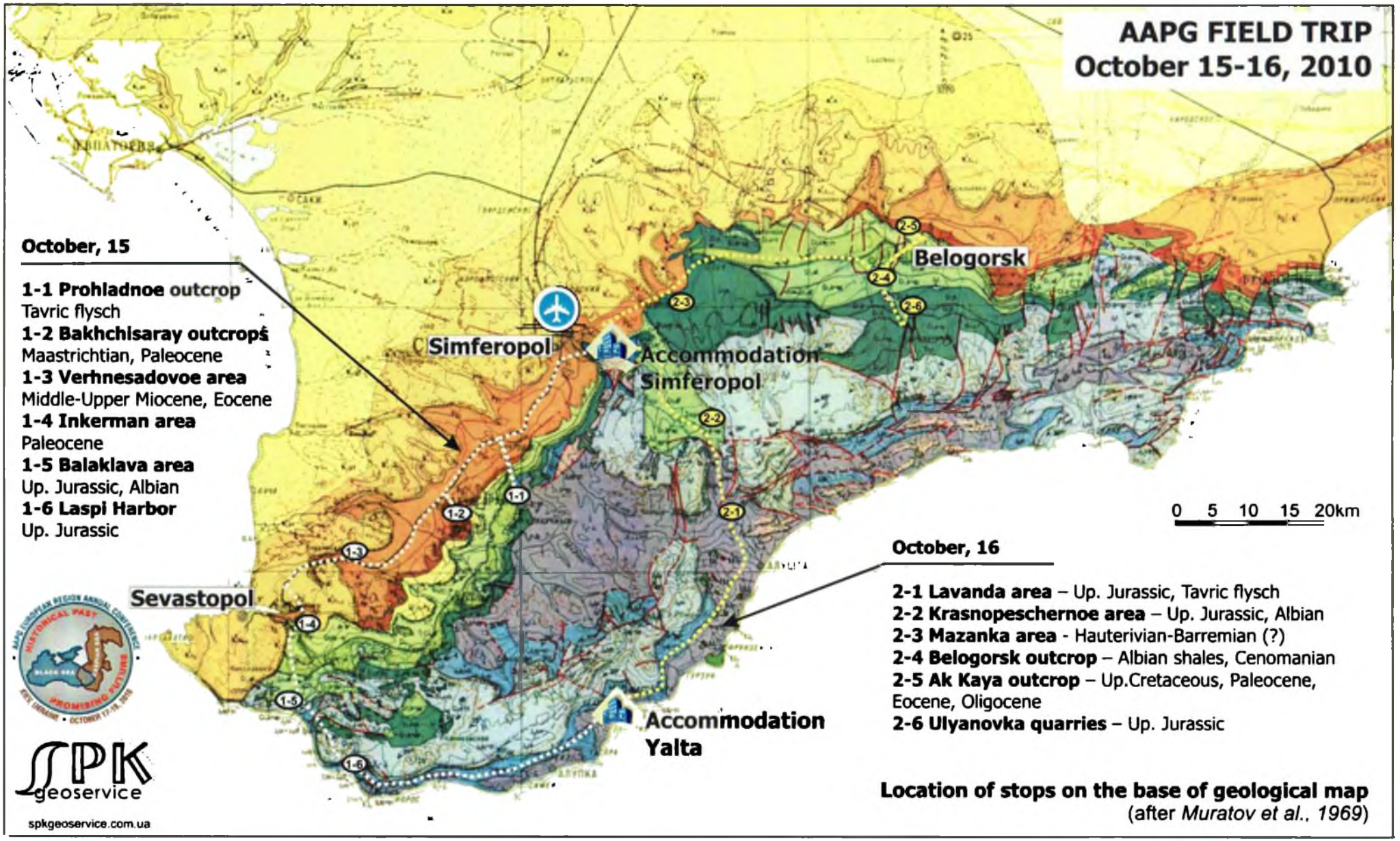


Figure 1. Location of stops of the field trip #1 on the base of geological map (from *Muratov et al., 1969*)

Figure 2. Location of stops of the field trip #1 on the base of regional satellite map (from *Google resource*)

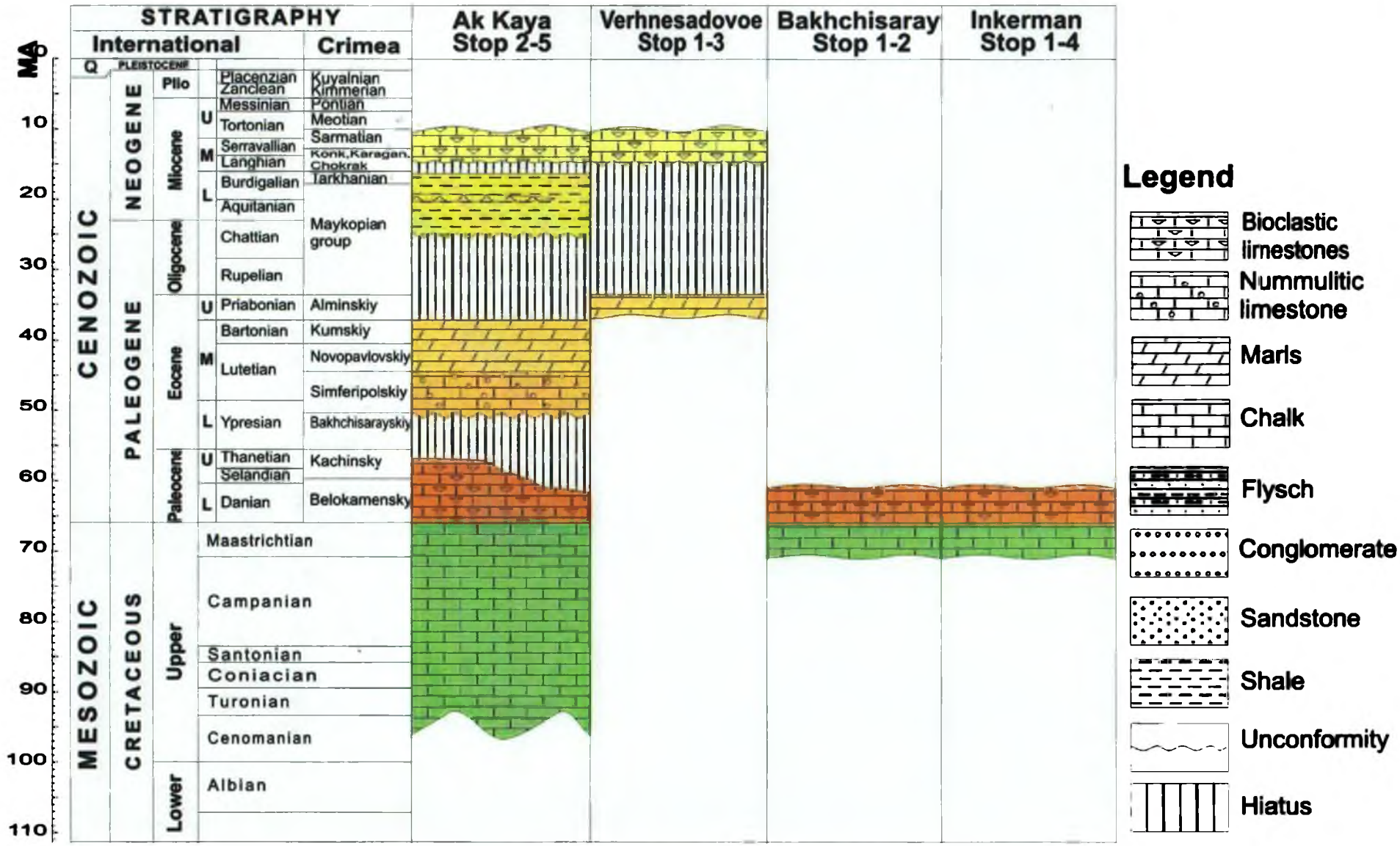


Figure 3. Neogene-Cretaceous columns of outcrop sections of the field trip #1 (according to the common stratiphication)

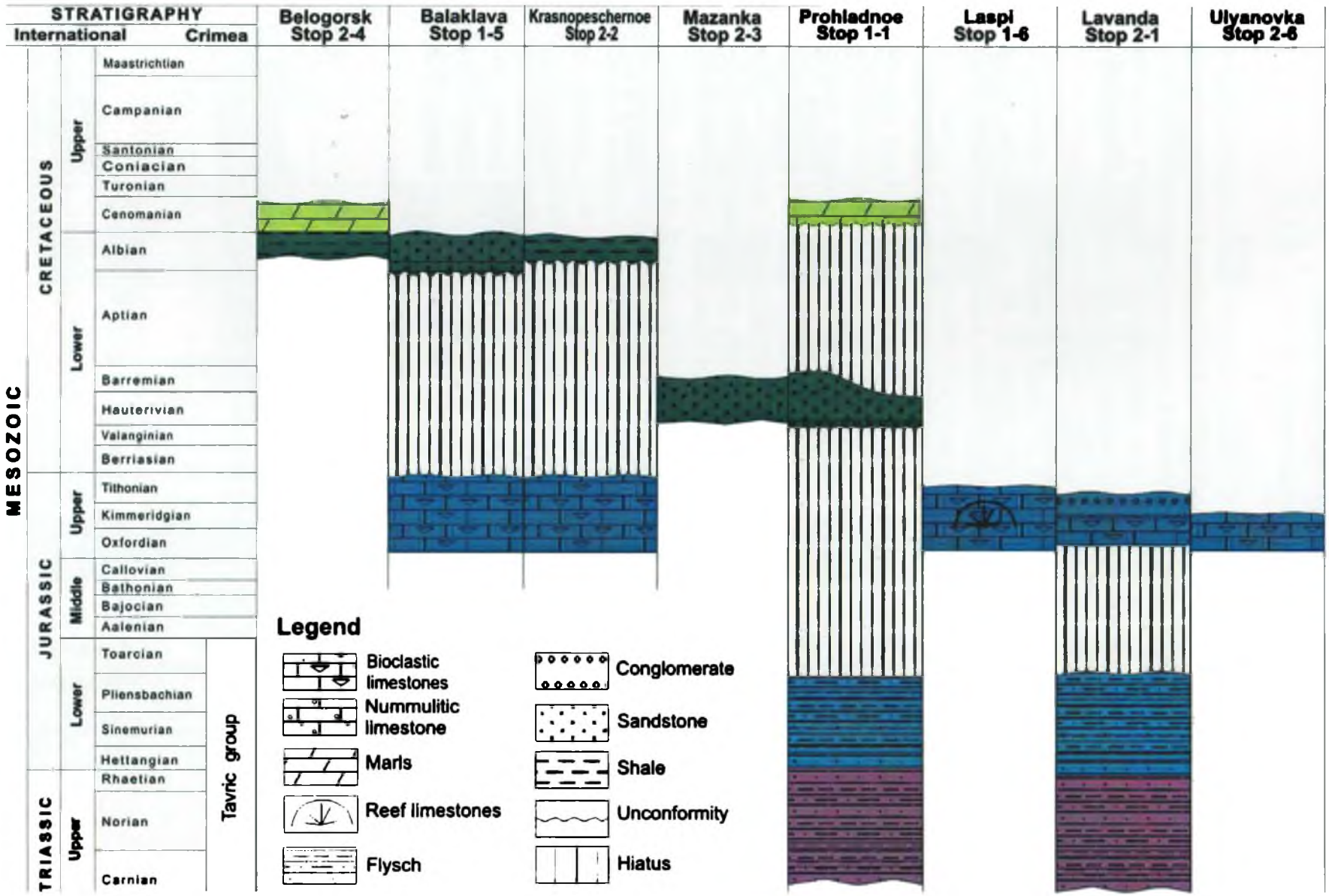


Figure 4. Mesozoic columns of outcrop sections of the field trip #1 (according to the common stratiphication)

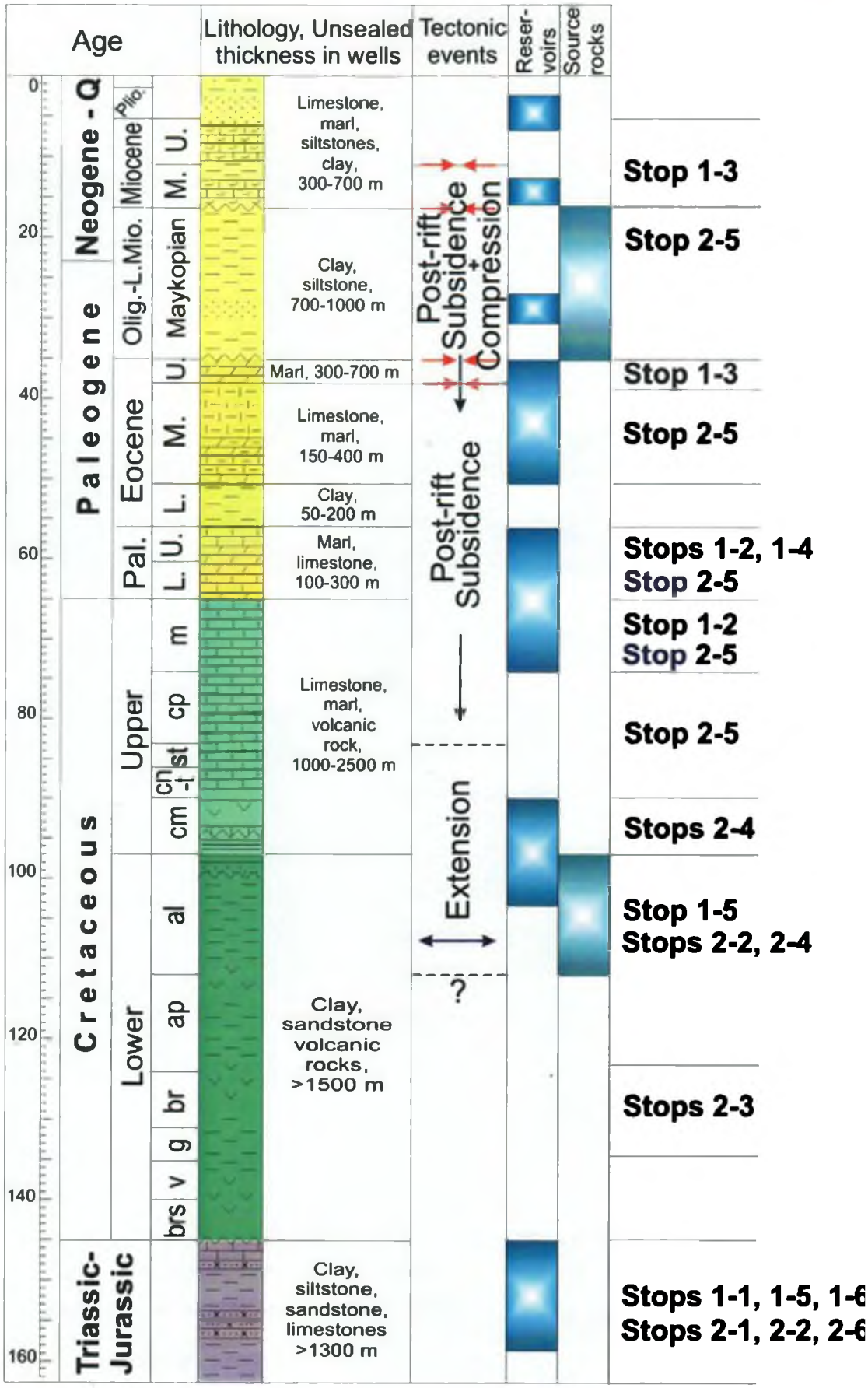


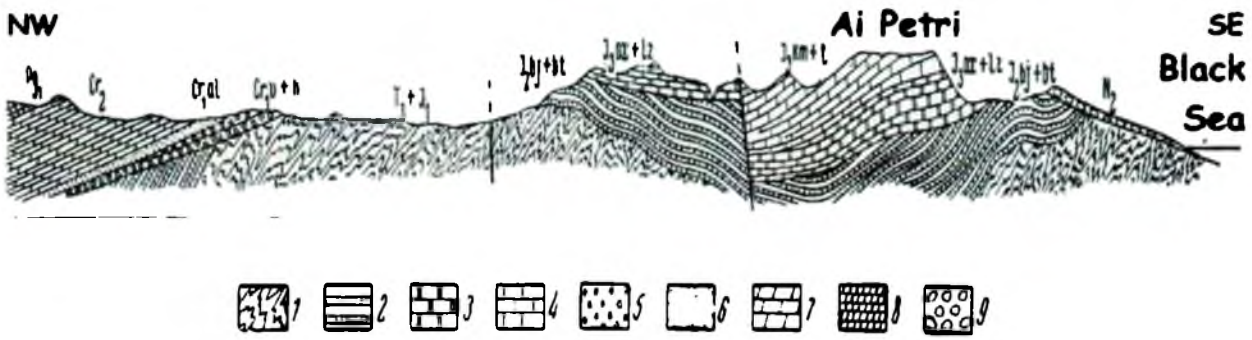
Figure 5. Lithostratigraphic column, tectonic events, play elements of the Black Sea region (*Khriachtchevskaia et al., 2009*) and their correspondence with stops of trip # 1

GENERAL NOTES

The Crimea Mountains hold keys for understanding of the Geology of the Ukrainian Black Sea and of the whole Black Sea region. The Crimea terrain is the most marine protruding land giving the unique possibilities to put fingers into the rocks deeply subsided offshore. In contrast to well known European Mountains like Alps or Pyrenees, or even relatively less known Carpathians, the Crimea Mountains remains almost unknown to the outside world first of all because of languages barriers retarded the scientific communications.

The geological study of Crimea Mountains lasts for more than century and half. The main progress was attained in the XX century with efforts of Geological Committee of Russia and after the First World War with different geological organizations of Soviet Union. The Golden Age of Crimea geology between the Second World War and 70-th of the last century was resulted in fundamental Geological Map of Crimea of 1 : 200 000 scale and the extended Geological Description of the Crimea, both edited by M. Muratov. The Geological Description of the Crimea was published in 1969 (*Muratov, et al., 1969*). The book generalized the knowledge of Crimea geology at classical, pre-plate tectonics period and till now it remains to serve as very valuable source of geological data (**Fig. 6**).

Despite of several attempts to modernize the structural model of the Crimea in thrust-style tectonics (*Kazantsev, 1982; Popadyuk and Smirnov, 1991, 1996; Yudin, 1993, 2001; Afanasenkov et al., 2007*) these models left, with some exceptions, the core of stratigraphy unchanged. Due to this the stratigraphy of the main sedimentary successions and magmatic rocks dating up to date are generally the same they were in 60-th of XX century. Recently because of a lot of controversies in post-classical models, new paleontological data inconsistent with previous ones and some observations allowing new interpretation of structural relationships it is impossible to present the consistent, comprehensive, well constrained model of the Crimea Mountains. The clarity of Golden Age of classical period is gone and now the Crimea geology is in hard time of accumulation of extended and improved with new techniques data for the better understanding of the nature of Crimea Mountains.



1 - Tavric group, 2 – Middle Jurassic, 3 – Oxfordian limestones, 4 – Tithonian limestones, 5 – Valanginian-Hauterivian, 6 – Upper Albian, 7 – Upper Cretaceous, 8 – Paleogene, 9 - Pliocene

Figure 6. Geological section across Crimea Mountains (from *Muratov et al., 1969*)

GENERAL DESCRIPTION OF THE FIELD TRIP

The field trip starts in Simferopol and proceeds to the south-west by the road Simferopol – Bakhchisaray along the Crimea Mountains foothills which display rather simple geology of monoclinally dipping to the north-north-west succession of Cretaceous and Tertiary rocks. In the Skalyste village we turn left to the south-east on the road to the Nauchnyi city, the location of Crimea astronomic observatory of National Academy of Science. From the village the road runs through the small canyon in Eocene and Paleocene limestones and further to the south-east it climbs to the Prohladnoe village through the gentle hills composed of Upper Cretaceous chalk. The first stop (Stop 1-1) is in Prohladnoe village. Here we can observe the relationships of strongly deformated Tavric flysch and nondeformated succession of younger rocks.

The second stop (Stop 1-2) will be in the outskirt of Bakhchisaray, the old Tatar city, located in the spectacular, narrow canyon. The canyon formed in Upper Cretaceous and covering them Paleocene rocks is the paradise for tourists, geologists, especially stratigraphers and carbonate sedimentologists. The third stop (Stop 1-3) is in the Verkhnesadovoye village where the Middle-Upper Miocene rocks unconformably overlay the Upper Eocene sediments. The Middle-Upper Miocene succession is very important as future promising target for deep water exploration in the Ukrainian Black Sea. The forth stop (Stop 1-4) will be in Inkerman, the suburb of Sevastopol, the main navy base in Ukraine. The Inkerman Paleocene exposure is the southernmost outcrop of Paleocene rocks at the monocline of Crimea foothills. The fifth stop (Stop 1-5) will be in the Zolotaya Balka valley oppositely to the Balaklava city. The small outcrop gives the possibility to study the grading of Albian volcanoclastics into Cenomanian marls and to observe the relationships of Upper Jurassic and Albian sequences that could be interpreted different way. The final for the first trip day stop (Stop 1-6) will be in the beautiful Laspi Harbor at the foothills of Kokiya Kaya Mountain, the Late Jurassic stromatoporoid-microbial patch reef. In contrast to relatively simple geology of Crimea monocline the last two stops give the room for controversial structural interpretations of main rock assemblages exposed along the Crimea seashore.

The second day trip starts in Yalta, the best known seaside resort in Crimea. From Yalta the route leads to the north-east to the Alushta city. Between Yalta and Alushta stretches the highest part of Crimea Mountains called Babugan Yayla. It is elevated about 1 500 m above sea level, its upper part of some 800 m is composed by Upper Jurassic shallow marine carbonates. The first stop of the second day (Stop 2-1) will be done in the Lavanda area located between the Chatyr Dag Plateau and Demerji Mountain. The location is very nice place giving the possibility to discuss some puzzling issues of structural relationships of Tavric Group, Upper Jurassic carbonates, and Demerji conglomerates of controversial age. The second stop (Stop 2-2) is located in the Angara River Valley where we can observe relationships between Upper Jurassic limestones of Karabi Yayla Plateau and Albian shales of Angara Valley. As in case of stop in the outskirts of Balaklava city (Stop 1-5) the relationships of these sequences could be controversial. The third stop (Stop 2-3) is in the Mazanka village at the small outcrops of Mazanka fm of Hauterivian – Barremian age. This section is very important for understanding of structural relationships of Upper Jurassic and Cretaceous successions. The forth stop (Stop 2-4) will be in Belogorsk city where we can observe the excellent outcrop of Albian shales which supposedly could be considered as source rocks. The fifth stop (Stop 2-5) is on the flattened top of Ak Kaya Plateau like Mountain where in one glance we can ketch the whole sedimentary succession of the Odessa Shelf. The last, sixth, stop (Stop 2-6) will be in Ulyanovka quarry where we can hummer rocks corresponding to those ones elevated above sea level of 1 500 m in the Babugan Yayla and probably subsided to more than 5 000 m below sea level at the Shatsky High in the Black Sea.

PETROLEUM SYSTEM ELEMENTS OF THE BLACK SEA – CRIMEA REGION

Reservoirs. Among hydrocarbon reservoirs the following ones are proved (**Fig. 5**):

- Upper Cretaceous (Maastrichtian) fractured limestones, which have an average porosity of 17% and contain gas/condensate accumulation of Shmidta field (**Fig. 7**);
- Paleocene and Middle-Upper Eocene limestones and marls, which have a porosity up to 14% and comprise gas/condensate and gas pools of Shmidta, Golitsyno, Shtormovoe, Odeskoe and Bezumyannoe fields;
- Maykopian (Oligocene – Lower Miocene) sandstones, which have a porosity up to 30% and contain gas pools of Golitsyno, Southern Golitsyno, Arkhangelskoe, Shmidta and Krymskoe fields
- Middle Miocene fractured limestones and marls, which have an average porosity of 15-30% and contain gas accumulation of Arkhangelskoe field.

Among potential and untested reservoirs the following can be identified:

- Upper Jurassic carbonate reefs and limestones with paleocarst voids and fractures are well-known in Crimea;
- Albian, Lower Cretaceous sandstones are main reservoirs of Romania's offshore and have given noncommercial gas flow from some offshore wells within the Odessa Shelf;
- Miocene-Pliocene sandstones of paleochannels and paleofans expected mainly within the deep water area.

Seals. The role of seals is playing by intraformational mudstones.

Source Rocks. Data from Romania, Georgia point out that Maykopian and Lower Cretaceous (Aptian-Albian) mudstones are the source rocks, although special investigations on the subject have not been done yet in Ukraine.

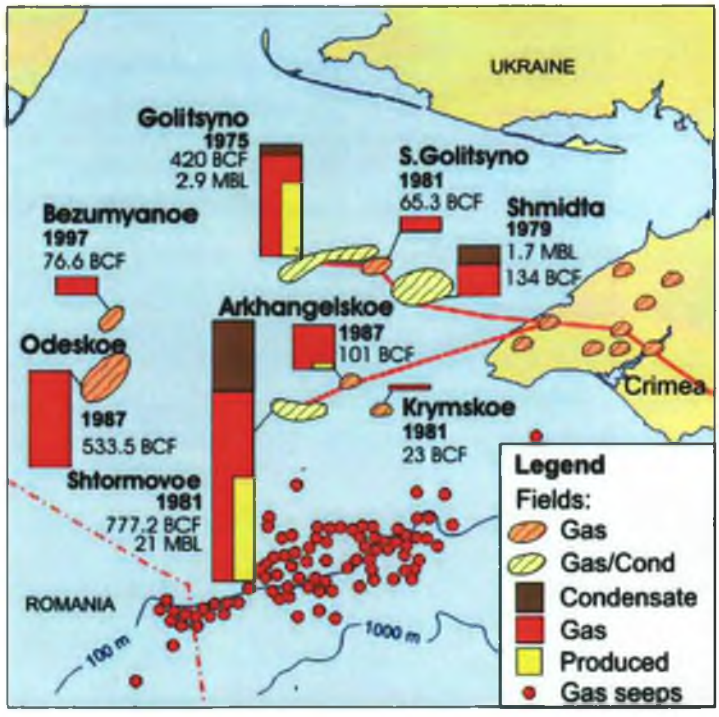


Figure 7. Discoveries of the Odessa Shelf *(Khriachtchevskaia et al., 2009)*

TRIP ROUTE #1

15th, October, Friday

Trip route #1 (187 km):
Simferopol
– Prohladnoe (~30 km)
– Bakhchisaray (~25 km)
– Verhnesadovoe (~20 km)
– Inkerman (~17 km)
– Balaklava (~16 km)
– Laspy Bay (~29 km)
– Yalta (~50 km).

Figure 8. Location of stops of the field trip route # 1

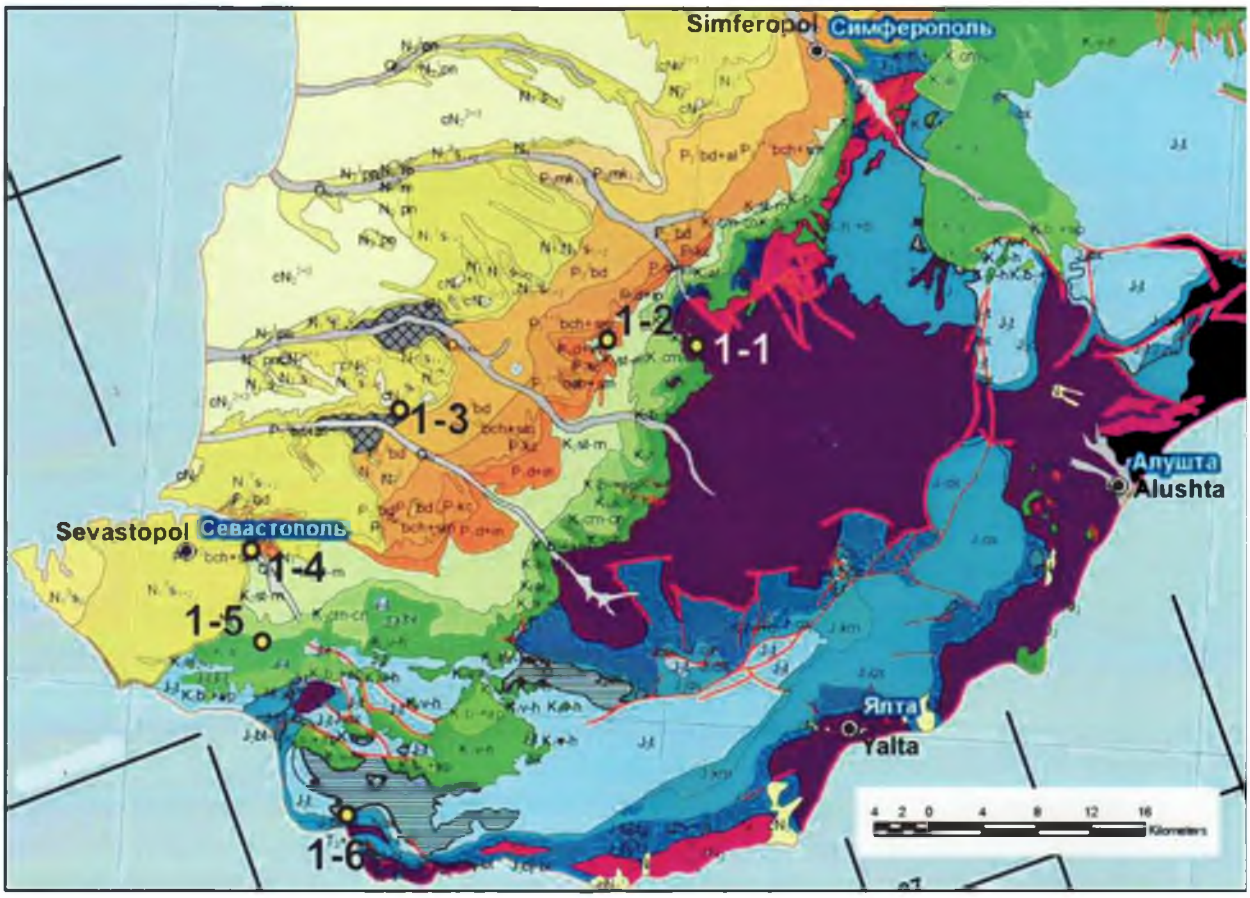
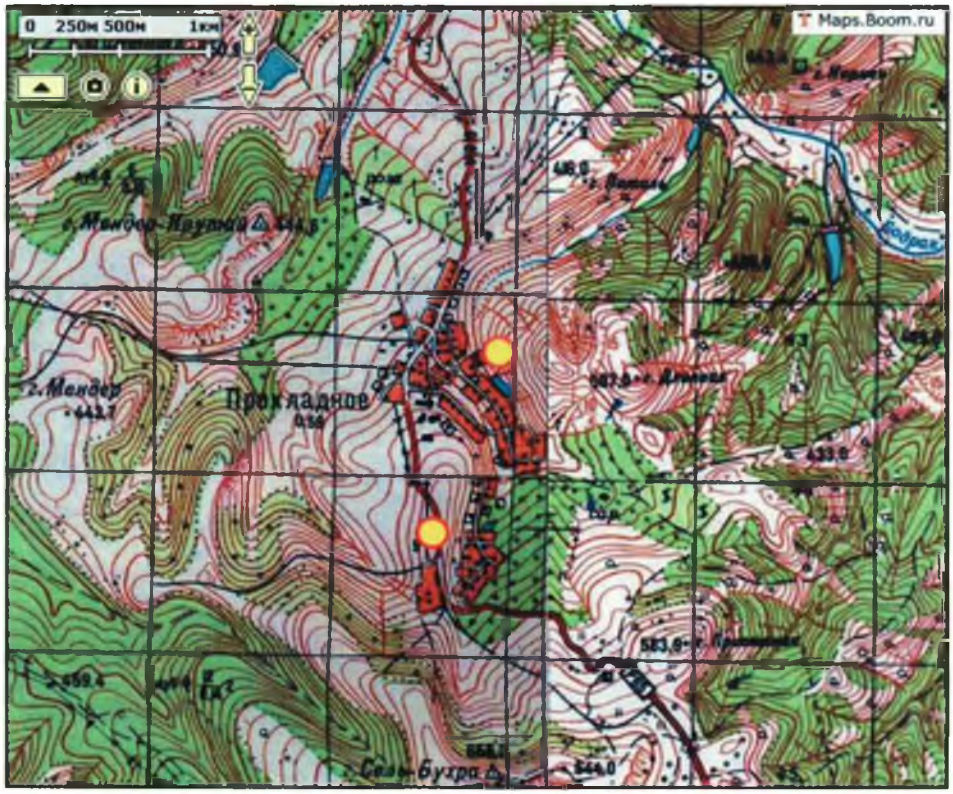


Figure 9. The fragment of Geological map (from *Muratov et al., 1969*), field trip route # 1

Stop 1-1. Prohladnoe outcrop

- Tavric Group (Up. Triassic – L. Jurassic) disconformably overlain by Valanginian-Hauterivian succession

Stop 1-1(1) – N 44°44´50.39˝ E 33°59´31.12˝
Stop 1-1(2) – N 44°45´28.13˝ E 33°59´45.51˝



Location of Stop 1-1 on the base of topographic map

Location of Stops 1-1(1) and 1-1(2) on the base of satellite map (from Google resource)

The Tavric Group comprises a thick dark coloured succession of rhythmically bedded sandstones, siltstones and shales with locally occurred packages of siliciclastic rocks containing exotic blocks.

Due to rhythmical architecture of the Tavric succession in Russian and Ukrainian literature it is often called Tavric flysch.

The Tavric Group is widely exposed in the Crimea Mountains from the Laspi Harbour at the west to the Kara Dag volcanic massif at the east. Tavric Group is strongly deformated and in the vicinity of Prohladnoye village it is disconformably overlain with undeformated succession of Cretaceous and Tertiary rocks at the base with the succession dated as Valanginian-Hauterivian (**Figs. 1-1-1, 1-1-3, 1-1-4,** *Muratov et al., 1969*).

The underlying rocks and the thickness of the Tavric Group are unknown. Three deep wells drilled in the area of Tavric group occurrence were abandoned in Tavric succession at depths as follows: Yalta well at 2.250 m, Kacha #1 well at 2.299 m, Kacha #2 well at 4.032 m.

Since 1901 when K. Vogdt established "Tavric beds" in the neighborhoods of Simferopol city the Tauric Group is commonly dated as Late Triassic – Early Jurassic (Liassic). Fauna remnants are generally rare and often derived from exotic blocks or siderites nodules. The exotic blocks of Carboniferous and Early Permian limestones were reported not far from Trudolubovka village to the north-west of Prohladnoye village (*Muratov et al., 1969*). Besides the Late Triassic and Liassic fauna remnants the Cretaceous (Barremian – Aptian) *Ammonites* were found in exotic limestone blocks in Tavric Group from the vicinity of Simferopol (*Degtyareva et al., 1978).* The latter in fact allows making supposition that Tavric Group is younger than it is commonly accepted, and probably is of Aptian-Albian age (?). However if Tavric Group is Aptian-Albian in age the commonly accepted dating of the overlaying succession became confusing, because the rocks covering Tauric Group occurred older than sub cropping staff.

Fig. 1-1-5 illustrates a new interpretation of geology of the Prohladnoye locality. According to the model Tavric Group of Aptian-Albian age was folded, uplifted and eroded before the Latest Albian. The erosional lows in Tavric folded assemblage were filled with Latest Albian deltaic sediments that were completely buried under the Cenomanian rocks. The interpretation suggested for the case supposes beside the younger age of Tavric Group also the younger age (Cenomanian vs. Valanginian-Hauterivian) of its covering succession.

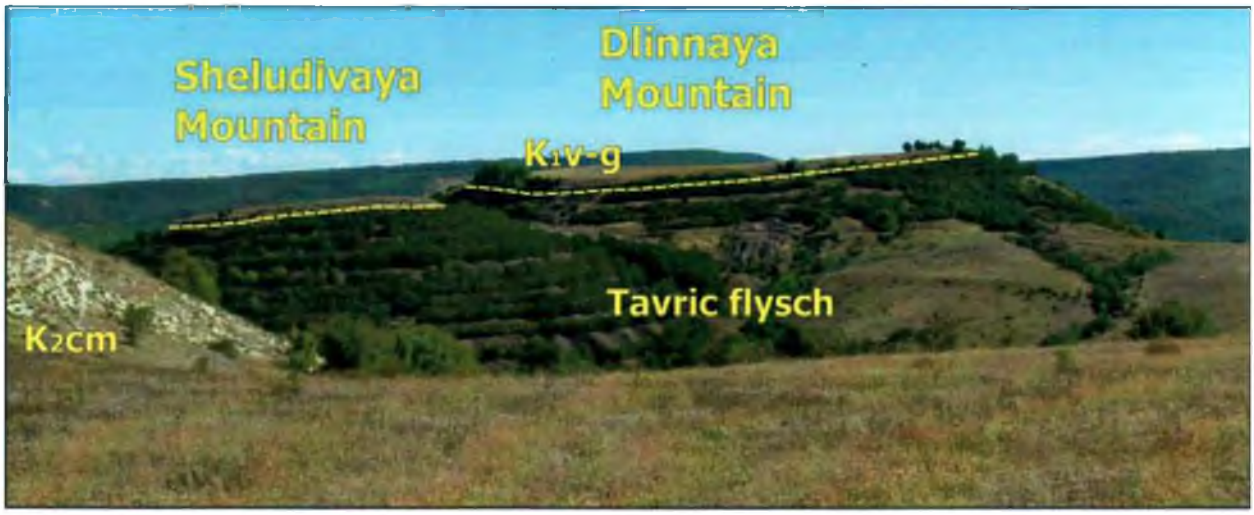


Fig. 1-1-1 – Panoramic view of Sheludivaya and Dlinnaya Mountains from the Moscow State University Camp, Stop 1-1(1)

Fig. 1-1-2 – Cenomanian bioclastic limestones and marls beneath the road near the Moscow State University Camp, Stop 1-1(1)

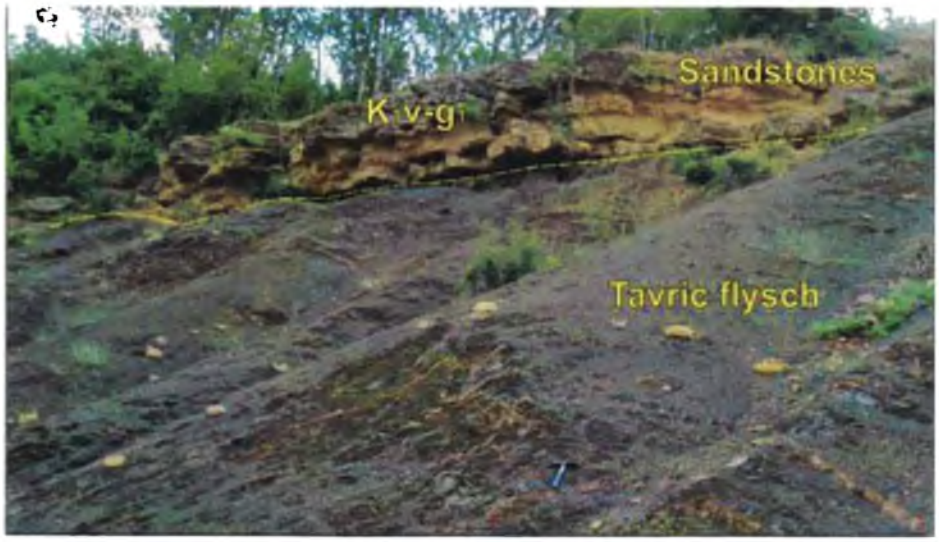


Fig. 1-1-3 – The unconformable boundary between Tavric flysch and younger sandstones, Stop 1-1(2)

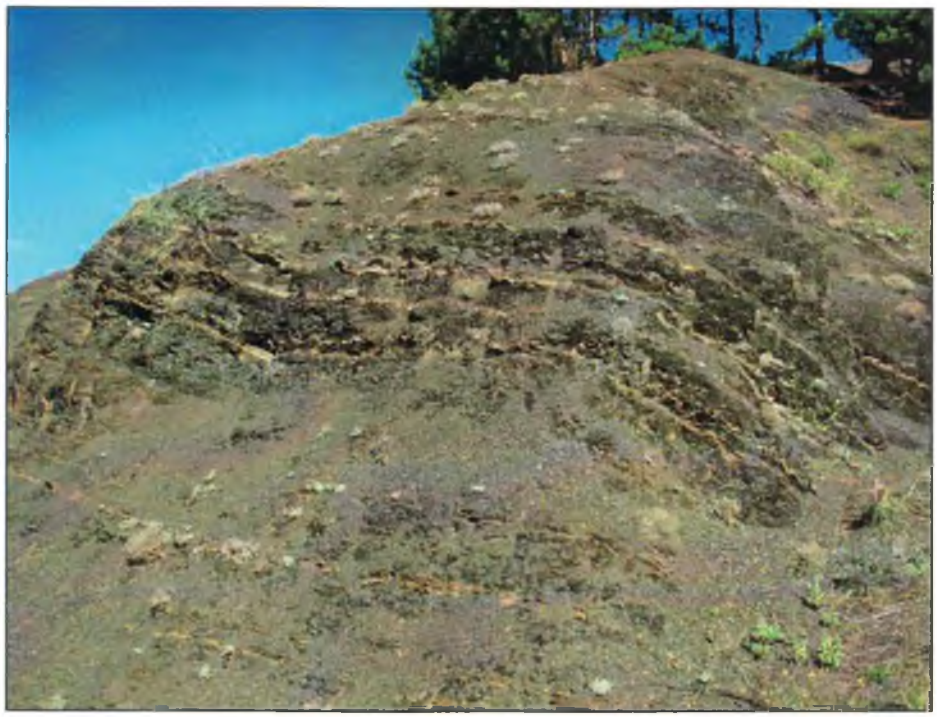


Fig. 1-1-4 – Tavric group, Stop 1-1(2)

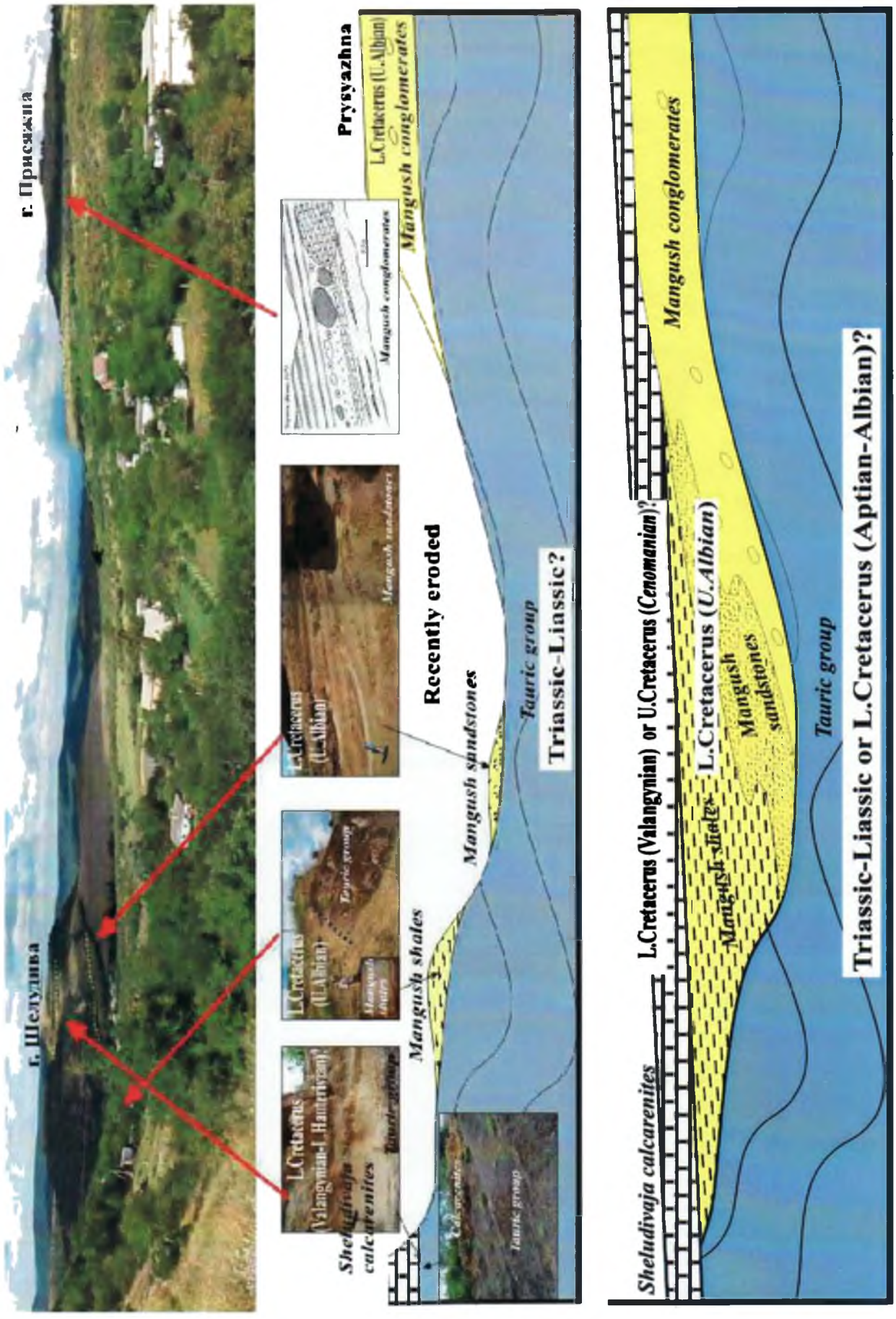
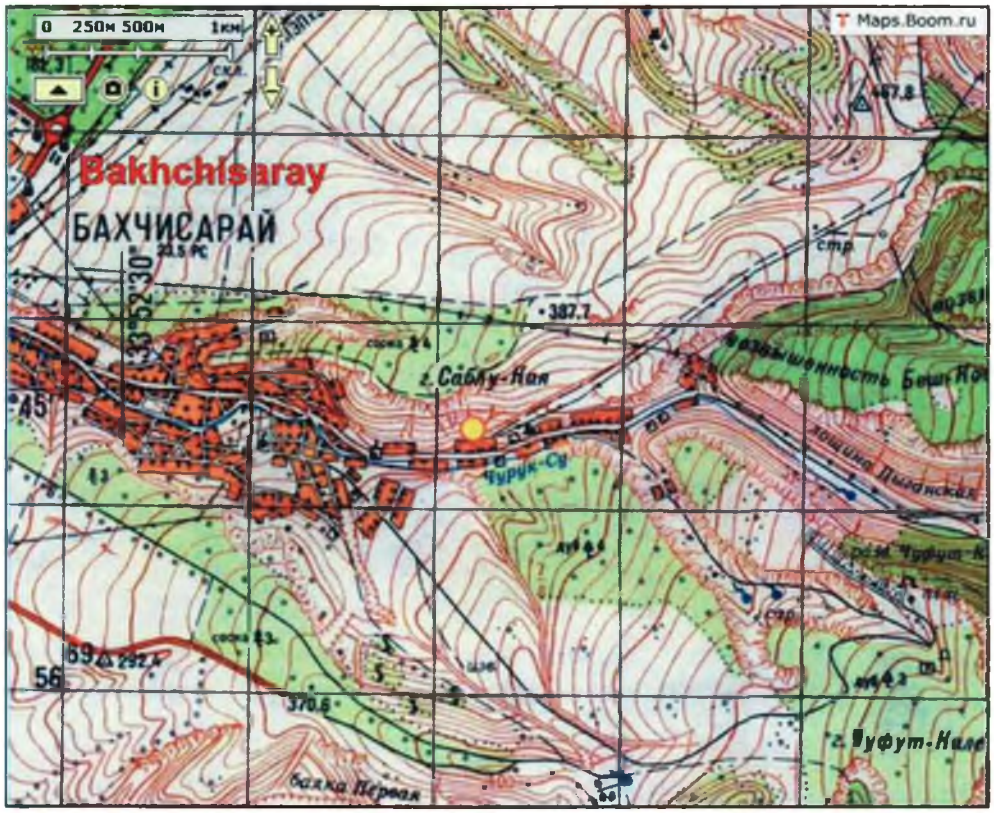


Fig. 1-1-5 – Schematic section of Prohladnoe area showing the relationship of main stratigraphic units

Stop 1-2. Bakhchisaray outcrops

– Maastrichtian, Lower Paleocene

Stop 1-2 – N 44°44´59.34˝ E 33°54´43.09˝



Location of Stop 1-2 on the base of topographic map

Location of Stop 1-2 on the base of satellite map (from Google resource)

The stop locality is situated at the eastern suburb of the Backchisaray city in the spectacular place of canyons junction (**Figs. 1-2-1, 1-2-2, 1-2-3**).

In the vicinity of Bakhchisaray the thickest, more than 100 m, succession of Paleocene and Eocene shallow marine sediments is accessible for study in many locations. The uppermost part of Maastrichtian and lower part of Early Paleocene is demonstrated. The section begins with about 15 m thick unit of Maastrichtian marls. These sediments are overlain by about 10 m thick massive bedded rather monotonous bioclastic limestones containing fragments of bryozoans, crinoids, molluscs, oysters, serpulides, and crab claws. The limestones are partly recristallized. This unit gradually passes upward into medium to thick bedded bioclastic and foraminiferal limestones with interbeds of bioclastic limestones composed mostly of fragments of mollusc shells. Besides the molluscs the fragments of colonial and single corrals, bryozoans, echinoids are also common.

The contact between Maastrichtian marls and Paleocene limestones looks like continuous despite of evidently different lithology of units (**Fig. 1-2-4, 1-2-5**).

The demonstrated section is very important for petroleum geology because the Lower Paleocene deposits are the main reservoir rocks at the gas condensate fields in Crimea (Glibivskie, Karlavskie) and the Odessa Shelf (Golitsynske, Shtormove, Shmidtivske, Odeske). The porosity of Paleocene reservoir rocks ranges from 23 to 30%. Permeability ranges from 1 to 10 mD, microfracturing improves permeability up to 80-100 mD.

The reservoir rocks of Maastrichtian succession produce gas in the Shtormove field in the Odessa Shelf. Open porosity varies from <1 to 22%, permeability ranges from <1 to 860mD.

Fig. 1-2-1 – The view of Sablu Kaya Mountain at the eastern outskirts of Bakhchsaray city

Fig. 1-2-2 – The boundary of Paleocene limestones and Maastrichtian marls

Fig. 1-2-3 – The view of Beshkosh Mountain at the eastern outskirts of Bakhchsaray city

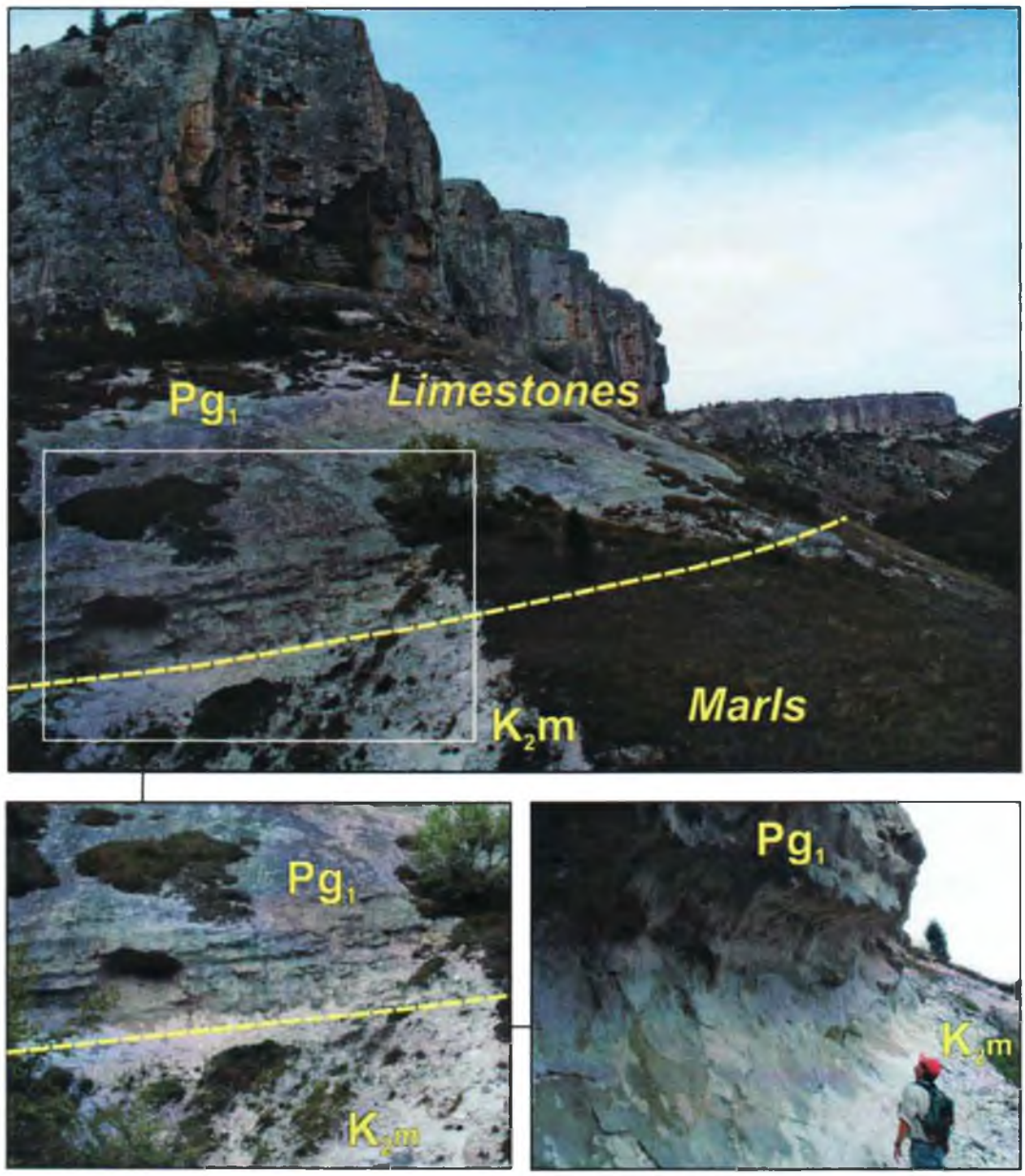


Fig. 1-2-4 – The contact of Paleocene organogenic limestones and Upper Cretaceous, Maastrichtian marls (eastern outskirts of Bakhchsaray city)

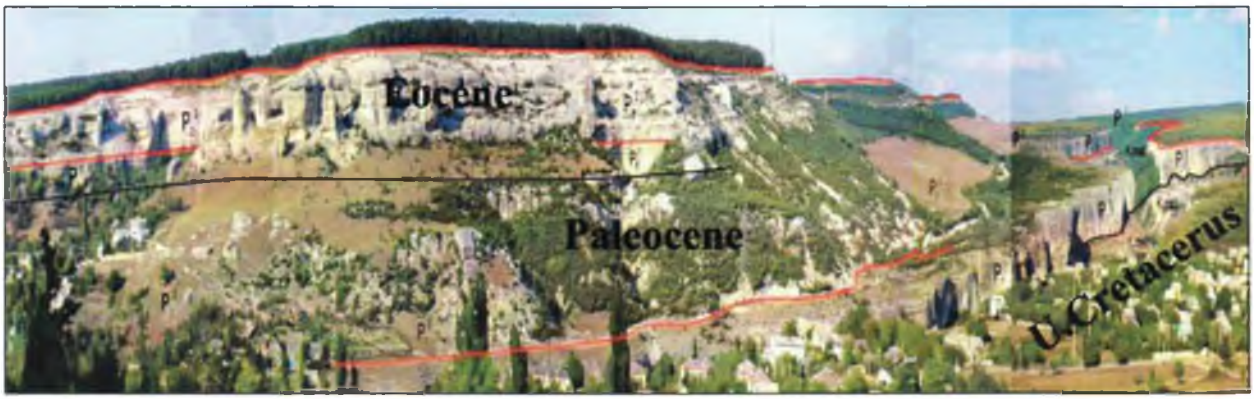


Fig. 1-2-5 – Panoramic view of Eocene-Paleocene-Upper Cretaceous succession at Bakhchsaray area

Stop 1-3. Verhnesadovoe area

– Upper Eocene / Miocene angular unconformity, Middle-Upper Miocene section

Stop 1-3 – N 44°41´44.60˝ E 33°42´28.70˝

Location of Stop 1-3 on the base of topographic map

Location of Stop 1-3 on the base of satellite map (from Google resource)

The outcrop is located at the outskirt of Verhnesadovoe village, some 20 km to the south-west of Bakhchisaray city. The village is surrounded from the north and south by the outcrops of Upper Eocene light coloured marls unconformably overlain by Middle (?) to Upper Miocene (Sarmatian ?) succession (**Fig. 1-3-1, 1-3-2, 1-3-3**).

The Miocene section begins with sandstones grading upward into 50 m succession of bioclastic light-grey, yellowish limestones (packstones, grainstones), hummocky stratificated calcarenites, occasionally matrix supported microconglomerates with well rounded gravels of milky-white quartz.

This shallow marine succession is very important for petroleum geology because the Middle Miocene deposits are the reservoir rocks at the gas field Arkhangelske in the Odessa shelf, small oil fields in the Kerch Peninsula in Crimea (Preozerne, Voikivske, Borzivske, Semenivske, Aktaske). The porosity of Miocene reservoir rocks ranges porosity 18-30%, permeability from 5 to 2000 mD. The Middle-Upper Miocene reservoir rocks supposedly could be of primary significance reservoir in some structures in the deep water Ukrainian Black Sea.

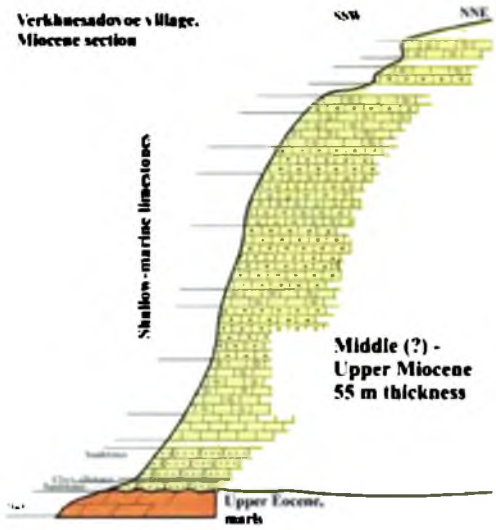


Fig. 1-3-1 – Eocene / Miocene unconformity, lithological section (*by courtesy of A.Nikishin*)

Fig. 1-3-2 – Unconformity between the Upper Eocene marls and Middle (?) and Upper Miocene (Sarmatian ?) limestones (to the south of Verknesadovoe village)

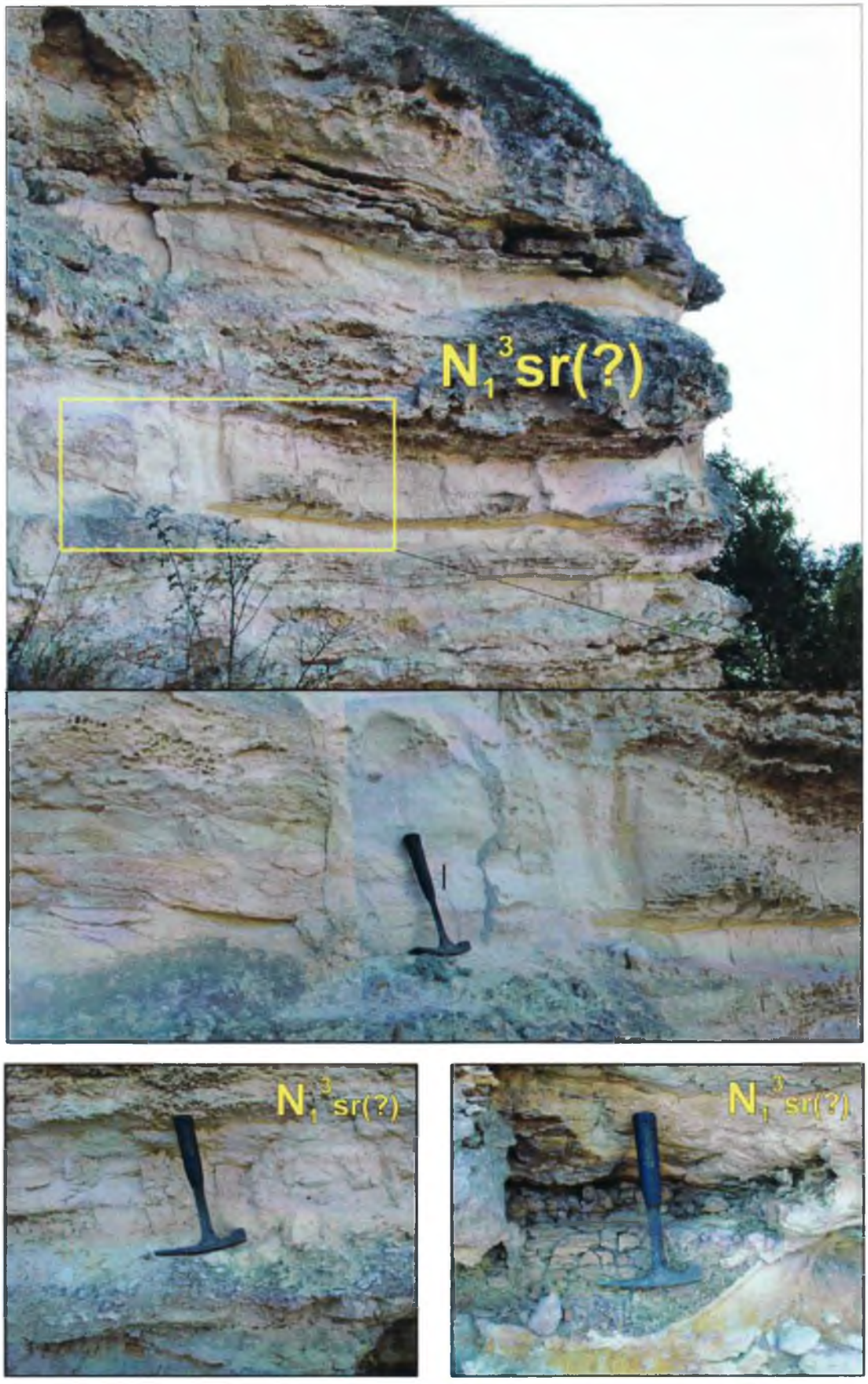


Fig. 1-3-3 – Upper Miocene (Sarmatian ?) bioclastic limestones

Stop 1-4. Inkerman outcrop

– Maastrichtian / Paleocene

Stop 1-4 – N 44°35´12.60˝ E 33°36´39.70˝

Location of Stop 1-4 on the base of topographic map

Location of Stop 1-4 on the base of satellite map (from Google resource)

The stop locality is situated at the north-eastern (Inkerman) suburb of the Sevastopol. The upper part of Upper Cretaceous (Campanian – Maastrichtian) and Lower Paleocene sediments outcrop in the foothills of so called Mackenzie highlands (e.g. Kira Koba Mountain, **Fig. 1-4-1**). The Maastrichtian marls are overlain by about 10 m thick massive bedded monotonous bioclastic limestones gradually passes upward into medium to thick bedded bioclastic and foraminiferal limestones with interbeds of bioclastic limestones composed mostly of fragments of mollusc shells.

The contact between Maastrichtian marls and Paleocene limestones is conformable (**Fig. 1-4-2**). The exposed section corresponds to the Bakhchisaray section located at stop 1-2 at the distance of 28 km demonstrating very similar sedimentary environments at the sedimentary basin during the Latest Cretaceous and Early Paleocene across wide areas.

Fig. 1-4-1 – Panoramic view at Kira Koba Mountain

Fig. 1-4-2 – The boundary between Paleocene limestones and Maastrichtian marls at Kira Koba Mountain

Stop 1-5. Balaklava area

– Upper Jurassic, Albian

Stop 1-5 – N 44°31´59.20˝ E 33°36´56.40˝

Location of Stop 1-5 on the base of topographic map

Location of Stop 1-5 on the base of satellite map (from Google resource)

The stop is located 1,7 km to the north of Balaklava city close to the bridge over rail-road Simferopol – Balaklava. In the small outcrop the uppermost part of Albian and lowermost part of Cenomanian are accessible for observations (**Fig. 1-5-1**). The total length of expose is about 30 m. The exposed section begins with 4,5 m of massive volcanoclastics containing litoclasts and fragments of volcanic rocks (**Fig. 1-5-2**). These unit passes upward into clearly bedded medium to coarse grained volcanoclastic sandstones in turn grading into succession of interbedded fine grained sandstones and marls of Albian age. The lowermost part of Cenomanian is cropped out close to the bridge and is composed by marls. The contact between Albian and Cenomanian most likely is conformable.

Fig. 1-5-1 – View of Albian volcanoclastic sandstones

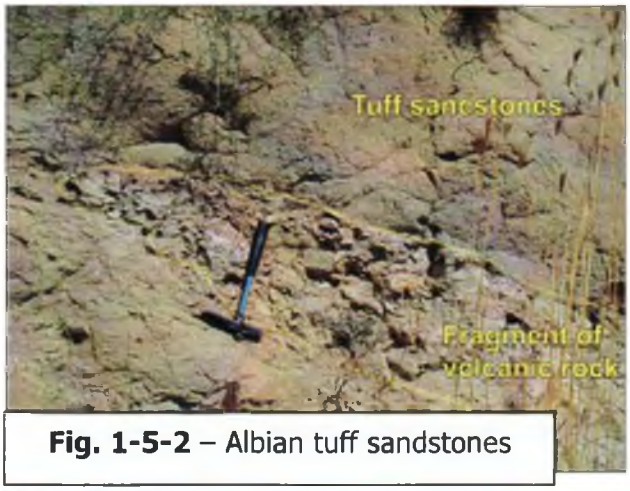


Fig. 1-5-2 – Albian tuff sandstones

From the stop location it is possible to view an excellent panorama on the Zolotaya Balka Valley and located in it Balaklava city (**Fig. 1-5-3**). The southern bank of the valley is composed of Upper Jurassic limestones in some places unconfomably overlain by Albian shales which most likely filled the erosional lows in the carbonate assemblage. The Upper Jurassic massif is probably thrusted over autochthonous Albian extended over the central part of the Zolotaya Balka Valley.

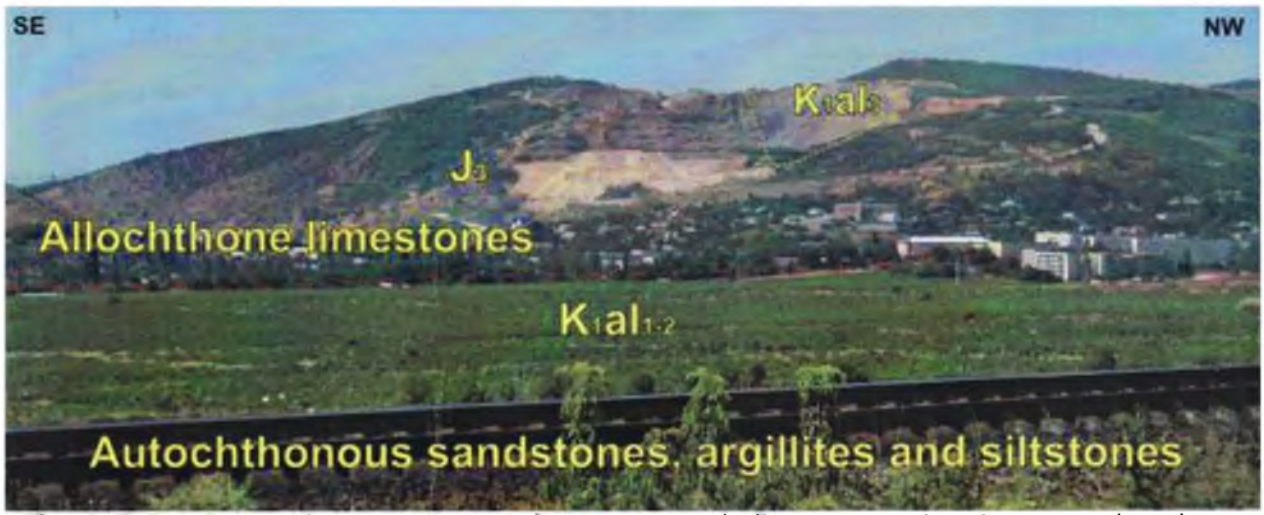
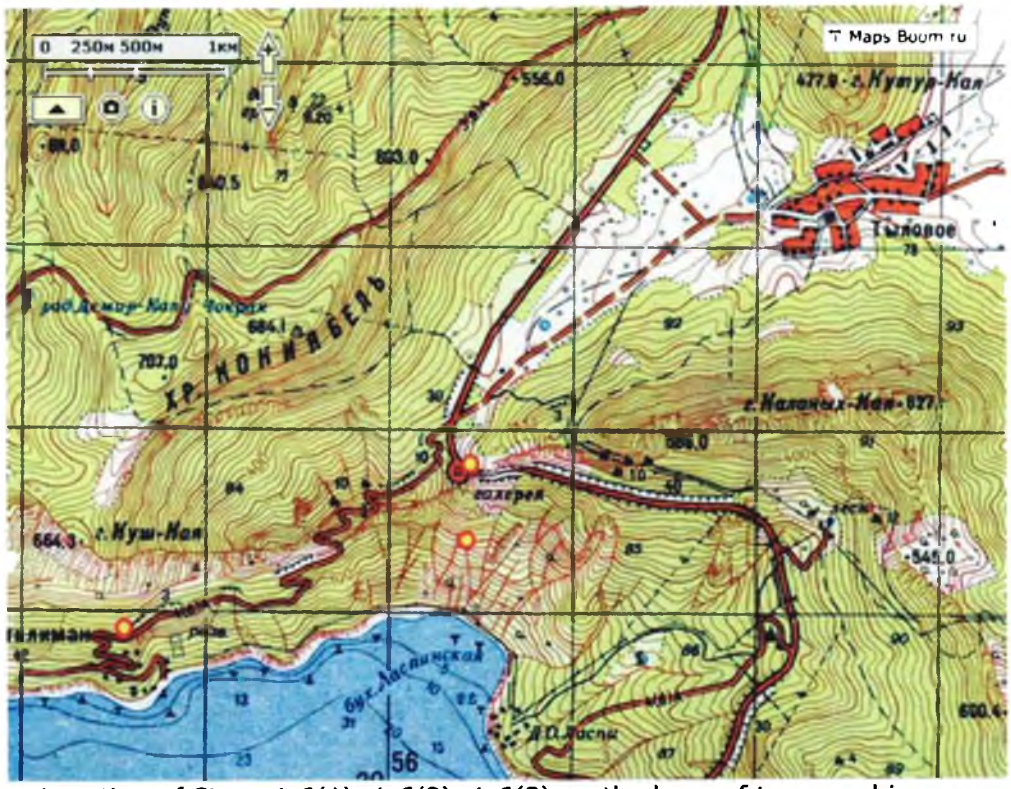


Fig. 1-5-3 – Contact between Jurassic limestones and Albian succession, interpreted as thrust

Stop 1-6. Laspi Harbor

- Upper Jurassic

Stop 1-6(1) – N 44°25´43.50˝ E 33°42´25.80˝
Stop 1-6(2) – N 44°25´33.00˝ E 33°42´16.40˝
Stop 1-6(3) – N 44°25´13.60˝ E 33°40´56.00˝



Location of Stops 1-6(1), 1-6(2), 1-6(3) on the base of topographic map

Location of Stops 1-6(1), 1-6(2), 1-6(3) on the base of satellite map (from Google resource)

The Laspi Harbor is located at the southern Crimea sea shore between the Aya Cape and the Sarych Cape. The bay is surrounded by picturesque rocky chains elevated to more than 600 m above the sea. The stop is located at the foot of Kokiya Kaya Mountain shutting the Laspi Harbor from the North West.

The central part of the Kokiya Kaya Mountain (Kokiya Kaya and Kush Kaya Mountains) is composed by massive limestones laterally passing into bedded limestones (**Figs. 1-6-1 – 1-6-5**). The massive limestones are relatively homogenous and strongly cemented and due to this the outcrop of massive limestones appears as almost vertical wall inaccessible for study without climber's equipment (**Fig. 1-6-5**). The lithological assemblages exposed in the Kokiya Kaya Mountain are common on the span from Laspi bay to Ay Petry Mountain in the vicinity of Yalta city. This part of hardly accessible Crimea Mountains known as Kastropol Wall is almost continuous assemblage of massive and bedded megafacies of Late Jurassic carbonates. Recent study of Ay Petry massive revealed that massive limestones constitute the stromatoporoid-microbial patch reef of Tithonian-Berriassian age (*Krajewski, 2008*). Bedded limestones surrounding the patch reef are represented by different bioclastic limestones (wackstones, packstones, floatstones, grainstones). Main components of bedded limestones are various bioclasts, mainly fragments of stromatoporoids, algae, corals, gastropods, bivalves, foraminifers (*Krajewski, 2008*).

The carbonate reef-and-bedded limestone succession in the Laspi Harbor is subcropped by strongly deformated Tavric Group. The contact between these thick rock assemblages is not exposed despite of relatively good expose of the area. Most likely the Upper Jurassic is thrusted over Tavric Group.

Fig. 1-6-1 – Panoramic view at Upper Jurassic limestones of Kalanyh Kaya Mountain, Stop 1-6(1)

Fig. 1-6-2 – Upper Jurassic patch reef, Stop 1-6(2)

Fig. 1-6-3 – Kokiya Kaya and Kush Kaya Mountains, Stop 1-6(2)

Fig. 1-6-4 – View at Upper Jurassic limestones of Kush Kaya Mountain, Stop 1-6(3)

Fig. 1-6-5 – View at Upper Jurassic limestones of Kush Kaya Mountain, Stop 1-6(3)

TRIP ROUTE # 2.

16th, October, Sunday

Trip route #2 (222 km):
Yalta
– Lavanda (~46 km)
– Krasnopeschernoe (~15 km)
– Mazanka (~45 km)
– Belogorsk (~30 km)
– Ak Kaya (~14 km)
– Ulyanovka (~23 km)
– Simferopol (~49 km).

Figure 10. Location of stops of the field trip route #2

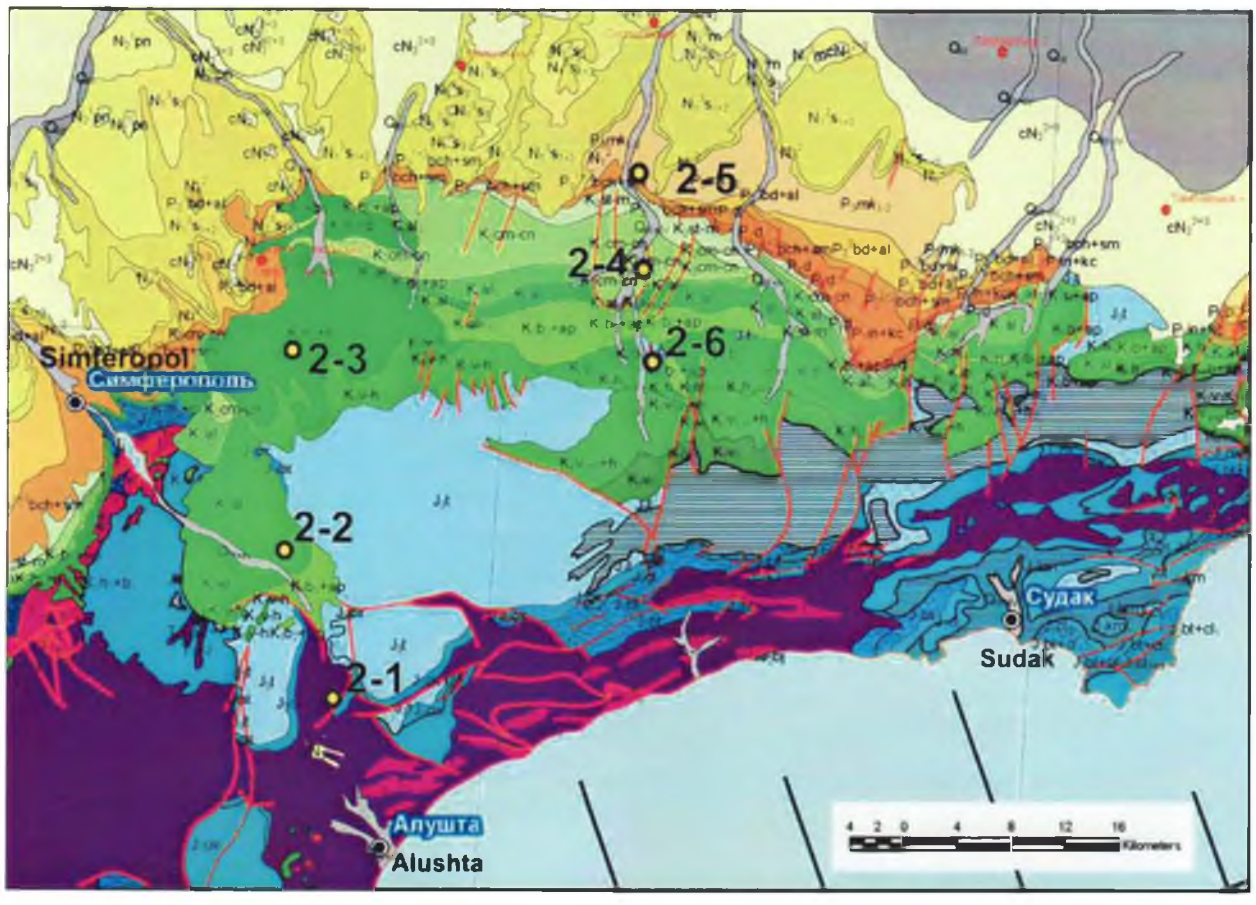
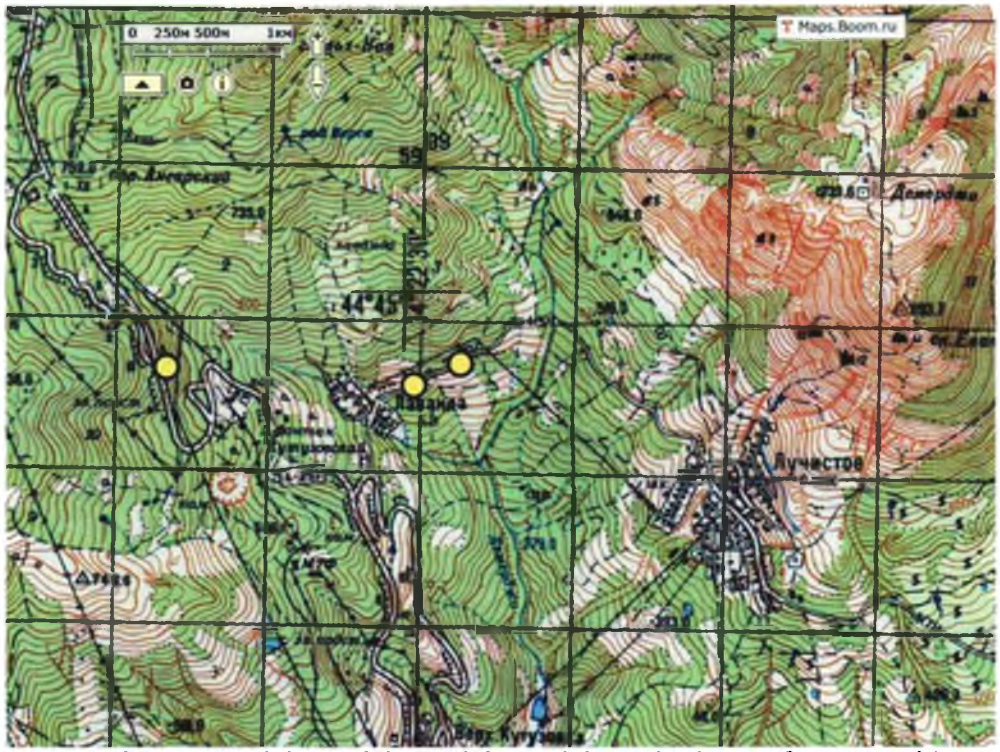


Figure 11. The fragment of Geological map (after *Muratov et al., 1969*), field trip route #2

Stop 2-1. Lavanda area

– Upper Jurassic of Demerdji and Chatyr-Dag Mountains, Tavric flysch

Stop 2-1(1) – N 44°44´42.70˝ E 34°22´35.80˝
Stop 2-1(2) – N 44°44´38.60˝ E 34°22´31.10˝
Stop 2-1(3) – N 44°44´42.50˝ E 34°21´11.50˝
Stop 2-1(4) – N 44°46´08.80˝ E 34°20´31.96



Location of Stops 2-1(1), 2-1(2), 2-1(3), 2-1(4) on the base of topographic map

Location of Stops 2-1(1), 2-1(2), 2-1(3), 2-1(4) on the base of satellite map (from Google resource)

The area is located between the Chatyr Dag Plateau (**Fig. 2-1-4**) and Demerdji Mountain (**Fig. 2-1-1**).

The Chatyr Dag is a small isolated plateau composed of Upper Jurassic (Tithonian) thick to thin bedded shallow marine limestones. In the south-western part of Chatyr Dag Plateau Tithonian carbonates rest directly upon the deformed Tavric Group where as from the west and east the Plateau is rimmed with the thick conglomerates dated commonly as Oxfordian. These conglomerates are well exposed at the southern slope of Demerdji Mountain. The thickness of the Demerdji conglomerates (**Fig. 2-1-2**) is measured as about 1.450 m (*Muratov et. al., 1969*). The conglomerates overlay the eroded Tavric flysch and are composed of fragments of rocks of local provenance).

At the stop locality the Tavric Group is composed of thin to medium bedded shales, silts and sandstones. The succession is strongly folded and faulted (**Figs. 2-1-3, 2-1-5**).

Fig. 2-1-1 – Panoramic view of Demerdji Mountain (Upper Jurassic ? conglomerates), Stop 2-1(1)

Fig. 2-1-2 – Conglomerates of Demerdji Mountain (*photo by courtesy of A.Nikishin*)

Fig. 2-1-3 – Faulted Upper Triassic – Lower Jurassic (Tavric) flysch, Stop 2-1(2)

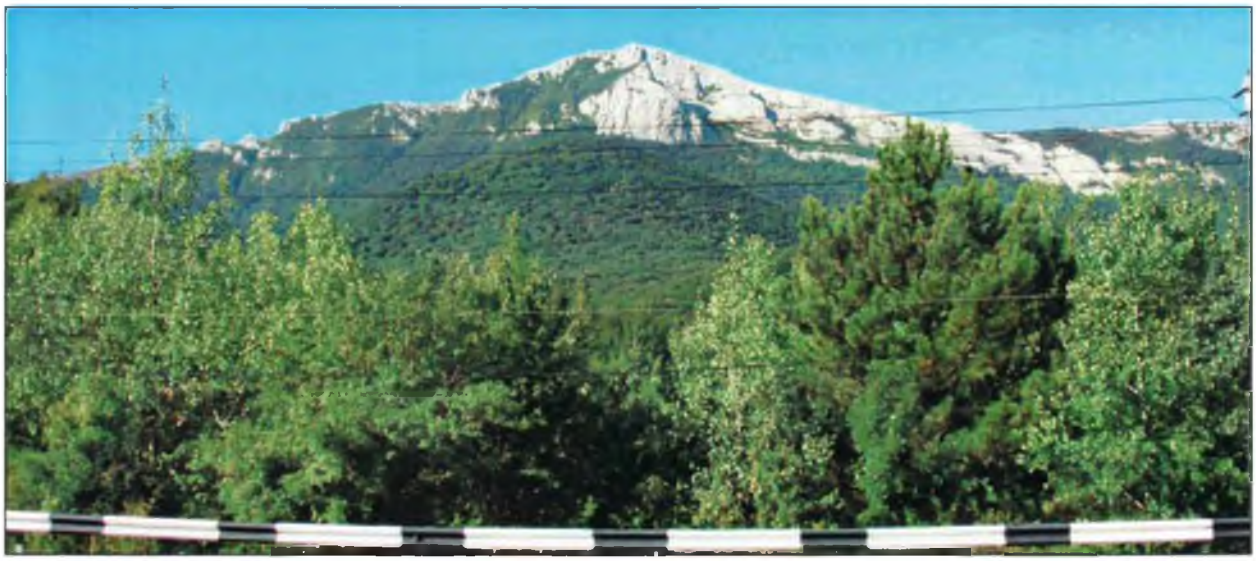


Fig. 2-1-4 – Panoramic view of Chatyr Dag Mountain (Upper Jurassic limestones), Stop 2-1(3)

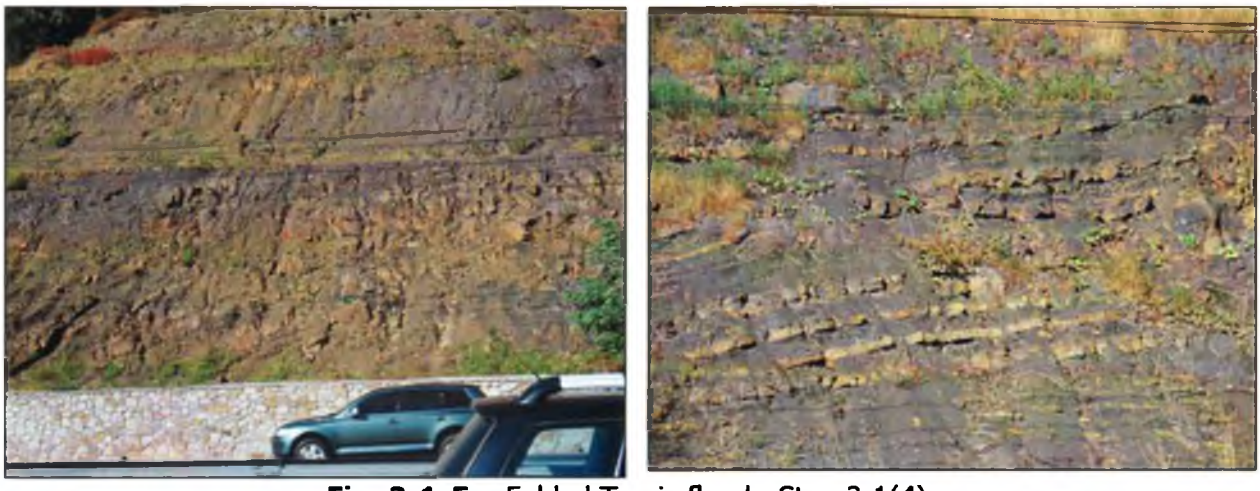


Fig. 2-1-5 – Folded Tavric flysch, Stop 2-1(4)

Stop 2-2. Krasnopeschernoe

- Upper Jurassic, Albian

Stop 2-2 – N 44°51´35.50˝ E 34°19´46.90˝

Location of Stop 2-2 on the base of topographic map

Location of Stop 2-2 on the base of satellite map (from Google resource)

The area is located to the south-east of Simferopol at the Valley of Angara River. The valley is rimmed from the east by foothills of Karabi Yayla Plateau which is composed of thin to thick bedded Tithonian limestones (**Figs. 2-2-1, 2-2-2**). Albian dark grey shales with siderites nodules are exposed from place to place in the central part of the Angara River Valley, mostly along its eastern tributaries (**Fig. 2-2-3**). The contact between topographically higher outcropped Upper Jurassic succession and Albian shales is not exposed. Supposedly Upper Jurassic carbonates are thrusted over Albian shales along the almost flat, slightly tilted to the north detachment.

Fig. 2-2-1 – Panoramic view at Karabi Yayla Plateau

Fig. 2-2-2 – The contact of Upper Jurassic limestones and Albian shales

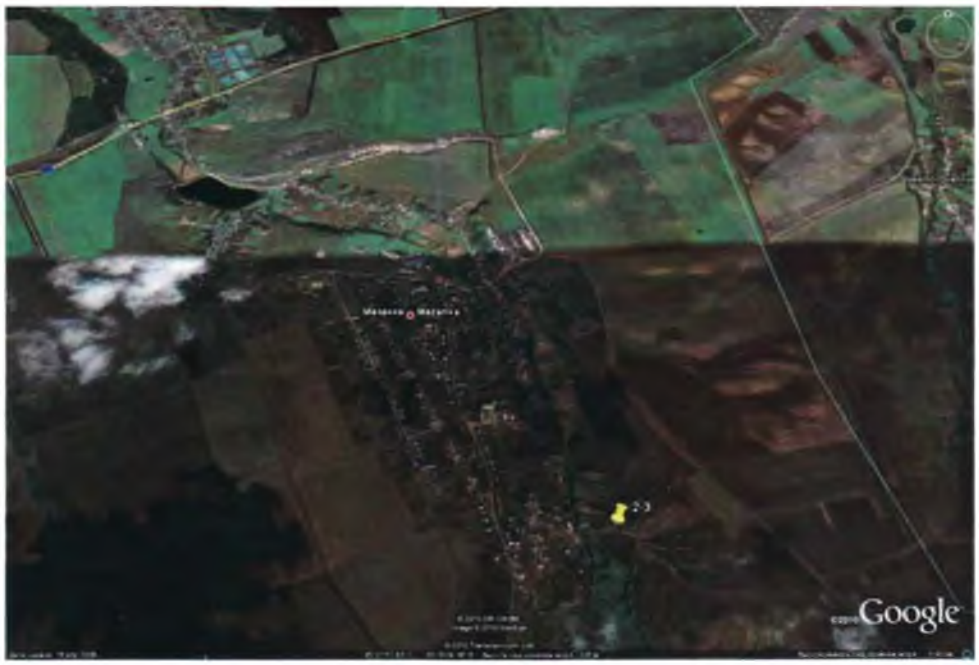
Fig. 2-2-3 – Albian shales

Stop 2-3. Mazanka area

– Hauterivian-Barremian (?) sandstones

Stop 2-3 – N 44°59´36.44" E 34°15´49.84"

Location of Stop 2-3 on the base of topographic map



Location of Stop 2-3 on the base of satellite map (from Google resource)

Between the Mazanka and Soloviovka villages located to the south from the road Simferopol - Belogorsk the Mazanka Formation is exposed in some small outcrops scattered along the Valley of Beshtrek River (**Figs. 2-3-1, 2-3-2**). At the south of the 8 km span Mazanka fm. disconformably overlays Late Jurassic (Tithonian) or Neocomian (Valanginian) limestones and at the north it is overlap by Nummulitic limestones of Simferopol fm. of Eocene (Ypresian-Lutetian) age.

The Mazanka fm. consists of conglomerates, sandstones with interbeds of microconglomerates passing upward into coarse to fine grained well sorted sands (**Fig. 2-3-3**). The thickness of Mazanka fm. is about 200 – 250 m (*Muratov et al., 1969*).

In the neighbouthood of Zuya city to the north east from Mazanka Village the Mazanka fm. was penetrated by numerous shallow wells where it overlays Proterozoic (?) metamorphic "green shists" and subcrops nummulitic limestones of Simferopol fm. of Ypresian- Lutetian age.

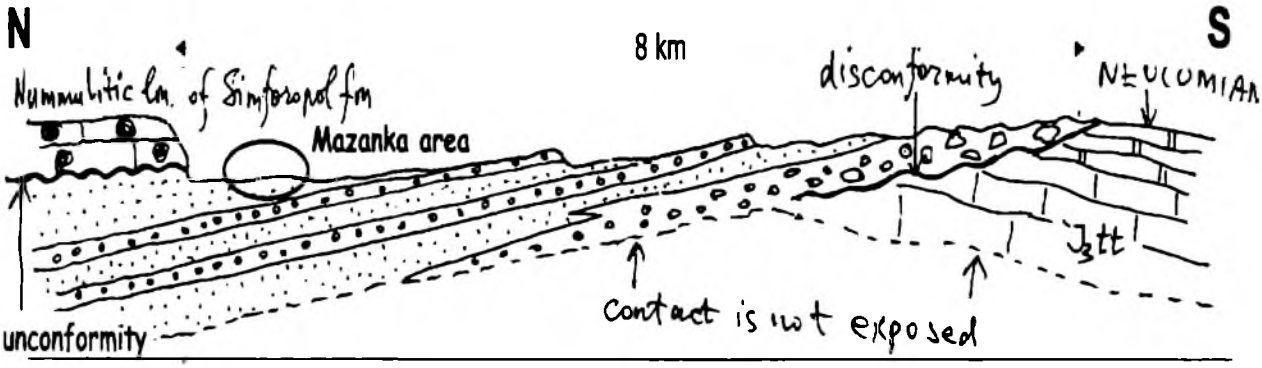


Fig. 2-3-1 – Sketch cross section showing the relationships of Mazanka fr. with underlaying and overlapping rocks

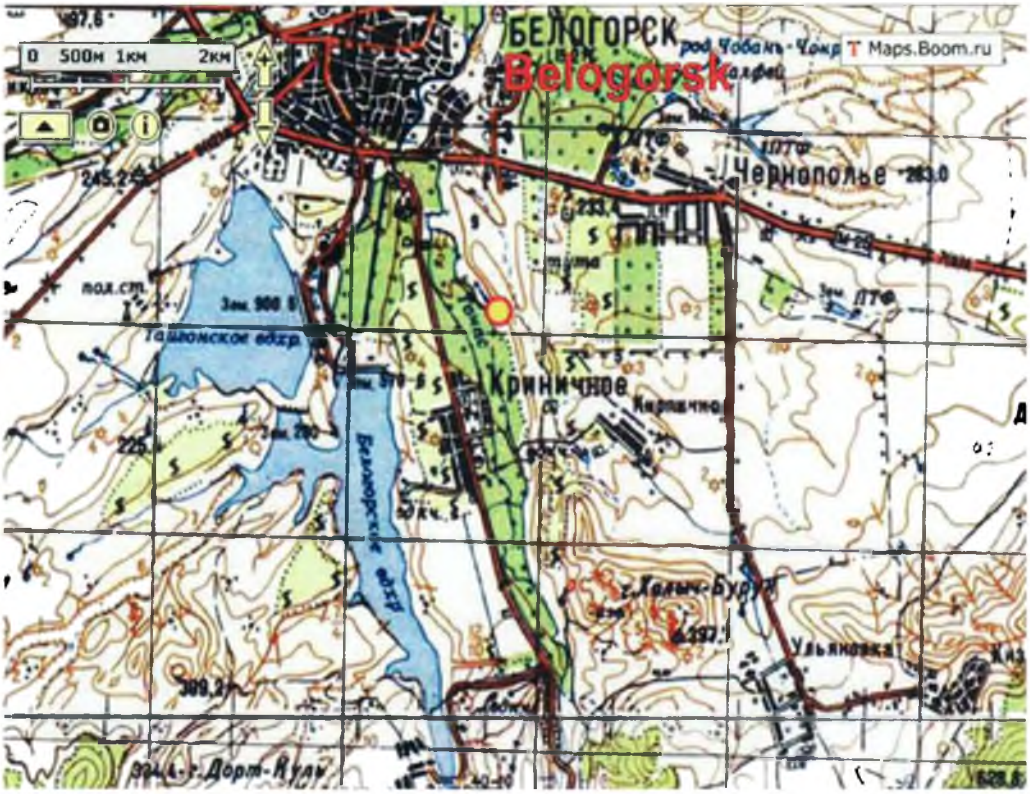
Fig. 2-3-2 – View at outcrop of Hauterivian-Barremian (?) grainstones

Fig. 2-3-3 – Hauterivian-Barremian (?) microconglomerates

Stop 2-4. Belogorsk outcrop

- Albian shales, Cenomanian marls

Stop 2-4 – N 45°02´33.40˝ E 34°36´42.22˝



Location of Stop 2-4 on the base of topographic map

Location of Stop 2-4 on the base of satellite map (from Google resource)

The outcrop begins close at the bridge across the Kara Su River in the southern outskirt of Belogorsk city and interruptedly proceeds southward at the distance of almost 3 km upstream the Tona Su River, the right tributary of the Kara Su.

The Cenomanian section is composed mostly of thin bedded light-grey marls with some interbeds of shaly fine grained limestones passing statigraphically down in the thin laminated grey marls of the lowermost part of Cenomanian section (**Fig. 2-4-1**). The contact between Cenomanian marls and Albian dark grey shales containing big nodules of siderites (**Fig. 2-4-2**) is not exposed directly but most likely is gradual.

The demonstrated section is very important for petroleum geology because the Albian shales could be considered as supposedly source rocks and the long proceeding outcrop gives the possibility to measure the section in details and collect samples for geochemical study what have never been done (**Fig. 2-4-3**).

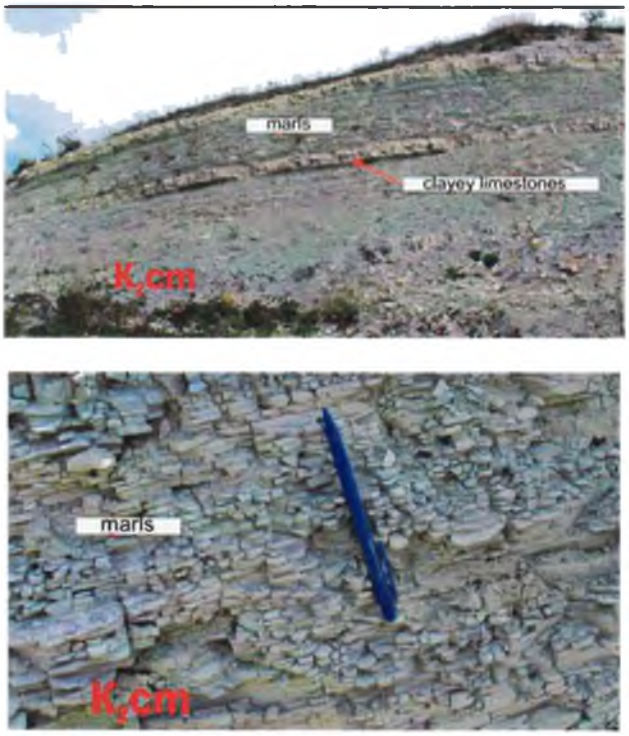


Fig. 2-4-1 – Cenomanian section (north-east of Krynichne village, right bank of Tona Su river)

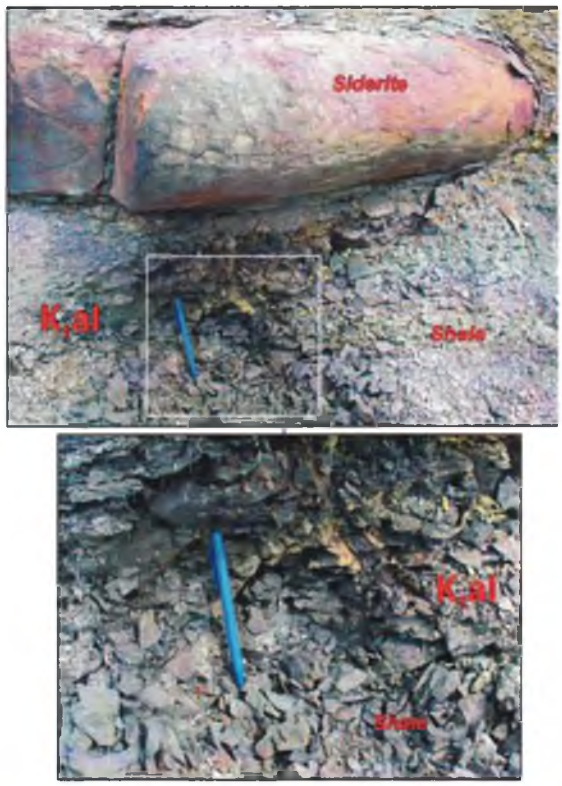


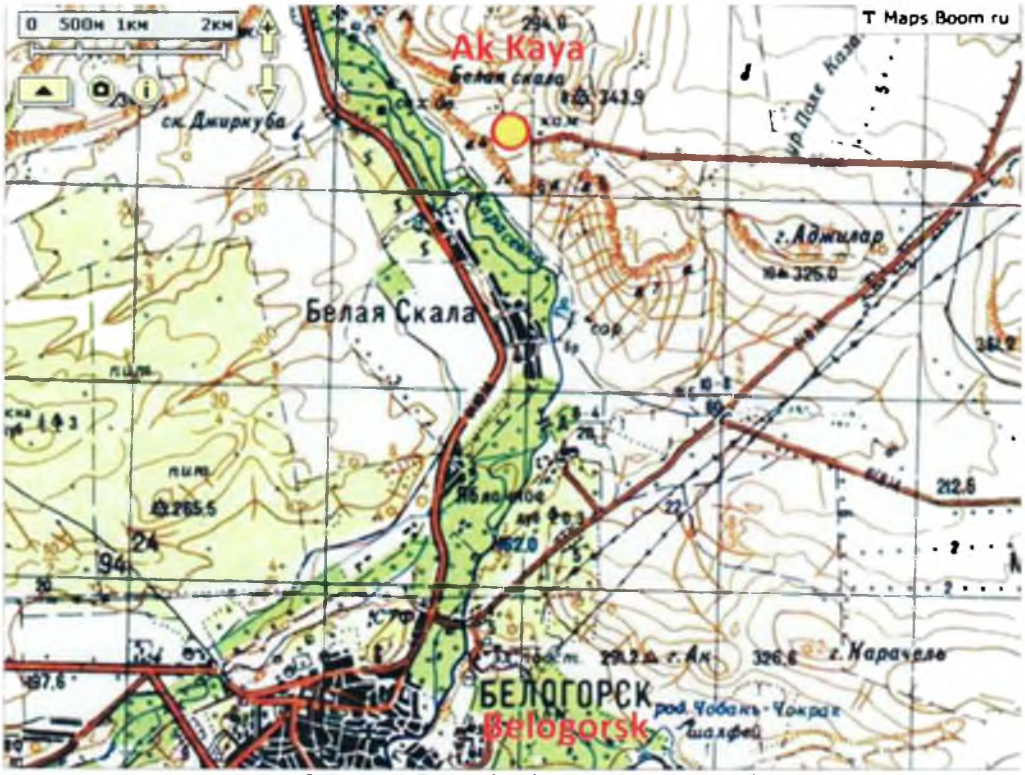
Fig. 2-4-2 – Albian shales with siderites

Fig. 2-4-3 – Albian shales with siderites (NE of Krynichne village, right bank of Tona Su river)

Stop 2-5. Ak Kaya outcrop

– Upper Cretaceous, Paleocene, Eocene, Oligocene

Stop 2-5 – N 45°06´34.11˝ E 34°38´00.42˝



Location of Stop 2-5 on the base of topographic map

Location of Stop 2-5 on the base of satellite map (from Google resource)

The stop is located close to the top of Ak-Kaya plateau-like Mountain (Tatar "White Cliff", **Fig. 2-5-1**). From the stop 2-4 to the top of White Cliff almost continuous succession of Upper Cretaceous sediments, mainly chalk and marl, from Cenomanian to Masastrichtian, is exposed (**Fig. 2-5-2**). Maastrichtian rocks constitute the most of upper part of the Ak Kaya Mountain slope. The Lower Paleocene biocloastic limestones exposed at the lower part of the plateau cornice in the south-eastern margin of the Ak Kaya plateau are thinning towards the stop location due to Pre-Ypresian erosional truncation. The latter is evident due to pebbles of rewashed Paleocene rocks in the base of nummilitic limestones of Simferopol fm of Ypresian-Lutetian age (**Figs. 2-5-3, 2-5-4**). The nummulitic limestones form the cornice of the Ak Kaya plateau at the stop location. The total estimated thickness of the Cenomanian – Eocene (Simferopol fm.) sediments is a bit less than 100 m. Nummulitic limestones exposed at the top of Ak Kaya plateau a few hundred meters from the stop to the north-east are unconformably overlayn by the Maykopian shales containing lenses and veins of gypsum (**Fig. 2-5-5**). The contact between the Nummulitic limestones and Maykopian shales is not well exposed because of weathering of shales.

Fig. 2-5-1 – Overview of Ak Kaya Mountain from the road #6(8)A

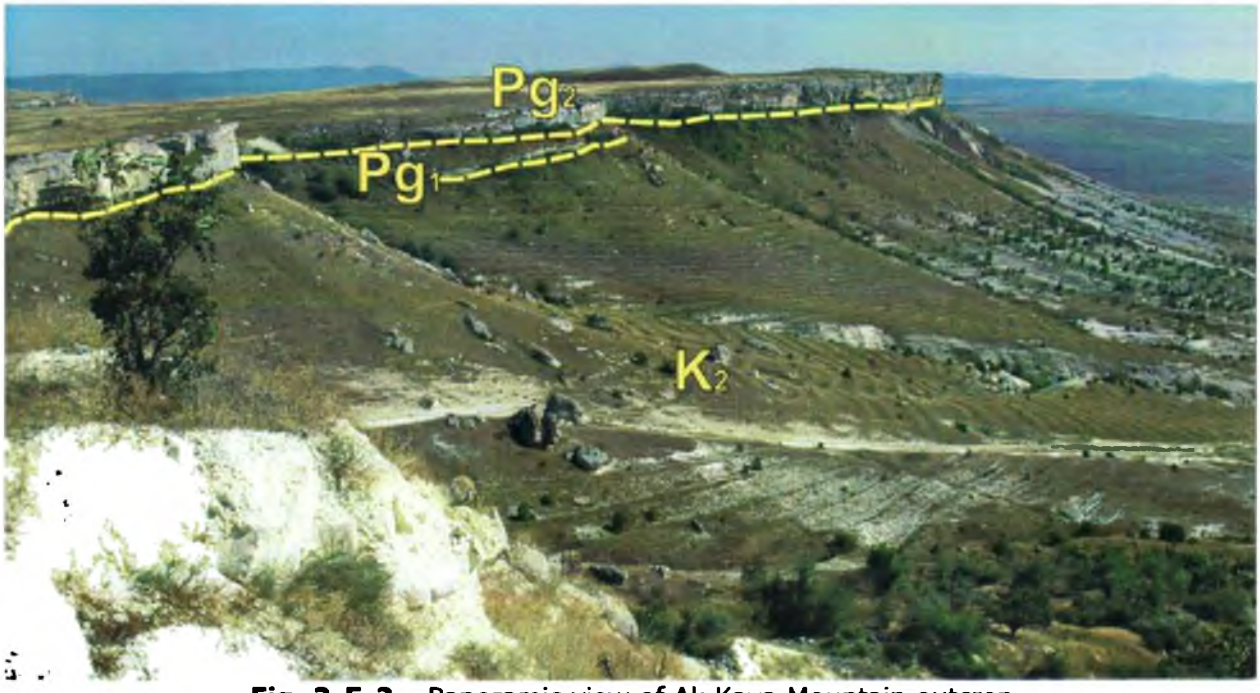


Fig. 2-5-2 – Panoramic view of Ak Kaya Mountain outcrop

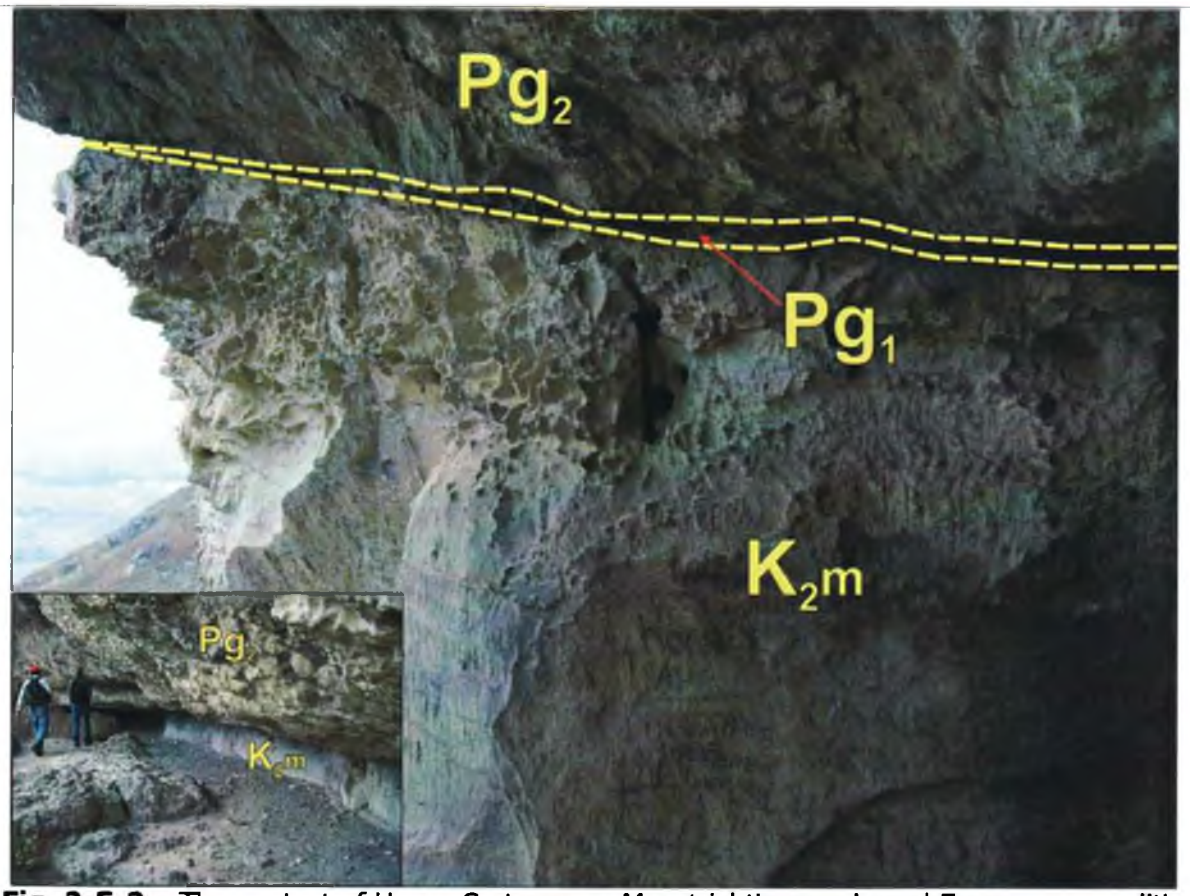


Fig. 2-5-3 – The contact of Upper Cretaceous, Maastrichtian marls and Eocene nummulitic limestones with interlayer of Paleocene limestones (10-15 cm)

Fig. 2-5-4 – Big nummulites of the Eocene (*photo* by courtesy of A.Nikishin)

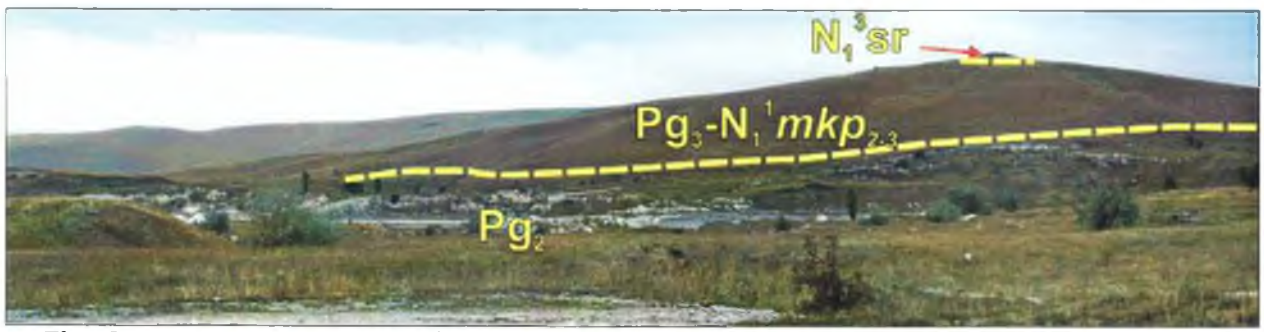


Fig. 2-5-5 – Panoramic view from the top of Ak Kaya Mountain at quarry with Eocene and Maykopian section

Stop 2-6. Ulyanovka quarries

- Upper Jurassic carbonates

Stop 2-6 – N 45°00´14.06˝ E 34°38´19.60˝

Location of Stop 2-6 on the base of topographic map

Location of Stop 2-6 on the base of satellite map (from Google resource)

The two quarries located at the upper part of Khalych Buruk Hill elevated at 397 m above sea level and of some 150 m above the bottom of Tona Su River flowing at its western foothill (**Figs. 2-6-1**). Some 110 m thick section of shallow marine Tithonian (?) carbonates is accessible for study in the quarries and nearby natural outcrops. The Khalych Buruk Hill is composed of thin to thick bedded bioclastic limestones, micritic, chalky limestones with marl interbeds (**Figs. 2-6-3, 2-6-4**). The most likely the Khalych Buruk Hill is the isolated remnant of thrust sheet (Klippenn) rested on Albian shales of the autochthonous succession outcropped between Belogorsk city and Krinichnoye village (see the Stop 2–4).

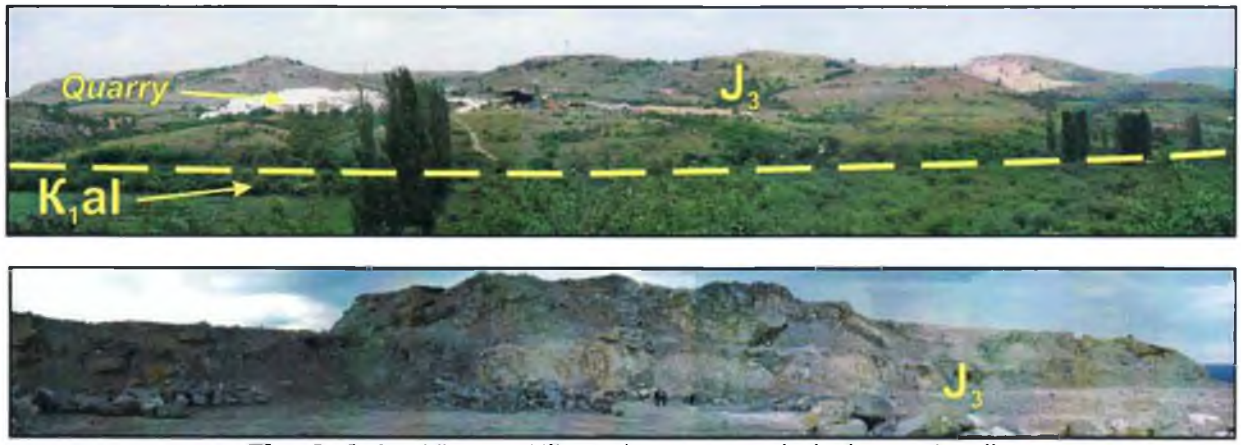


Fig. 2-6-1 – View at Ulianovka quarry, Khalych Buruk Hill

Fig. 2-6-2 – Khalych Buruk Hill, Lower quarry. Layered massive limestones without fossils (photos by courtesy of A.Nikishin)

Fig. 2-6-3 – Khalych Buruk Hill, Upper quarry. Layered massive limestones (photos by courtesy of A.Nikishin)

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WWW resource

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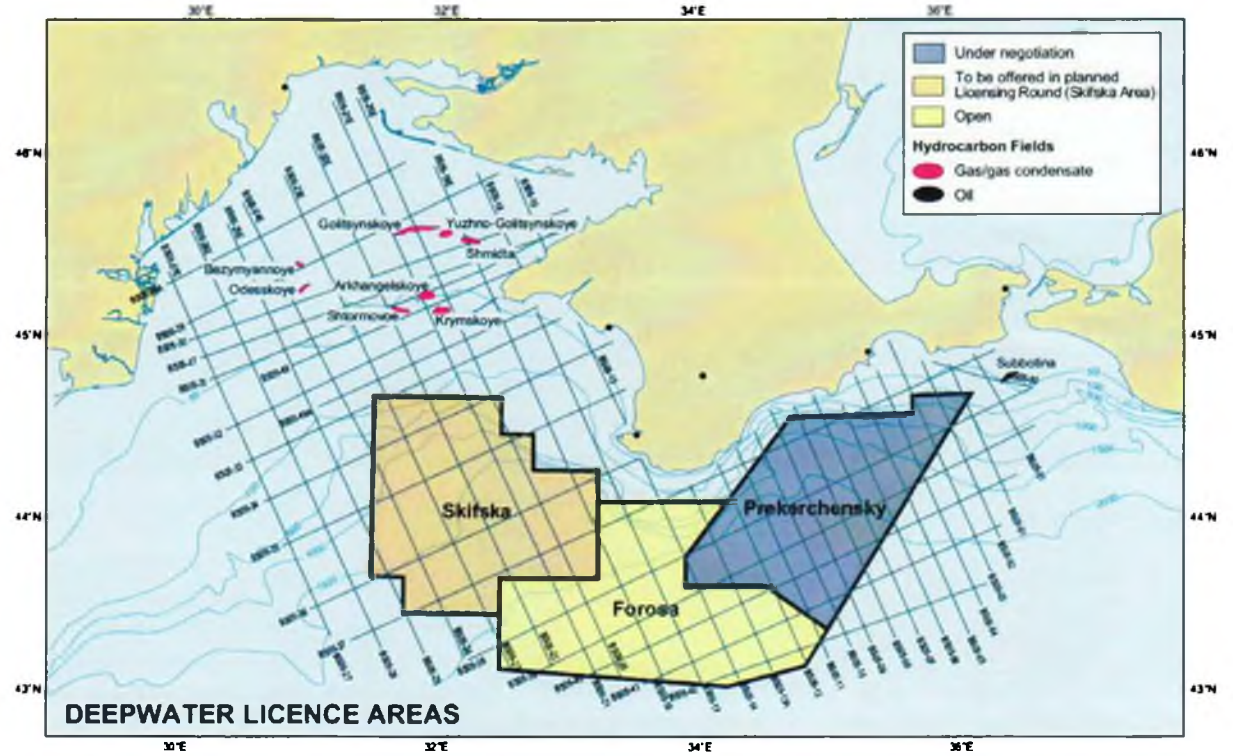
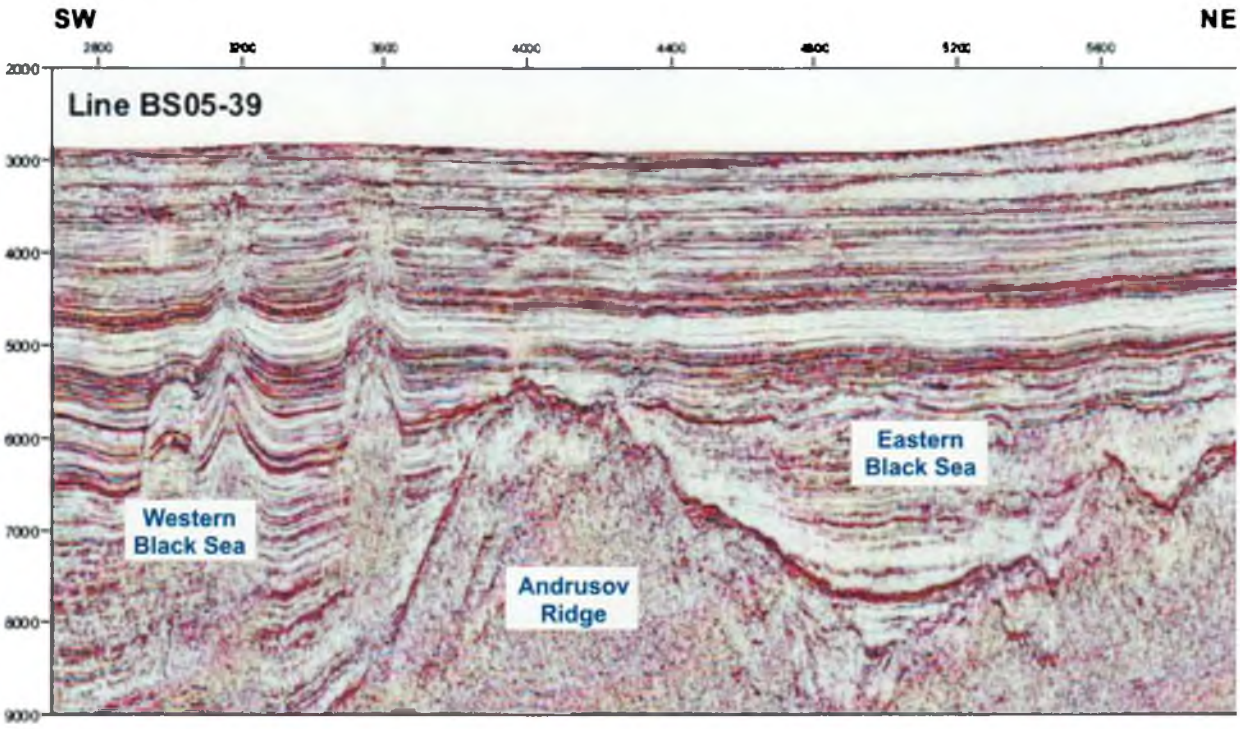
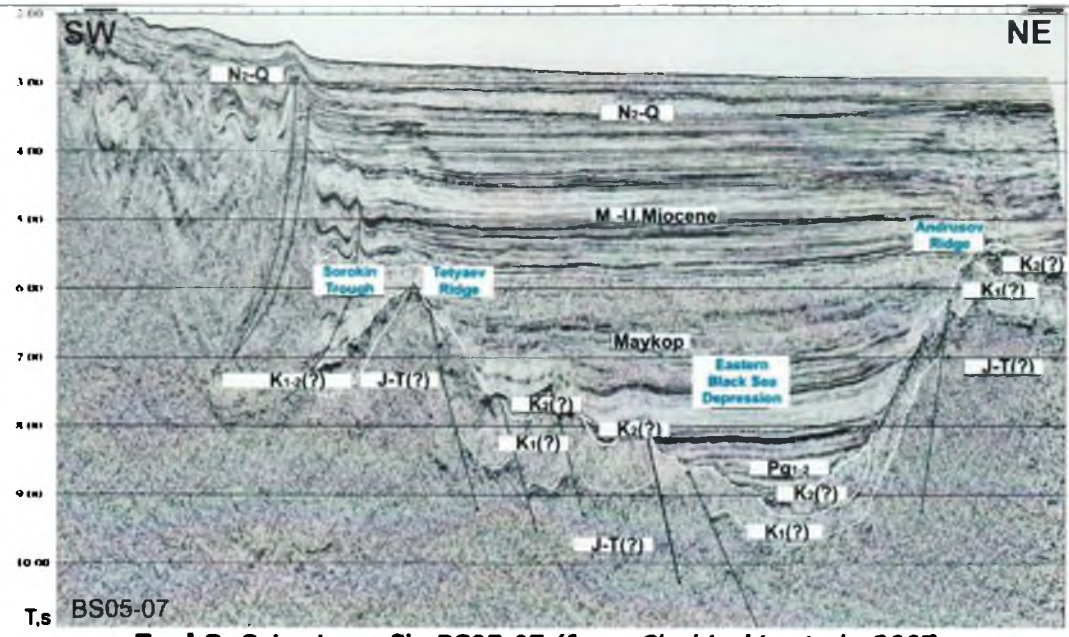
ENCLOSURES



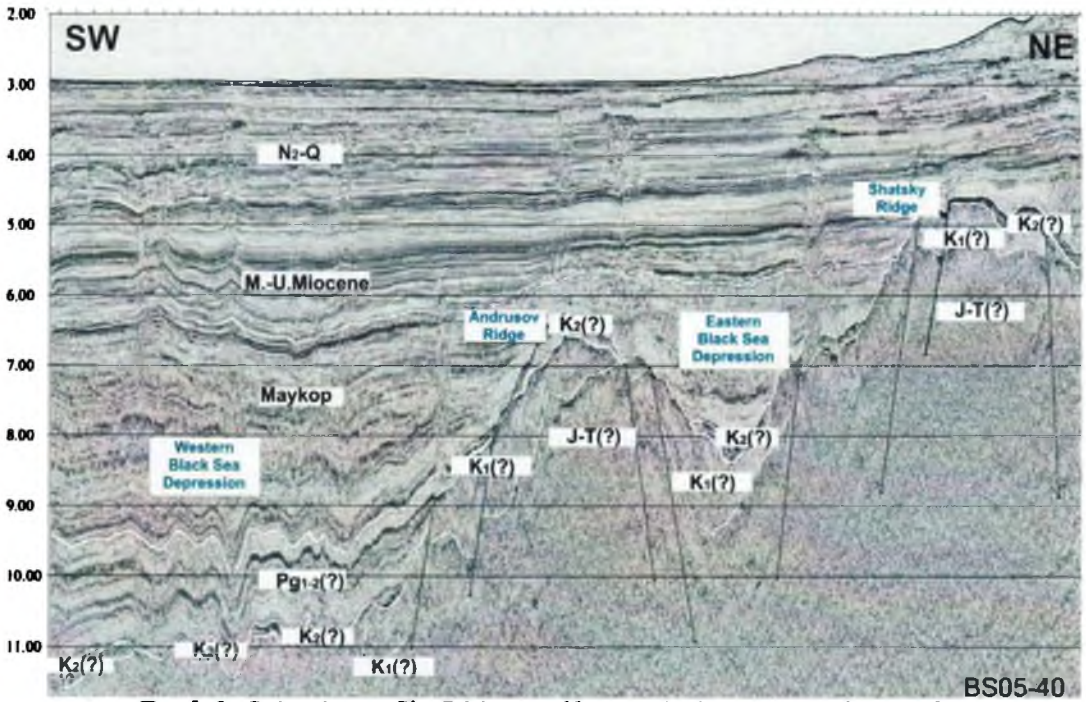
Encl.1. Set of seismic profiles BS05 commenced in 2005
(from http://www.blacksea-seismic.com/pdf_files/ukraine_2d_seismic_brochure.pdf)



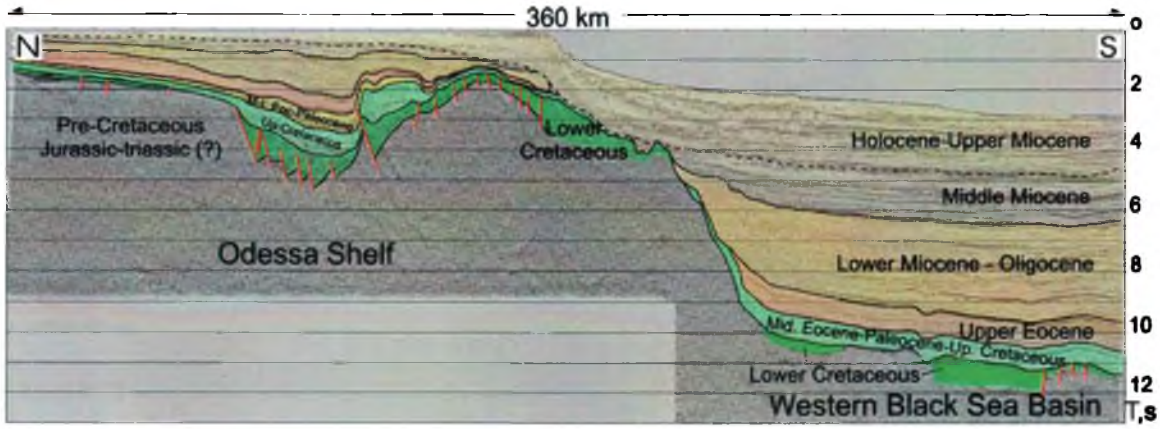
Encl.2. Seismic profile BS05-39
(from http://www.blacksea-seismic.com/pdf_files/ukraine_2d_seismic_brochure.pdf with comments)



Encl.3. Seismic profile BS05-07 (from *Slyshinskiy et al., 2007*)



Encl.4. Seismic profile BS05-40 (from *Slyshinskiy et al., 2007*)



Encl.5. Regional seismic profile (from *Khriachtchevskaia et al., 2009*)