Engineering geological methods of sea coastal area researches excursion programe

II INTERNATIONAL YOUTH SCIENTIFIC AND PRACTICAL CONFERENCE
FIELD EXCURSIONS

V.S. Isaev[1], A.V. Koshurnikov[1], А.И. Gushchin[1], O.I. Komarov[1], P.Yu. Pushkarev[1], M.L.Vladov[1], P.I. Kotov[1], V.G. Shulyakovsky[3], R.M.Amanzhurov[4]

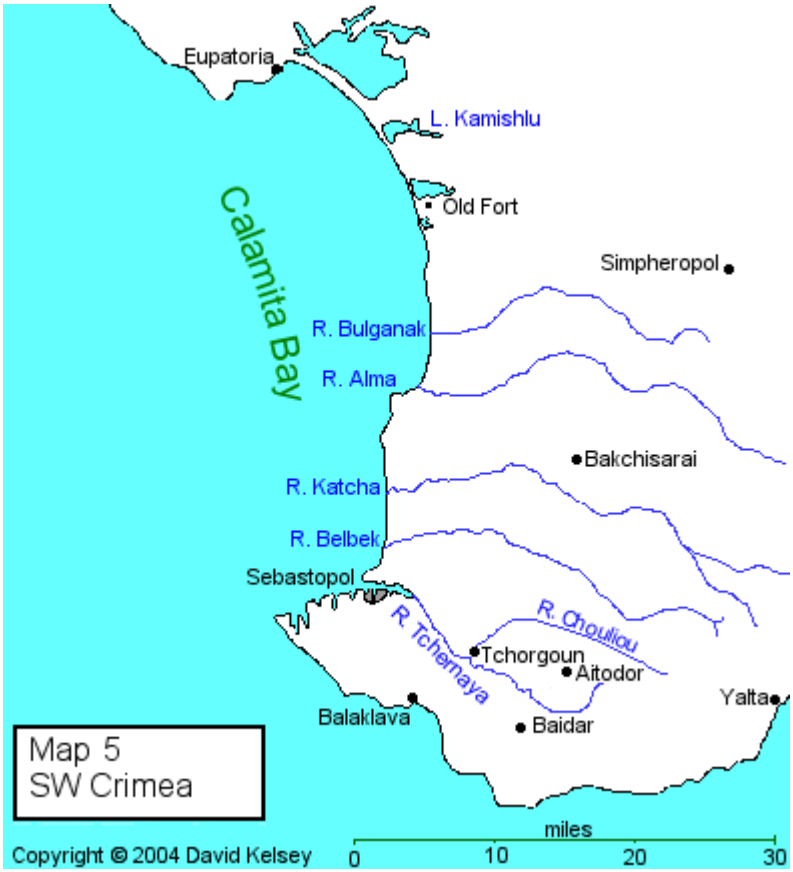
[1]The Geological Faculty of Lomonosov Moscow State University [2]Filial of Lomonosov Moscow State University in Sevastopol [3]OOO "ArtGeo", Moscow [4]OOO "Modern GeoTechnologies", Moscow

Day 10.07.2017. Geological structure of the western coastal zone of Crimea peninsula

Schedule

9-00-10-00 Lection of Professor Alexander Gushin at the Filial MSU in Sevastopol

10-00-17-00 Bus excursion



Location: Republic Crimea, Russia

Trip: By bus, follow from Sevastopol to around sites alone the coastal line – to the place of rivers (Belbek, Katcha) confluences

Necessary gears and outfit: Good hiking boots and trousers of dense textile are a must. Raincoat, sun glasses and sun hat can be very useful. Ruler, photo-camera, shovel, sampling bags, gloves are optional.

Recommended reading prior to the field trip:

Kozhevnikov AV, Naidina N.N. Taurian Formation of the South-Western Crimea. - Byull. MOIP, Dep. Geol., 1983. Vol. 58. Issue 6. Pp. 105-120 (In Russian).

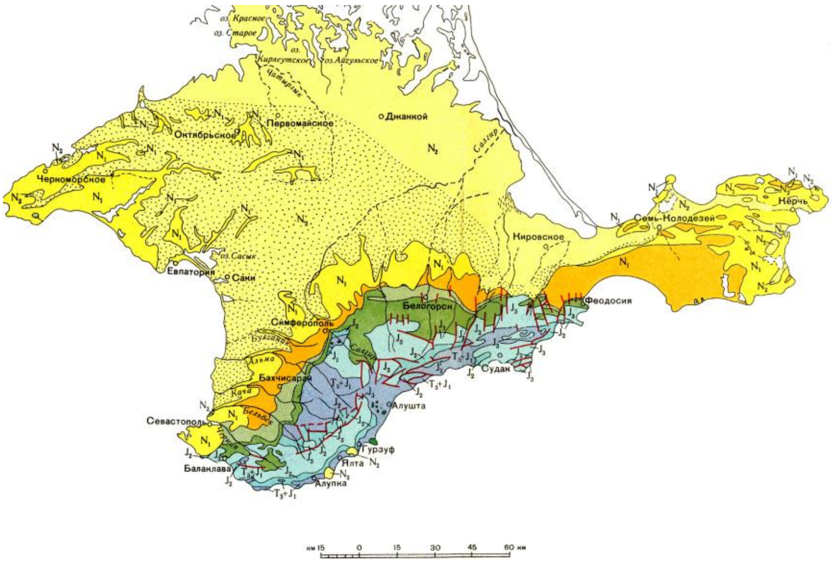
Muratov M.V. On the Miocene and Pliocene History of the Crimean Peninsula. Bull. MOIP, Dep. Geol., 1954. T. 29. Issue 1. Pp. 3-20. (In Russian)

Muratov M.V. Neogene system of the Crimea. Continental sediments. - In the book: Geol. USSR, vol. 8, Moscow, 1969, p. 264-271. (In Russian)

Geology and Geoarheology of the Black sea region: beyond the flood hypothesis, Ilya Val Buynevich, Geological Society of America, USA, 2011, pp.196

Introduction: Mostly from Muratov M.V.

In the practice area, covering the entire western part of the Mountainous Crimea, the rocks of the Triassic, Jurassic, Cretaceous, Paleogene and Neogene are exposed on the surface. On the river and sea terraces, and partly on the mountain slopes, they are covered by Quaternary sediments, which become larger in the foothills and steppe Crimea, where they form an almost continuous cover(Fig.1).



(Fig.1) Geological map of the Crimea (according to M.V. Muratov)

The Taurian suite, allotted by M.V. Muratov in 1954 is developed in the flat part of the western Crimea, mainly within the Almin depression between the meganticlinorium of the Mountainous Crimea in the southeast and the Novoselovsky uplift in the northwest (Fig. 2).

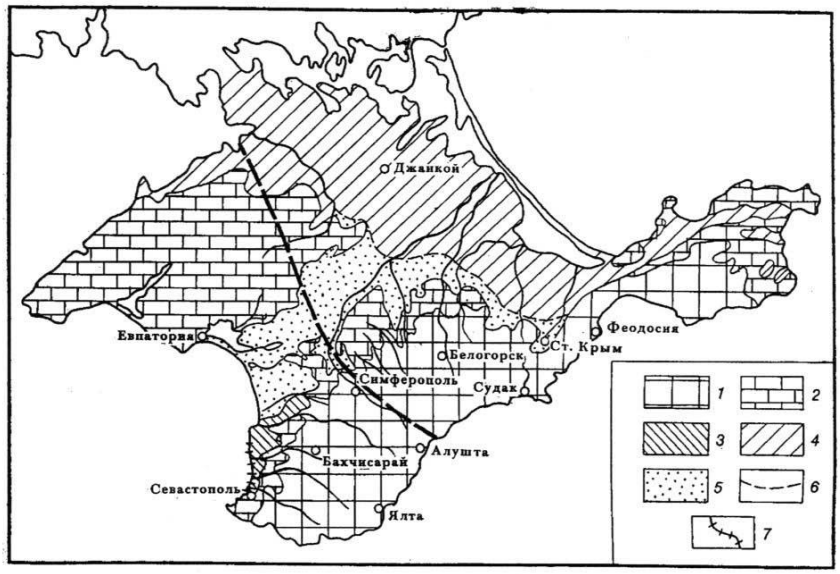


Fig. 2. Distribution of Taurian and Beregovo Formations on the Crimean Territory: 1 - Mesozoic and Cenozoic deposits of the Crimean meganticlinorium; 2 - Miocene and Lower Pleistocene deposits of the Tarkhankut, Kerch Peninsula and the Third Ridge of the Crimean Mountains (carbonate facies); 3 - Taurian Formation (Pont-Kimmeria); 4 - beregovskaya retinue (cimmerian - a fork); 5- Marine Cimmerian-Kujalnitskie deposits; 6 - Salgir-October transverse fault; 7 - location of the examined sections.

The section of the Taurian Formation on the southern side of the Almin depression begins almost immediately behind the Sevastopol Bay on the northern side of the city in the Radiogorka area. And further to the north the Taurian Formation is exposed by a continuous strip along the shore of the Kalamitsky Bay to Lake Kizil-Yar in the area of the village of. Novofedorivka. The main outcrops, unaffected by landslide and landslide processes, are confined to steep coastal cliffs in the mouth of the Belbek, Kacha, Alma and Bulganak rivers.

In general, the Taurian suite is composed of yellowish-brown light aleurites and silty clays with a thickness of 1-2 m or more, alternating with characteristic thinner layers colored with a reddish-brown or bright red color. The red layers, which are fossil soils with a thickness of up to 0.5 m and more, stand out well on the slopes of the cliffs, giving them a characteristic banded appearance and a general reddish tint (Fig. 3). Usually at a cliff in the height of 15-20 m, up to 7-8 red interlayers can be identified, but sometimes they are more up to 10-12 m.

Fig. 3. Clive of the Taurus deposits between Orlovka and Kacha sites

<u>Practical exercises for participants of the field excursion</u>:

- to identify rocks of the Triassic, Jurassic, Cretaceous, Paleogene and Neogene, basing on lithological description;
- to identify rock of the Taurian suite, basing a crack and an lithological description;
- to collect and to make “on-hand” lithological descriptions of some sites of Triassic, Jurassic, Cretaceous, Paleogene and Neogene depositions.

Day 11 July 2017 Studying and forecasting the development of slope processes by remote methods

Scientific Educational polygon Ychkuevka

44.642049, 33.527941

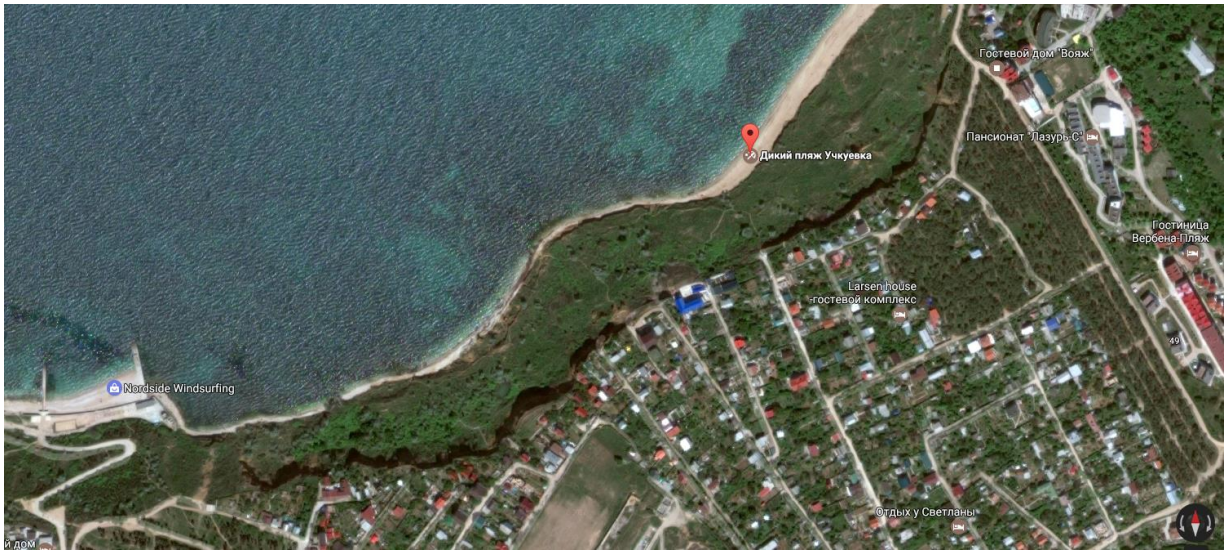


Fig. 4. Coastal area of Uchkuevka scientific educational polygon.

Schedule

9-00-17-00 Complex field geoengineering methods activity

13-00-13-30 Field lunch

Trip: By bus, follow from Sevastopol to Scientific Educational polygon Ychkuevka

Necessary gears and outfit: Good hiking boots and trousers of dense textile are a must. Raincoat, sun glasses and sun hat can be very useful. Ruler, photo-camera, shovel, sampling bags, gloves are optional.

Recommended reading prior to the field trip:

1/ The civil engineering – handbook, manuals, etc. I. Chen, Wai-Fah, 1936 - TA151.C57, 1995

2/ Educational manual of engineering geology, etc. I. Zolotarev G.S., MSU publishing, pp. 294, 1990 (in Russian)

3/ Method manuals on geological mapping in 1:50000 scale, etc. I. Kupman A.S., Nedra Leningrad, 287, 1978 (in Russian)

4/ Geomorphological mapping on survey scale, etc. I Bashenina N.V., MSU publishing, 264, 1975 (in Russian)

Introduction:

3D laser scanning (lidar survey (http://art-geo.ru/))

Laser scanning, as a method of remote acquisition of a large set of measurement data, has been successfully used since the 80s of the last century. At first, this technology was used only for aerial survey purposes for topographic works, as a technology that accompanies the classical aerial photography from manned carriers.

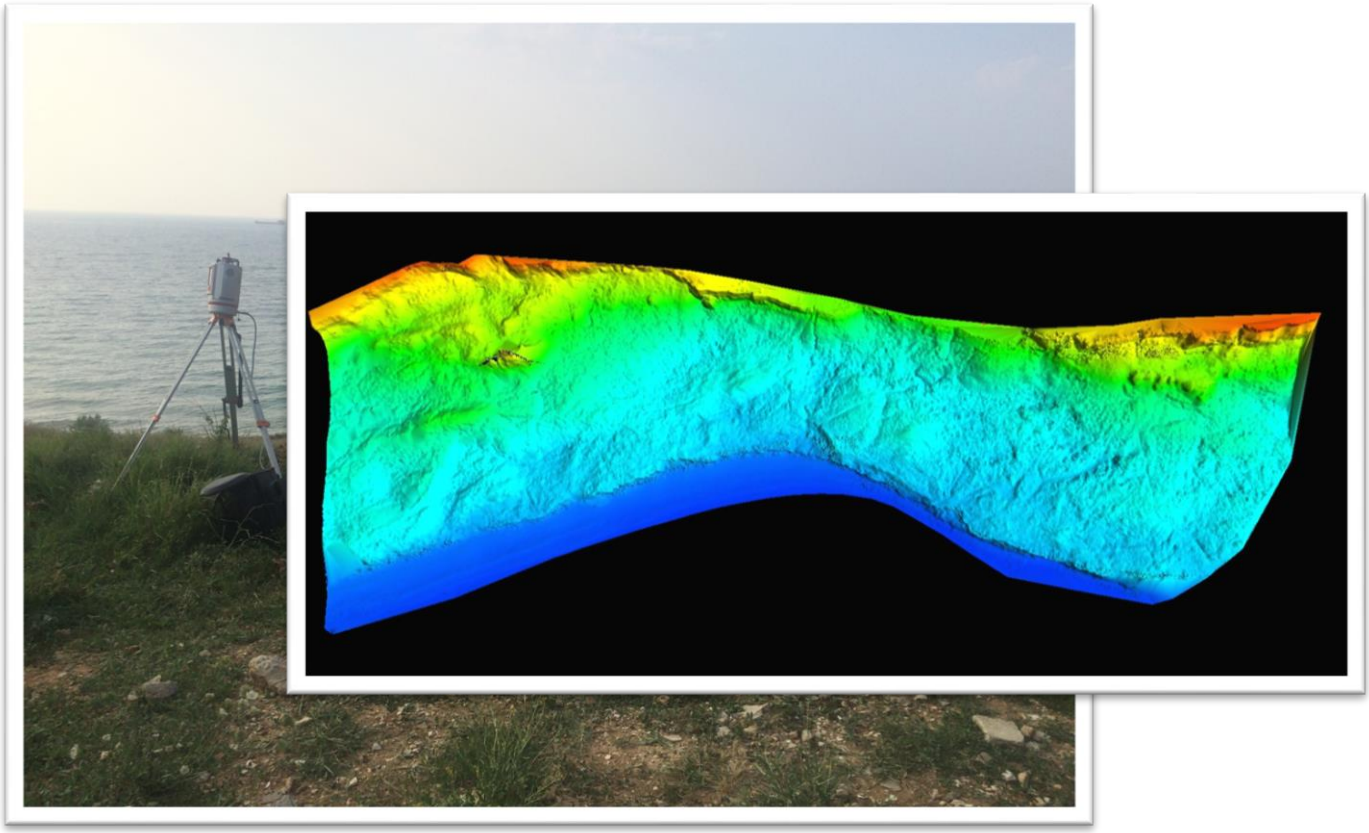


Fig. 5. Laser scanning of complicate multistage landslide slope on Uchkuevka scientific educational polygon.

The essence of the method lies in the distance measurements carried out by the laser scanner and the calculation of the laser pulse travel time from the moment of its emission to the moment of fixing the

signal reflected from the surface by the laser scanner. The process of ranging measurements is repeated many times, and the outgoing laser beam is directed to a mirror, which in turn is located on a rotating stepper motor mechanically distributing laser pulses in a given direction. The angle of rotation of the mirror is taken into account and applied to the corresponding range-finding measurement. Then, in a mathematical way from polar coordinates (direction and range), the measurements are recalculated into Cartesian (X, Y, Z). Thus, each point of laser reflections (THO) from the surface has its own clear coordinates in space.

However, in order to obtain an acceptable result that would satisfy the requirements of cartographic products, it is also necessary to obtain a position and orientation in the reference point space (the point from which laser reflection points are calculated in the polar coordinate system). It is important to synchronize all received data (position and orientation in space) with the time of execution of a specific measurement by the laser scanner. With the development of global satellite positioning systems, all these tasks have simply been solved. The exact definition of coordinates is a direct function of such systems. Time synchronization is carried out thanks to time stamps of high-precision atomic clocks installed on satellites of the same navigation systems. These labels are contained (by default) in the signals of the navigation satellites. Thus, only when all three data sets are combined (laser ranging, high-precision positioning, high-precision determination of orientation angles in space) synchronized as accurately as possible in time, can provide the same three-dimensional material, now called the digital surface model (CMP) Or digital terrain model (DEM).

Excursion is organized and guide "ArtGeo" company specialists – official representative of RIEGL laser scanner producer in Russia (http://art-geo.ru/).

Air mapping by drones.

The civilian application of UAV is very extensive: from agriculture and construction to the oil and gas sector and the security sector [Samuel Greengard. Internet of things: The future is here = The Internet of Things. - Moscow: Alpina Pablisher, 2016. - 188 p. - ISBN 978-5-9614-5853-4]. "Drones" of civil purpose can be used in the work of emergency services (fire safety control); Police (patrolling zones); Agricultural enterprises (monitoring of crops), forestry and fisheries (forest protection and fisheries control); Companies engaged in geodesy (mapping); Institutes of geography and geology; Oil and gas companies (monitoring of oil and gas facilities) [Rajesh Kumar. Tactical Reconnaissance: Uavs Versus Manned Aircraft // The Pennsylvania State University. - 1997. - No. AU / ACSC / 0349 / 97-03]; Construction companies (inspection of construction projects); Media (aerial and video shooting), etc.

Drone (English drone - drone, idler, buzzing, buzzing, buzzing) - an unmanned aerial vehicle (UAV) originally a military, mostly reconnaissance, a kind of military robot. The task of these autonomous systems created for the flight is to carry out missions that are potentially dangerous for humans. In a broader sense: a mobile, stand-alone device programmed to perform any tasks.

Often in the literature, drones of the military model are called "drones", civilian aircraft of smaller dimensions are usually called "drones".

According to the publicly available documents of the European Union organizations, the distribution of consumer demand for civilian UAVs between 2015 and 2020 is as follows: 45% - government structures, 25% - firefighters, 13% - agriculture and forestry, 10% Energy, 6% - a survey of the earth's surface, 1% - communication and broadcasting.

Fig. 6. Demonstrations of possibilities of modern technology of area mapping by Drones on Uchkuevka scientific educational polygon.

Air Dron mapping demonstration includes – preliminary lection/presentation, field activity – selection of scanning sites, Laser scanning, workout of field data, presentation of 2D & 3D topo model, workout with model – “bug” removal and preparing to “ready” level.

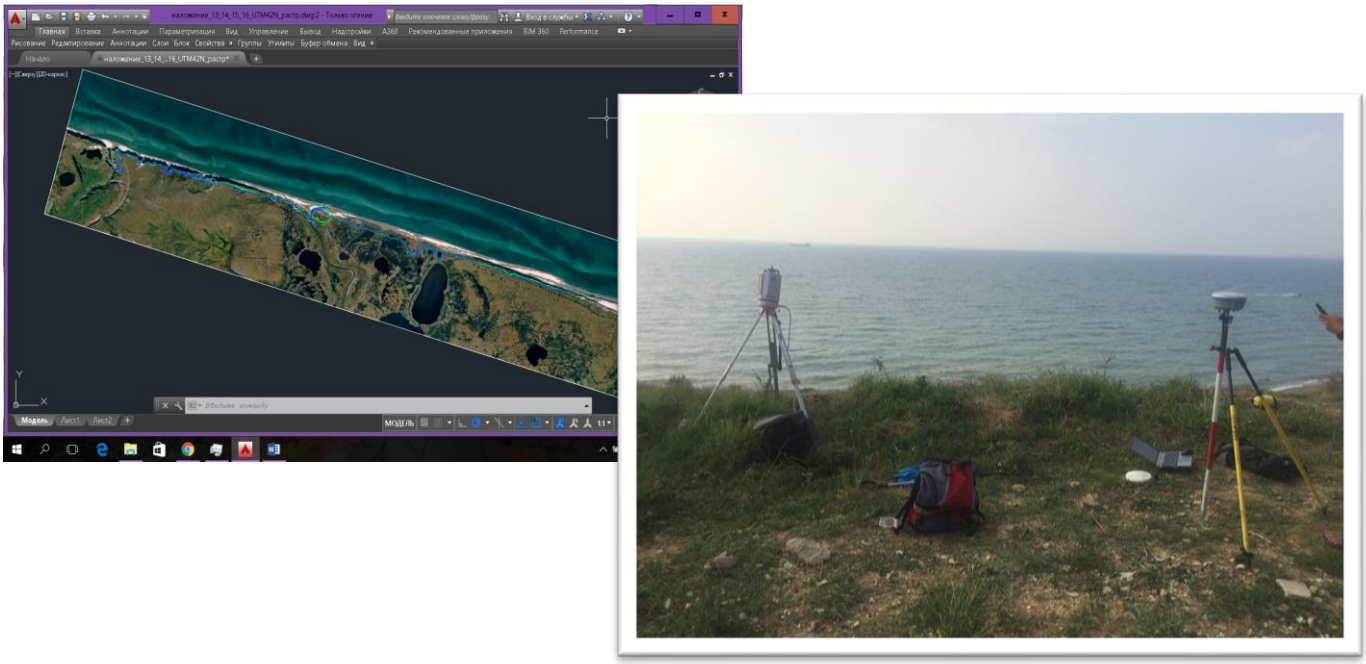


Fig.7. Mapping of coastal line by RTK on Uchkuevka scientific educational polygon.

Methods and approaches of satellite geodesy in the construction of relief models

At present geodetic surveying with the help of geodetic satellite receivers has a number of advantages: globality, efficiency, all-weatherness, optimal accuracy and efficiency. Depending on the task, the required accuracy, the area of work, the following types of geodetic survey are used:

• Statics • Rapid statics • Kinematics "Stop & go" • Kinematics • Kinematics in real time (RTK).

In the framework of studies of the shores of the Western Crimea, we conducted a survey of "Statics", "Kinematics" Stop & Go "and" Kinematics in real time (RTK) ". The measurements are carried out by two-frequency receivers using the global satellite navigation system (GNSS). Our work was carried out using the following equipment: the Trimble R8 receiver and the Stonex S3 receiver (Fig. 7). In our studies, two-frequency satellite receivers are used.

The "Statics" method is a classical method of surveying with the help of geodetic satellite receivers and provides the highest measurement accuracy. Measurements are performed simultaneously between two or more fixed receivers for a long period of time. These two receivers must simultaneously track four (or more) satellites, record data with the same period and have the same elevation angle values. The duration of a measurement session can vary from a few minutes to several hours. The static survey method is necessary for determining the planned altitude position of temporary bases from the support points of the State Geodetic Network.

Measurement mode "Kinematics" Stop & Go "" allows you to quickly observe a large number of points, but require that the receiver keep the capture of satellites during the entire time travel between points. At the first point, it is necessary to stay until a sufficient number of measurements are collected to resolve the ambiguity (initialization period). After initialization, the receiver can move between points as long as the capture of the observed satellites is supported. If the seizure of satellites is violated, the operator must again remain in a stationary position until enough data is again collected to resolve the ambiguity.

The Kinematics "Stop & Go" mode is ideal for small areas where observation points are located next to each other and at which observation points are located next to each other and without obstacles to the passage of radio signals from satellites. In this mode, as a rule, it is necessary to use the field controller to switch between the "stop" and "go" modes, as well as to control the shooting process.

When using the Real Time Kinematic Survey (RTK) method, differential corrections are transmitted from the base receiver to one or more mobile receivers so that they perform position determination in real time. In this mode, it is necessary that the base receiver has a built-in or external VHF or GSM modem to transmit corrections to the mobile receiver, which in turn must also have an appropriate modem for receiving these corrections. The RTK method is the fastest method of shooting with satellite receivers and is ideally suited for topographic surveying, land surveying, staking out points in nature.

Fieldwork will include:

Preliminary lection/presentation, demonstration of topo reconnaissance to the State system of coordinates (GSK), field work on coastal line of complicated multistage landslide slope close to the Uchkuevka city beach, the rear line of beach area and orthogonal profiles to the coastal line for the workout of some methodical recommendation of monitoring organization of coastal retreat due to abrasion processes progressing.Excursion is organized and guide by MSU & MGRI scientific staff.

Engineering & geological probing (research) of sediment rocks of coastal cliff.

The nature and intensity of the retreat of the sea coasts are determined by the interaction of hydrometeorological, geological, geomorphological, hydrogeological, technogenic factors.

Principles for the study of geological, geomorphological, hydrogeological factors, of which the main ones are:

1) the geological structure of the coastal slopes - lithological composition, occurrence conditions, the presence of faults, the nature and intensity of fracturing, the nature of stratification, the composition and thickness of loose sediments, the state, the physical and mechanical properties of the rocks;

2) the shape and dimensions of the coastal slopes, the depth and relief of the bottom of the coastal part, genetic types of shores, the history of their formation and the current state;

3) other dangerous geological processes, caused or activated-weathering of rocks, caving, shedding, landslides, karst, suffusion, erosion, landslides, etc .;

4) hydrogeological conditions - presence of outcrops of groundwater on the coastal slopes, in their base and underwater slope, their distribution, conditions of movement and unloading.

Fig. 8. Sampling of slide slopes on Uchkuevka scientific educational polygon.

Preliminary lection "Methods of engineering and geological probing of research objects in engineer geology". Field work includes: Probing of monolith samples for lab surveys; Probing of samples for lab surveys by "ring" method. Geological section description methods. AutoCad engineering geological table of geosection workout. Demonstration of 2016 results of lab surveys by the industrial kind of report in accordance with SNIP (construction standards and rules of Russia).

GeoInfoSystem (GIS) based on the field data collected during the School activity as the main aim of field work.

Recently, the cartographic science is actively developing methodological and technological aspects of the new cartography - geoinformation mapping. Electronic technologies of geoinformation mapping practically replaced the methods of analog mapping. The tools for creating digital maps and databases are geographic information systems (GIS).

At the stage of field work, coordination, filling in the field survey log and photographing the objects is done.

Coordination of objects means obtaining geographical coordinates by a portable GPS navigator.

The compilation stage includes the whole complex of works on drawing up a map, which is carried out by means of geoinformation technologies.

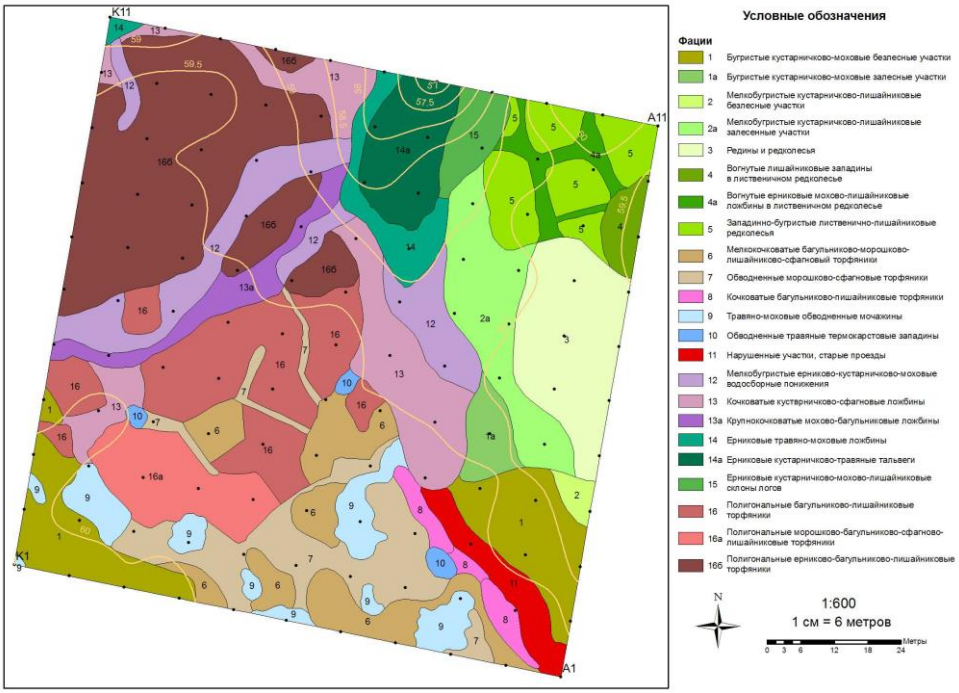


Fig.9. Engineering geological map in scale 1:600

In GIS, the main components are spatial and attributive data. The first include all spatially encoded data: descriptions of objects of reality, digital images, digital maps, coordinate catalogs of the points of the reference geodetic network, and so on. Attribute data is represented in the form of special attributive tables, consisting of rows and columns. The attribute attributes table is a special type of data file that stores information about each point, arc, or polygon. It contains standard attributes that appear in a specific order. Tables of this type contain all the thematic attributes data associated with spatial map information. The totality of these data constitutes a geodatabase, or a model of spatial objects.

Each layer of the map corresponds to tables with thematic attributes, which together makes up the attributive database of the map. When a set of data for the semantic characteristics of objects is taken into account in the general geographic and thematic layers of the digital one, one can perform analysis, obtain the coefficients of the dependences of the phenomena among themselves, densities, and so on. With the help of GIS-analysis, it becomes possible to obtain new cartographic results.

A digital map created in GIS allows users to:

- promptly make changes to the interactive component of the map;

- update attributive information; Convert to other data formats;

- print individual fragments and the entire digital map in different scale hierarchies;

- execute queries and search for objects of certain semantic properties;

- carry out GIS analysis and obtain new estimated cartographic results;

- Obtain optimal visualization by building 3D terrain models, etc.

Field will include: demonstration of GIS project of Uchkuevka scientific educational polygon included results of complexed engineering-geological research.

Geophysical researches

Electrical tomography (electromotography) is a modification of the method of vertical electrical sounding (VES) using multi-channel (multi-electrode) installations. In this modification of the VES method along the observation profile, a set of electrodes arranged at equal distances is established. When performing measurements, the electrodes are repeatedly used in the quality of both receiving and feeding. The application of the method of electro tomography is regulated in normative documents (SP 11-105-97 part VI) for detailed studies of two-dimensional inhomogeneous media. Practical experience shows that electric tomography has proved itself well for studying complex environments, improving the structure of the upper part of the geological section and identifying local inhomogeneities, studying karst-suffusion processes, mapping slide mirrors of landslide bodies, studying permafrost peaks and sluggish permafrost, and solving other Tasks. An additional advantage of the technology is the use of relief data as a raw material along with the measured values of the apparent resistance for calculating the geoelectrical model of the medium, which makes it possible to apply this method to any, even very significant relief.

As a result of the primary processing, a data file is prepared for building the geoelectrical model. Interpretation of the data of electromotography is carried out within the framework of a two-dimensional class of models using special software. Selection of the geoelectric model of the medium was carried out using a two-dimensional automatic inversion procedure of the measured field of apparent resistance.

Two-dimensional inversion is an algorithm that recalculates the observed electric field into a corresponding two-dimensional distribution of resistivity. With this approach, the whole set of measured data is taken into account in the search for a solution. When you change the parameters of model selection, the introduction of a priori information into the base model, the application of various filtering and smoothing algorithms, the operator influences the result obtained. After the introduction of the necessary parameters, the program automatically calculates a mathematical model of the environment and builds a geoelectric section. Since such a problem is incorrect, then the solution is regularized due to models with a smooth change in the resistivity. Because of the integral nature of the resistance method,

the solution obtained, as a rule, simplifies and smoothes out the real details of the geological structure of the section. In addition, false anomalies associated with objects located near the observation profile and the instability of inversion may appear on the section. A separate problem is also very contrasting objects of technogenic origin (for example, water supply and sewage communication lines, etc.). Depths based on the results of surface geophysical studies are estimated, due to the presence of equivalent bonds between the resistance and the thickness of the soil.

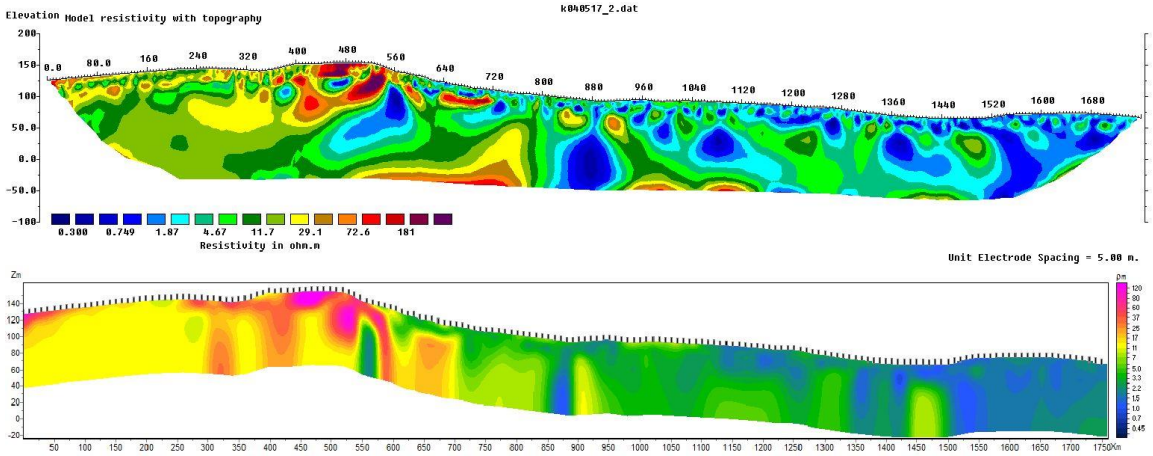


Fig. 10. Examples of electro tomography workout (Kerch mud volcano Bulganak, data 2017)

Sounding by the method of transient processes (ZPPP, MPP) and sounding by formation (ES, ZSB) - widely used geophysical electro prospecting methods for studying the geological environment. In the Russian geophysical school, the term "probing by the method of formation" (ZS) or probing by the method of formation in the near zone (ZSB) has historically been used in the performance of oil exploration, and sounding by the transient process (ZPPP, MPP) in ore prospecting and engineering-geological surveys. According to the international classification, both methods are referred to as the time-domain electromagnetics method (TDEM).

As an electromagnetic field source, an ungrounded oscillator loop is used through which a current pulse is passed. According to Faraday's law, this leads to the appearance of eddy currents in the conducting layers of the geological section. The maximum current density with time after the current is turned off, moves to ever greater depths, allowing you to scan the geological environment. The rate of decay of eddy currents is determined by the thermal losses in the conductor. All this allows to perform electromagnetic scanning of the geological environment and to determine the specific electrical resistance of geological layers.

As the receiver of the electromagnetic field, mobile sensors or the same loop are used, which serves as a source during the current pulse and the receiver in a pause between pulses.

An increase in the depth of research is performed by increasing the power of the source of the electromagnetic field-the size of the generator loop and the current flowing through the loop. Thus, for geotechnical studies, with a depth of study of the first ten meters, a generator loop with dimensions from 5 × 5 m to 50 × 50 m and a current of 1 to 4 A is used. In oil search operations, a 500 × 500 m loop or more is used, with Current strength not less than 100 A.

The method of sounding by becoming refers to inductive electrical exploration, so it works very well under conditions where a high-resistance medium contains a conducting object that is the result of a search or research.

Electrical exploration using the MPP and WSS is widely used to solve the following problems:

• search for groundwater and hydrothermal deposits;

• monitoring the development of hydrogeological processes;

• study of the geological conditions of engineering and operating engineering structures;

• prospecting and exploration of ore deposits;

• solution of oil exploration tasks.

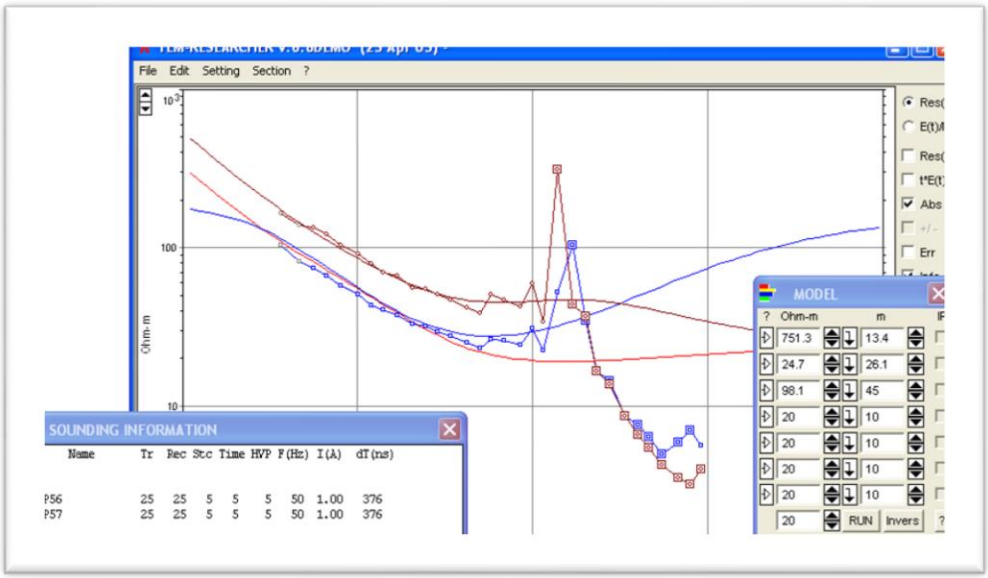


Fig. 11. Example of formation in the near zone (ZSB) method workout for the site in Bahchisaray region, Crimea

Day 12 July 2017 Studying and forecasting the development of slope processes by remote methods at Belbek site

44.680855, 33.549201

Fig. 12. Belbek airport research site.

Schedule

9-00-17-00 Complex field geoengineering methods activity

13-00-13-30 Field lunch

Trip: By bus, follow from Sevastopol to Belbek

Necessary gears and outfit: Good hiking boots and trousers of dense textile are a must. Raincoat, sun glasses and sun hat can be very useful. Ruler, photo-camera, shovel, sampling bags, gloves are optional.

Recommended reading prior to the field trip:

1/ The civil engineering – handbook, manuals, etc. I. Chen, Wai-Fah, 1936-TA151.C57, 1995

2/ Educational manual of engineering geology, etc. I. Zolotarev G.S., MSU publishing, pp. 294, 1990 (in Russian)

3/ Method manuals on geological mapping in 1:50000 scale, etc. I. Kupman A.S., Nedra Leningrad, 287, 1978 (in Russian)

4/ Geomorphological mapping on survey scale, etc. I Bashenina N.V., MSU publishing, 264, 1975 (in Russian)

The research site in the area of Belbek airport was chosen as a characteristic geomorphological example of the development of the ravine-girder system in the coastal zone of the Black Sea coast, located in the immediate vicinity of the civil facility.

As a zero sample, a lidar survey was performed and a 3D relief model was constructed on the basis of these data (Fig.13.)

Annual systematic observations at each of the sites monitoring the coasts of the Western Crimea will provide an array of data that will form the basis for the analysis of linear displacements of characteristic sections of the terrain, as well as assess the volume of moving masses of rocks.

Based on the generalized data, a forecast is made for processing the shores in order to develop them and obtain the data necessary for the development of bank protection measures, is one of the main tasks of engineering and geological study of coastal zones.

For forecasting the processing of shores, data on the progress of this process for the preceding period are used: geodetic observations; Materials of regime engineering geological and hydrometeorological observations.

Forecast calculations are performed on the basis of the schematized mathematical models of the "washout-accumulation" process using the known methods of Kachugin, Zolotarev, Pecherkin, etc., or by compiling predictive stochastic models of the process of bank remodeling using correlation regression analysis or heat and mass transfer model using similarity criteria, Proposed by I. A. Komarov. For statistical processing, parallel observations are required for the sections along the perimeter of the reservoir for the following coastal-forming factors: shore erosion coefficient (according to Kachugin m^3 / tm), wave energy, maximum wave height, the frequency of waves> 0.5 m in height, the height of the abrasion Ledge, the duration of the level standing on the NPG and above, the steepness of the underwater shoal, the morphology of the above-water part of the slope.

Introduction

3D laser scanning (lidar survey (http://art-geo.ru/))

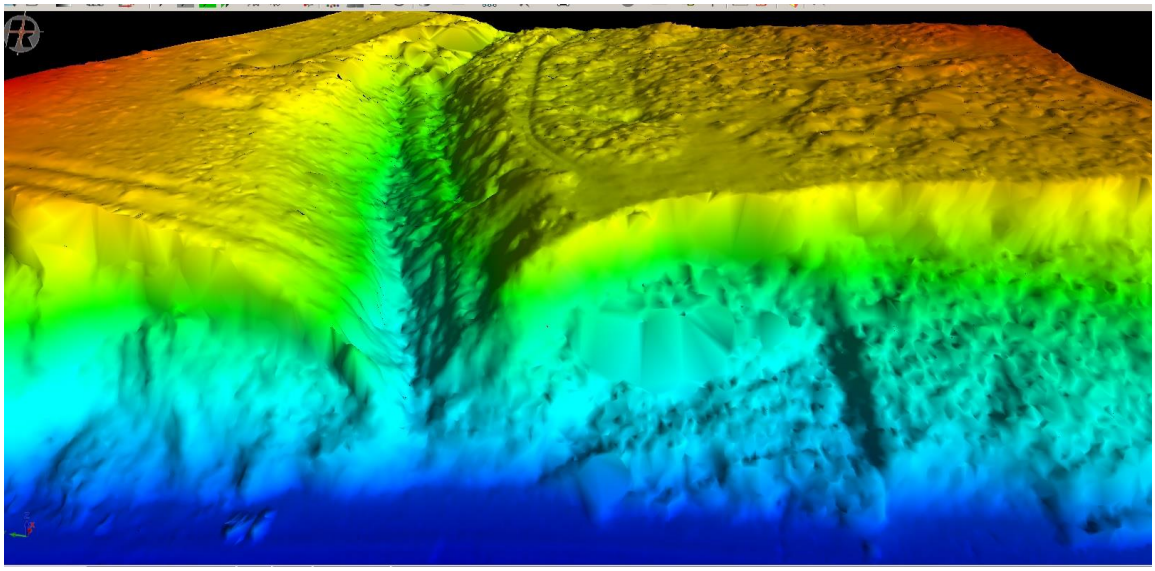


Fig. 13. Laser scanning relief model of complicate multistage landslide slope on Belbek site.

Engineering & geological probing (research) of sediment rocks of ravine and slide slopes.

Air Dron mapping

Methods and approaches of satellite geodesy in the construction of relief models

Sounding by the method of transient processes (ZPPP, MPP) and sounding by formation (ES, ZSB)

Electrical tomography (electromotography)

GeoInfoSystem (GIS)

Day 13 July 2017 Studying and forecasting the development of slope processes by remote methods at Nemeckaya Balka site

44.889908, 33.610810

Fig. 12. Nemeckaya Balka research site.

Schedule

9-00-17-00 Complex field geoengineering methods activity

13-00-13-30 Field lunch

Trip: By bus, follow from Sevastopol to Peschanoe sity to the Nemeckaya Balka site

Necessary gears and outfit: Good hiking boots and trousers of dense textile are a must. Raincoat, sun glasses and sun hat can be very useful. Ruler, photo-camera, shovel, sampling bags, gloves are optional.

Recommended reading prior to the field trip:

1/ The civil engineering – handbook, manuals, etc. I. Chen, Wai-Fah, 1936-TA151.C57, 1995

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4/ Geomorphological mapping on survey scale, etc. I Bashenina N.V., MSU publishing, 264, 1975 (in Russian)

The section of the coastal zone in the area of the Nemeckaya Balka was chosen from the point of view of the manifestation of shore abrasion, Here the characteristic features of this process are most clearly manifested - a large amount of clastic material of rocks of the Taurian suite is formed. There is a destruction of the coastal ledge, which has almost a vertical position.

To fix the speed of the abrasion coast retreat in 2016, an observation network of reference points was laid, a cartographic survey of the terrain was made and a topo- son survey was made for the study site.

The types of kinematic survey described above were applied by us during measurements on the monitoring sites of the Western coast of Crimea - a landslide slope near the city beach of Uchkuevka, a bank in the Lyubimovka, Nemeckaya Balka (Kacha) and Nikolaevka.

On each of the sites, work began with reconnaissance of the terrain, selection of points of installation of temporary bases fixed on the terrain, from which instrumental measurements would then be carried out. Then install the antenna. The tripod on which the antenna was mounted was securely fixed to ensure the antenna height remained unchanged during the measurements. The centering and leveling of the antenna was performed by an optical centering with an accuracy of 1 mm. The antenna was oriented to the north along the oriented arrows (marks).

The plan-altitude position of temporary bases is determined from constantly operating reference stations whose coordinates are in turn determined from the points of the State Geodetic Network.

At each monitoring site, we determined the planned altitude positions of characteristic points and relief lines (ie structural lines): the bank of the ledge of the root bank, the rear seam of the ledge and the sea edge. In a number of cases, additional surveying of characteristic and / or complicating forms of relief is carried out: the contours of landslide bodies, the position of cracks in the settling, the contour of cones-removal, etc.

It is also necessary to carry out the survey of the transverse profiles of the shore in different parts of the coast, including in complicated areas. If possible, the transverse profiles are fixed to the terrain for subsequent measurements.

The result of surveying with the help of geodetic satellite receivers is the catalog of the coordinates of the characteristic relief points. This catalog contains the points numbers, coordinates and codes denoting the characteristic of the point (the curb of the ledge, the sea edge, the ladder, the ditch, etc.). On the basis of this catalog it is possible to construct isolines of the relief of the monitoring section, and then to interpret the obtained materials and build a map of hypsometric levels.

3D laser scanning (lidar survey (http://art-geo.ru/))

Engineering & geological probing (research) of sediment rocks of ravine and slide slopes.

Air Dron mapping

Methods and approaches of satellite geodesy in the construction of relief models

Fig.13. The process of satellite geodetic work out on the Nemeckaya Balka research site.

Fig. 14. Part of the topographic map work out in ArcMap soft for the Nemeckaya Balka site.

Sounding by the method of transient processes (ZPPP, MPP) and sounding by formation (ES, ZSB)

Electrical tomography (electromotography)

GeoInfoSystem (GIS)

<u>Practical exercises for participants of the engineering field excursion</u>:

- to identify *in situ* coastal exogenic processes caused by erosion, abrasion, ground mass sliding, rock cracking rocks;
- to meet with classic and innovation engineering-geological methods of exogenic process research on the example of Uchkuevka scientific educational polygon;
- to meet with analytic way of complex engineering-geological method of evaluation of the risk of exogenic processes in the seaside;

Day 14 July 2017 Demonstration and discussion of some results of field research activity in 2016-2017/

Filial MSU in Sevastopol

Schedule

9-00-10-00 Lection "Geoinformation systems in engineering geology. Compilation of methods» Natalia Kosevich, MSU scientific staff

10-00-13-00 Demonstration and discussion of some results of field research activity in 2016-2017

13-00-14-00 Lunch

14-00-18-00 MARINE MAGNETIC EXPLORATION Andrey Koshurnikov, MSU Scientific staff

Trip: By bus, follow from Sevastopol to Balaklava sea port

Necessary gears and outfit: Raincoat, sun glasses and sun hat can be very useful. Photo-camera, gloves are optional.

Recommended reading prior to the field trip:

1. **Magnet survey: the Textbook, Grinkevich GI - Ekaterinburg: UGGA, 2001.-308 p.**
2. **Instruction on magnetic survey, Ministry of geology of the USSR. - L .: Nedra, 1981. - 263 p. (in Russian)**
3. **Magnet survey, Logachev AA, Zakharov VP 5 th ed., L., Nedra, 1979. 351 p.**
4. **Magnetorazvedka: Handbook of geophysics / Ed. VE Nikitsky, Yu.S. Glebovsky. - 2 nd ed. - M .: Nedra, 1990. 470 p.**

MARINE MAGNETIC SURVEY

Geophysicists have been able to develop a mathematical model for the earth's magnetic field, i.e., its shape and intensity across the surface of the earth, Magnetometer surveys indicate that there are many unexpected variations in this model, called "magnetic anomalies". A magnetic high anomaly is where the measured field strength is higher than the value predicted by the global model, and a magnetic low is where the measured field strength is lower than the value predicted by the global model. Anomalies in the earth's magnetic field are caused by induced or remanent magnetism. Induced magnetic anomalies are the result of secondary magnetization induced in a ferrous body by the earth's magnetic field. Possible causes for magnetic highs include the presence of magnetically charged rocks in the subsurface. Magnetic prospecting looks for variations in the magnetic field of the earth that are caused by changes in the subsurface geologic structure or by differences in the magnetic properties of near-surface rocks. The inherent magnetism of rocks is called the magnetic susceptibility. Sedimentary rocks generally have a very small magnetic susceptibility compared with igneous or metamorphic rocks, which tend to have a much higher magnetite (a common magnetic mineral) content. Most magnetic surveys are designed to map the geologic structure on or inside the basement rocks (the crystalline rocks that lie beneath the

sedimentary layers) or to detect magnetic minerals directly. The aim of a magnetic survey is to investigate subsurface geology on the basis of the anomalies in the earth's magnetic field resulting from the magnetic properties of the underlying rocks. In general, the magnetic content (susceptibility) of rocks is extremely variable depending on the type of rock and the environment it is in. Common causes of magnetic anomalies include dykes, faults and lava flows. Where the rocks have high magnetic susceptibility, the local magnetic field will be strong; where they have low magnetic susceptibility, it will be weaker. Rock units with higher susceptibility will show up as areas of high magnetic field strength. In a geothermal environment, due to high temperatures, the susceptibility decreases. Used with gravity, this method can be used to infer heat sources as seen from geothermal exploration at Olkaria. Ground magnetic measurements do provide more detailed information on sub-surface structures that could act as heat sources in comparison to aeromagnetic data. Magnetic gradient anomalies generally give a better definition of shallow buried features such as buried tanks and drums, but are less useful for investigating large geological features. Unlike EM surveys, the depth penetration of magnetic surveys is not impeded by high electrical ground conductivities associated with saline groundwater or high levels of contamination.

Fig.15. Magnet curvey from boats to determine the character of bottom sediments and tectonic disturbances on the coastal slope.

A magnetometer is a more complex instrument which measures both the orientation and strength of a magnetic field. When the magnetic field of a rock sample is measured, the result is actually a measure of the field as it is being effected by the earth’s magnetic field, as well as any other large bodies of magnetic rock which are near by. Magnetometer surveys measure small, localised variations in the Earth's magnetic field. Magnetometers are highly accurate instruments, allowing the local magnetic field to be measured to accuracies of 0.002%. There are several types of instruments on the market. The common ones used for commercial applications are the proton precession, fluxgate, caesium vapour and gradiometer magnetometer systems. The systems

operate on broadly similar principles utilising proton rich fluids surrounded by an electric coil. A momentary current is applied through the coil, which produces a corresponding magnetic field that temporarily polarises the protons. When the current is removed, the protons realign or precess into the orientation of the Earth's magnetic field. The precession generates a small electrical current in the surrounding coil, at a frequency directly proportional to the local magnetic field intensity. Gradiometers measure the magnetic field gradient rather than total field strength, which allows the removal of background noise. Gradiometers measure the magnetic field gradient rather than total field strength, which allows the removal of background noise.