

## GRAVITY AND MAGNETIC DATA INVENTORY FOR INVESTIGATION OF THE BLACK SEA REGION

The paper presents an inventory of the available gravity and geomagnetic data for studying geological structures and geodynamical processes in the Black Sea region. A short analysis of the compiled free-air gravity anomaly map from *in situ* data of the sea is performed. The geomagnetic data acquisition over the Bulgarian territory and western part of the Black sea is presented. Some new sources of the gravity and geomagnetic data from satellite missions are indicated.

**Key words:** gravity and geomagnetic field; data base; Black Sea.

### Introduction

Geological and geophysical studies of the Black Sea region help to clarify the various aspects of the often conflicting scientific views on evolution, geological, tectonic processes and crustal structures in depth. With the availability of advanced geophysical methods and satellite technologies for obtaining, processing and presentation of variety types of data, we have the capability to extract more useful information for discovering the geological structural heterogeneity and to expand the scientific exploration in this region. An overview of different sources for available national and international geophysical and geodetic data bases is done.

### Available gravity and geomagnetic data for the Black Sea region *In situ* and satellite gravity data

A gravity map of the Black Sea area (free-air anomalies at sea and Bouguer anomalies on land) is presented in Fig. 1. Its marine part is based on a 1:1000000 scale map compiled from about 35000 *in situ* observations made in the period around over 40 years. These data were collected by various industrial and academic organizations from the former Soviet Union [Starostenko et al., 2004]. Different instruments and navigation systems were used although all data have been reprocessed to a common standard and are referenced to IGSN71. The free-air anomaly error from all processed data is estimated to be  $\pm 1,6$  mGal. The Bouguer anomalies (onshore part on Fig. 1) are from ZNIIGAiK (the Central Research Institute of Geodesy, Air Survey and Cartography of the former Soviet Union).

Despite the significant thickness of young, roughly flat-lying sediments in the Black Sea and their more or less constant thickness within the basin, there exist local positive and negative gravity anomalies with magnitudes up to several tens of milligals. Near the Bulgarian shelf, for example, a circular anomaly with individual observable values below -85 mGal is observed. The center of another gravity anomaly (values below -80 mGal too) can be seen over the Sorokin Trough (southeast of Crimea). Other large gravity anomaly with amplitude of about -85 mGal is established adjacent to the Greater Caucasus coast. Near the eastern Anatolian coast, an offshore gravity anomaly is correlated with the significantly negative gravity field of the Eastern Pontides.

Further, isolated gravity anomalies with large amplitude are observed in or near to the margins of

the Black Sea Basin (northwestern shelf), which extend into the land areas. Their marine termination nearly always coincides with the 200 m isobath. In the western sub-basin, two positive anomalies of 60-70 mGal are occurring and they comprised the area from the western boundary of the Burgas zone to the West Pontides. On the boundary between the Black Sea Basin and the Gulf of Odessa, the Gubkinsky gravity maximum (over Gubkin Rise) is of about 80 mGal. On the northern margin, there is a gravity maximum which extreme value of over 180 mGal is associated with the Crimean Mountains. The large West Caucasus anomaly (with magnitude more than 100 mGal) is located on the northeast margin of the Black Sea. In the easternmost Black Sea, the positive anomaly is with magnitude of more than 40 mGal. The southern margin is characterized by two positive gravity anomalies each with values above 70 mGal. The first is situated southeast of Sinop and the second is to the west.

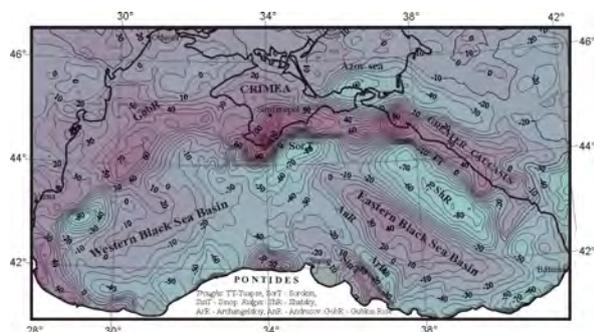
There are also several negative gravity anomalies along the Anatolian coast, with amplitudes considerably larger than the background values. These zones include gravity anomalies adjacent to the Western Pontides and big negative anomalies in the Eastern Pontides with values of -30 to -55 mGal, respectively. The gravity field in the adjacent continental areas correlates with deep structures of the individual geological features.

In Bulgaria, due to special regulations and license regime of the national legislation for geophysical exploration the acquired geophysical data are the property of the respective institutions and private companies. These data are collected, stored and processed by several organizations as the National Geological Fund, the Geocartfund at the Geodesy, Cartography and Cadastre Agency, the Military Geographic Service, several research institutes at the Bulgarian Academy of Sciences, etc.

The International Gravimetric Bureau (<http://bgi.omp.obs-mip.fr/>) collects, archives, validates and distributes the gravity data for all over the world. The density of the available marine gravity data coverage varies throughout for the Black Sea basin. Gravity data for this region are available from several shipboards surveying, which were carried out in the 60-70-ies of the last century. Data from new marine gravimetric measurements are available from national databases of the Black Sea countries.

Since October 2011 the NOAA's National Geophysical Data Center ([www.ngdc.noaa.gov](http://www.ngdc.noaa.gov)) as World

Data Service for Geophysics is one of the worlds's leading providers of geophysical and environmental data, information, and products. These data include gravity, bathymetry, magnetic, and seismic navigation data collected during marine cruises from 1953 to the present covering worldwide. Data sources include both US and foreign oceanographic institutions and government agencies.



**Fig. 1.** Simplified anomaly gravity map of the Black Sea region: free-air anomalies (at sea) and Bouguer anomalies (on land). Contour interval is 10 mGal

There are several gravity anomaly data sets for the Black Sea compiled from different satellite altimetry missions. Some of the international centers providing such data are: the International Altimetry Service (<http://ias.dgfi.badw.de>), the International Gravity Field Service ([www.igfs.net](http://www.igfs.net)), the Scripps Institute of Oceanography, University of California San Diego (<http://gdc.ucsd.edu>), USA, etc.

***In situ and space geomagnetic data***

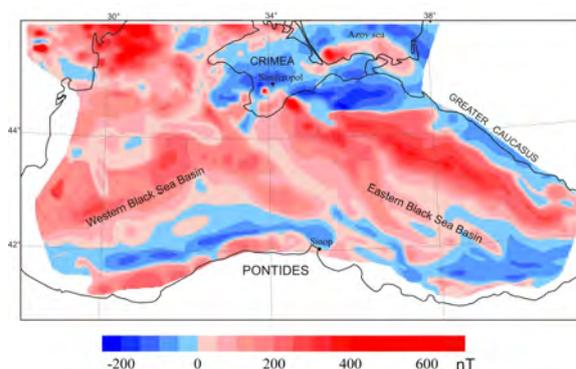
**Bulgarian coastal data.** The results of the general survey in 446 settlements (1958 - 1960), in which D, I, H, Z, T-components of the Earth's magnetic field have been measured are the basis of geomagnetic researches in Bulgaria. Based on these studies the normal field for all geomagnetic components was constructed and their anomalous values were calculated [Kostov & Nozharov, 1974]. For the territory of Bulgaria an anomaly map of the vertical component  $\Delta Z$  was made [Trifonova et al., 2012], as well as a map of the  $\Delta T$  anomalies for small part of the coast and the Black Sea water [Gerovska et al., 2010]. Geomagnetic measurements data for the total field intensity along the Bulgarian Black Sea coast for epoch 1970.0 are available in the Bulgarian Geomagnetic Service database at the National Institute of Geophysics, Geodesy and Geography at the Bulgarian Academy of Sciences. These data include observations for 104 points in geographical coordinates.

**Black Sea marine data.** The data for the Earth magnetic field for the Black Sea region are published in [Map..., 1990; Malovitskiy, 1972]. Marine data are available in the National Geophysical Data Center (OCN) Boulder, Colorado from 2003. The data are for profiles (trk68996 MAGNETICS) in the digital format

for the storage of XYZ geospatial potential field data ([www.ngdc.noaa.gov/mgg/geodas/trackline.html](http://www.ngdc.noaa.gov/mgg/geodas/trackline.html)).

Digital magnetic anomaly maps of the Black Sea and adjacent areas are given in [Kravchenko et al., 2003; Purucker, 2007]. On Fig. 2 a map of the anomalous magnetic field  $\Delta T$  for the studied area is presented.

**Black Sea MAGSAT and CHAMP satellite data.** NASA launched the magnetic field satellite MAGSAT to examine specifically large- and medium scale lithospheric anomalies. The data measured by MAGSAT have been used to study the distribution of crustal magnetization in an area between 25°- 45° E longitude and 35°- 45° N latitude. MAGSAT maps were prepared by extracting the external and main field from the measured data. The data indicates that negative magnetization values are over the east Black Sea due to a thick pile of the sedimentary rocks and semi-oceanic crust.



**Fig. 2.** The anomalous magnetic field  $\Delta T$  of the Black Sea

CHAMP satellite data are used for preparation of the World Magnetic Anomaly Map [Maus et al., 2007]. The magnetic fields shown on this map are designed to be internally consistent over the measurement domain, extending from the Earth's surface to the satellite altitude. The magnetic anomaly field model MF5 shown on this map is derived by upward continuation of the geomagnetic field data to the satellite altitude. Long-wavelength features shown on the map are based on downward continuation of the MF5 model. Short-wavelength anomalies are from marine and aeromagnetic compilations computed at 5 km altitude or from a model based on a digital age map of the ocean combined with the geomagnetic polarity time scale.

***Conclusions***

The recent progress in gravity and magnetic methods and the qualities of surface, marine, airborne, and satellite measurements expand the possibilities to study the Black Sea region. Up-to-date gravity and magnetic surveys are a valuable source of data for engineering, petroleum, mineral, environmental, geological and archeological exploration of the lithosphere as well as for improvement of potential-field interpretation, modeling of geological structures and

geodynamic processes. New satellite-derived gravity and geomagnetic data allow an optimal combination with *in situ* observations, which enable to perform researches everywhere in the sea. Further efforts for data standardization, homogenization and full-value usage of the available information are needed for resolving a broad spectrum of scientific and practical problems.

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### УЗАГАЛЬНЕННЯ ГРАВІТАЦІЙНИХ І МАГНІТНИХ ДАНИХ ДЛЯ ДОСЛІДЖЕНЬ ЧОРНОМОРСЬКОГО РЕГІОНУ

**Б. Сребров, М. Орлюк, Л. Пашова, І. Макаренко, О. Марченко, О. Савченко**

В статті наведено нові гравітаційні та магнітні дані для вивчення геологічних структур та геодинамічних процесів в регіоні Чорного моря. Проведено короткий аналіз створеної карти аномалій у вільному повітрі Чорного моря. Представлені геомагнітні дані території Болгарії та західної частини Чорного моря. Також наведені нові набори гравітаційних та геомагнітних даних, отриманих за допомогою супутникових місій.

**Ключові слова:** гравітаційне і магнітне поле; база даних; Чорне море.

### ОБОБЩЕНИЕ ГРАВИТАЦИОННЫХ И МАГНИТНЫХ ДАННЫХ ДЛЯ ИССЛЕДОВАНИЯ ЧЕРНОМОРСКОГО РЕГИОНА

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В статье приведены новые гравитационные и магнитные данные для изучения геологических структур и геодинамических процессов в регионе Черного моря. Проведен краткий анализ созданной карты аномалий в свободном воздухе Черного моря. Представленные геомагнитные данные территории Болгарии и западной части Черного моря. Также приведены новые наборы гравитационных и геомагнитных данных, полученных с помощью спутниковых миссий.

**Ключевые слова:** гравитационное и магнитное поле; база данных; Черное море.