MAGNETIC SOURVEY OF THE DANUBE RIVERBED FROM km 795^{+610} TO km 796^{+030} (THE AREA OF THE NEW BRIDGE OVER DANUBE RIVER VIDIN-KALAFAT)

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Abstract: *The article observe carried out of magnetic survey on the area of new bridge over Danube river Vidin-Kalafat The project for a new bridge over Danube river at Vidin-Kalafat started in the beginning of 2003. Organization and conduct of the field campaign take place during the months of July and August 2007.*

МАГНИТНО ПРОУЧВАНЕ НА КОРИТОТО НА РЕКА ДУНАВ ОТ km 795^{+610} ДО km 796^{+030} (РАЙОНА НА НОВИЯ МОСТ НА РЕКА ДУНАВ ВИДИН-КАЛАФАТ)

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Резюме: *Работата разглежда проведеното магнитно проучване на района на новия мост на река Дунав Видин-Калафат. Проектът за нов мост на река Дунав при Видин-Калафат стартира през 2003 г. Организацията и провеждането на полевите магнитни работи беше през м. юли и август 2007 г.*

The project for a new bridge over Danube river at Vidin-Kalafat started in the beginning of 2003. The project consortium was formed from UK and Spanish companies and Bulgarian participation and he predicted survey of the riverbed of Danube river at km 796, affected by construction works. According to the requirements for identification, assessment and risk management of construction of the facility has provaided a map of the riverbad 1:2000 and geomagnetic survey to detect buried objects including munitions of the wars.The task associated with the realization of such a project, implemented first in the country, was commissioned by the developer of the site Spanish FCC CONSTRUCTION of "VIDASOF" Ltd. with a contract from 04.07. 2007. Organization and conduct of the field campaign take place during the months of July and August 2007 by a team led by Bozidar Srebrov from Bulgarian Academy of Sciences (BAS) and participation of Iliya Cholacov and Dimitar Ognianov. The equipment for the task is provided by "HYDROREMONT IG" Ltd. - Varna, BAS and "VIDASOF" LTD. For correctly reporting the results of geomagnetic studies of the area affected by the construction of the bridge has been used 3D-model of riverbed provided by "VIDASOF" LTD.

Principal survey data:

1. Investigated section of the river Danube 70 m upstream 150 down-stream to km 795^{+910}
2. Coordinate system: local (bridge-related)
3. Scope of the magnetometric survey: 10.1 ha
4. Water level variation during magnetometric measurements in km 795^{+910}: 26.2 - 26.8 m Baltic Elevation System.
5. Water depth variation during magnetometric measurements in km 795^{+910}: 8.6 – 10.2 m.
6. Method of magnetometric survey: geomagnetic field deviation
7. Accuracy of the measurements of the geomagnetic field: 1 nT
8. Accuracy of positioning of the sensor: 1 m.
9. Method of hydrographic survey: echo sounding measurements
10. Total number of measured points in the digital model describing the anomalous field: 3080
11. Number of survey gals: 24
12. Number of land control points: 1
13. Average spacing between the survey gals: 18 m
14. Speed of the survey vessel along the survey gals: 2-3 km/h
15. Frequency of magnetic field measurements along the profile (gal): every two seconds
16. Total length of the navigation canal survey profiles: > 220 m

I. General Remarks

I.1. Scope of the task

The field campaign for magnetic survey of the riverbed of the river navigation canal touched by project "New Bridge over Danube River" was conducted between 31 July and 6 August 2007. The scope and contents of the performed activities comply with the Investor's Assignment Note and Bulgarian standards.

The investigation site-focus in water territory occupied of navigation canal from km 795^{+610} to km 796^{+030} and width 600 m (water level 27) , according to the investor's assignment. Equipment's setting-up is accordingly investor's requirements for detection of sunken objects; including ammunition from past wars - metal objects over 50 kg.

Before begging was executed:

- Equipment calibration.
- Site investigation of magnetic field.
- Set-up of work parameters
- Equipment synchronization

Magnetometric investigations were made in three stages:

1 stage - site investigation in general and determine the zones for detail investigations.

2 stage - Detail magnetometric survey.

3 stage - Result annalist, recommendations for addition investigation include diver inspection.

The detailed magnetometric survey of the riverbed covers the area 220 m along the coast and 460 m across the river 24 survey profiles along the coast with 18 m average interval was projected for preliminary investigation of geomagnetic field. The length of the survey profiles is 220 m. The parameters of implementation of the magnetometric survey comply with the requirements of Investor' Assignments.

I.2. Equipment

Equipment for localization of the metal objects includes:

- Magnetometer Proton-4 for investigations in the water territory
- Proton magnetometer PMP-5A for land measurements
- GPS- receiver – Aquarius 5000- Desault-Sersel
- Motor cater – 4.5 t.

Calibration of the Proton-4 magnetometer was made by PMP- 5A standard magnetometer from Geomagnetic Observatory (PAG) at the Geophysical Institute, Bulgarian Academy of Sciences.

I.3. Work organization

One team was established for implementation of the task composed of Capitan, Hydrograph, Geophysicists (specialists in the geomagnetism) and Surveyor.

Team participators:

- Assoc. prof. *Bozhidar Srebrov* – Head of Geomagnetic Service.
- Assoc. prof. *Iliya Cholakov* – Head of Geomagnetic Observatory.
- Diver- *Ivailo Dushkov*.
- Hydrograph – Dr. *Dimitar Ognianov*.
- Data processing - *Bozhidar Srebrov, Peter Petsinski.*

I.4. Methodology and technology

The investigations for obtaining of geomagnetic anomalies, caused by ammunitions from past wars or different artificial magnetic disturbers consist:

- Preliminary calibration of the Proton -4 magnetometer and reference land measurements by PMP-5A magnetometer.
- Carry-out of site investigation in general and determine the areas for detail investigations.
- Carry-out of the detail magnetometric survey.
- Data processing including comparison with data from the Geomagnetic Observatory Panagyurishte (PAG). Preparation of maps and 3D model of the disturbed geomagnetic field of the riverbed.

GPS technology for determination of positioning, geomagnetic survey and specialized software for design, control and processing of data have been used in the process of design of a geomagnetic map and a 3D model of the anomalous geomagnetic field near the riverbed.

I.5. Regulatory framework

See the References of this article.

II. Instrument Calibration and Site Survey in General

II.1. Instrument calibration

The operative geomagnetic control was made as follows:

1. Calibration of Proton-4 magnetometer was made by PMP-5A standard observatory magnetometer:

- The both magnetometers sensor in one place on the land was sited.
- With every one magnetometer 10 simultaneously measurements was made.
- The average values measured by the magnetometers are as follows:

Magnetometer	Average values of the magnetic field
Proton -4	48 617 nT
PMP -5A	47 643 nT

The instrument calibration value for Proton -4 magnetometer is:

48617 nT - 47 643 nT = - 973 nT.

2. Comparisons of geomagnetic field data from km 795^{+610} to km 796^{+030} area of Danube River with data for total geomagnetic field F from Geomagnetic Observatory PAG during time intervals during measurements on the every one of the geomagnetic profiles.

II.2 Site investigation in general

The magnetometric survey in general near the riverbed covers the area 220 m along the coast and 460 m across the river and 4 survey profiles along the coast with 100 m average interval were measured for preliminary investigation of geomagnetic field. The length of these survey profiles is > 220 m.

III. Detail Magnetometric Survey

III.1. Method and technology

The survey of the geomagnetic field has been conducted by the measurements in the river water with time interval 2 seconds. Water-depths during the geomagnetic measurements have been 8.6 – 10.2 m and the width of the accessible investigation area was 460 m. The number of survey gals was 24 with average spacing between the survey gals -18 m. For determination of positioning and time during the geomagnetic measurements the GPS receiver was used. The average distance between magnetometer sensor and the riverbed surface was 3.5 m. The distance between Motor cater and the magnetometer sensor was 60 m. The magnetometer investigation of the underwater area was made by JW FISHERS INC *Tracker II* software installed in a computer, which worked in synchronization with the magnetometer and the GPS receiver. The geomagnetic field was measured in 3080 points in the investigation area.

IV. 3D Model of the Anomalous Geomagnetic Field

IV.1. Description of the model

The 3D model of the anomalous geomagnetic field is created by separation of the geomagnetic variations (registered in the geomagnetic observatory) from the site-measured geomagnetic field data and by optimization procedure for obtaining of the disturbed areas which contain local minimums of the geomagnetic field. On the base of the model are obtained the areas with considerable negative geomagnetic field deviation. These disturbed areas could be associated with ferromagnetic bodies which eventually can change the normal geomagnetic field. After data processing was derived 73 points with anomalous geomagnetic field which can be used for planning of detailed diver searches in these areas.

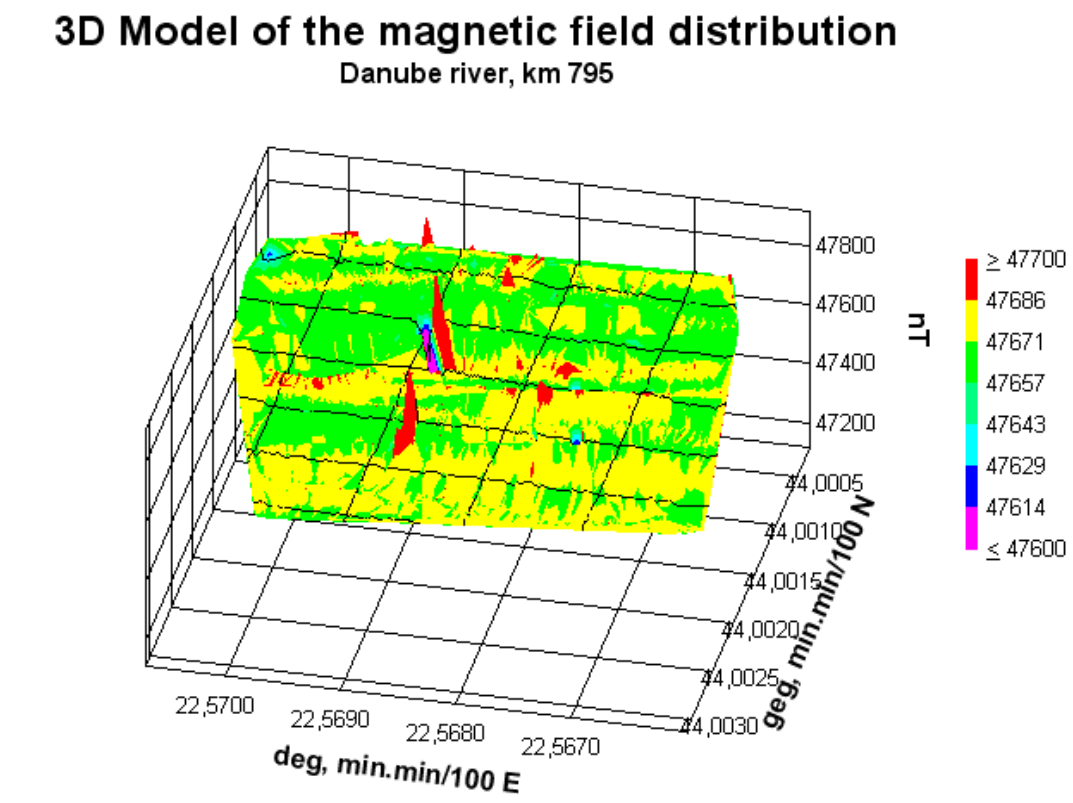
IV.2. Results

The all 3080 points in the water section have been used for representative description of the anomalous geomagnetic field and for creation of the 3D model. The accuracy of the measurements of the geomagnetic field is 1 nT and optimization level step for obtaining of the disturbed zones is 14 nT. The value of the negative geomagnetic field deviation at distance 3.5 m between magnetometer sensor and one ferromagnetic metal body with mass 50 kg is > 28 nT.
The equipment and the results from data processing are shown further down:

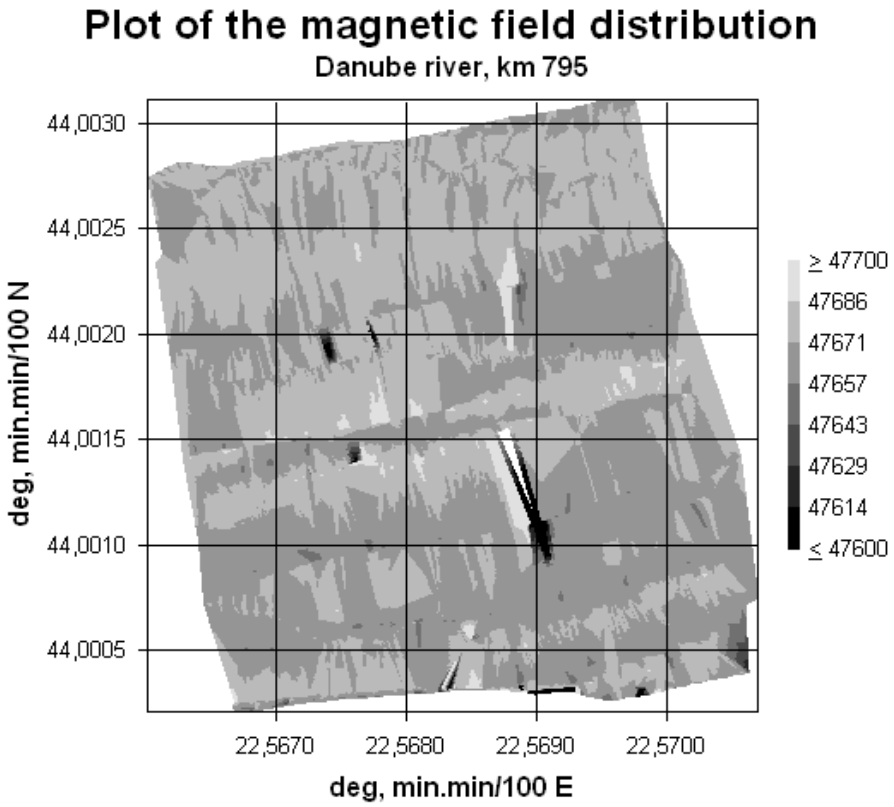
Equipment for magnetic water survey

The Sensor of Proton-4 magnetometer

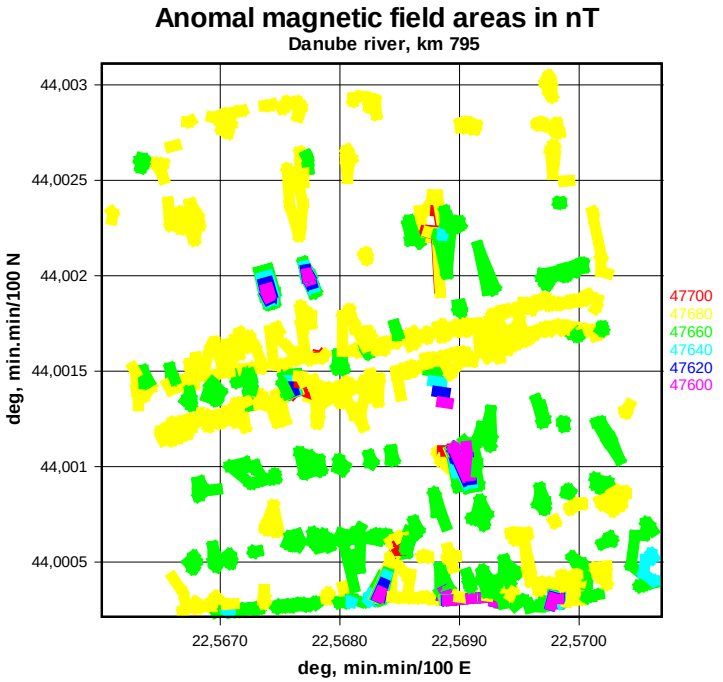
On the first picture is shown the 3D model of the disturbed geomagnetic field in the investigated area. The geomagnetic field values are in the interval between 47 600 and 47 700 nT. The magnetic field with values below 47 671 nT is eventually influenced by disturbers on the riverbed and under the riverbed surface in small dept.



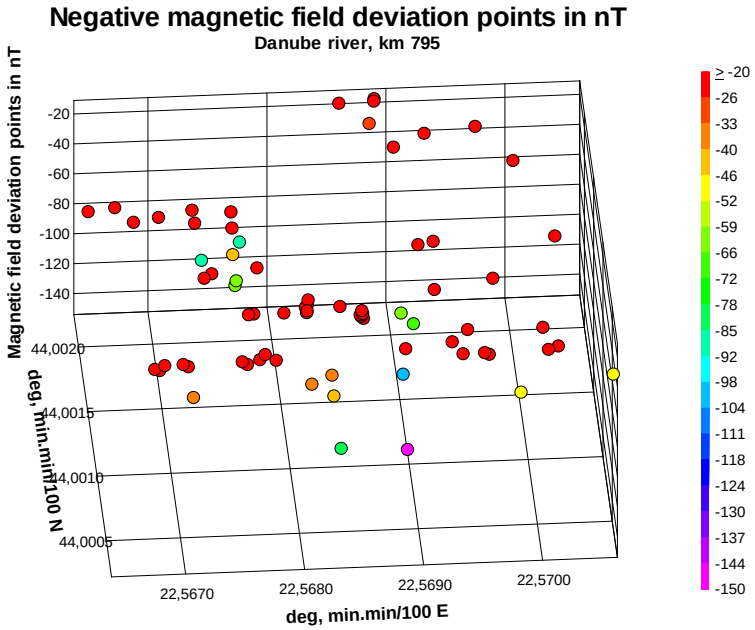
The next picture is a plot of magnetic field distribution in the investigated area.



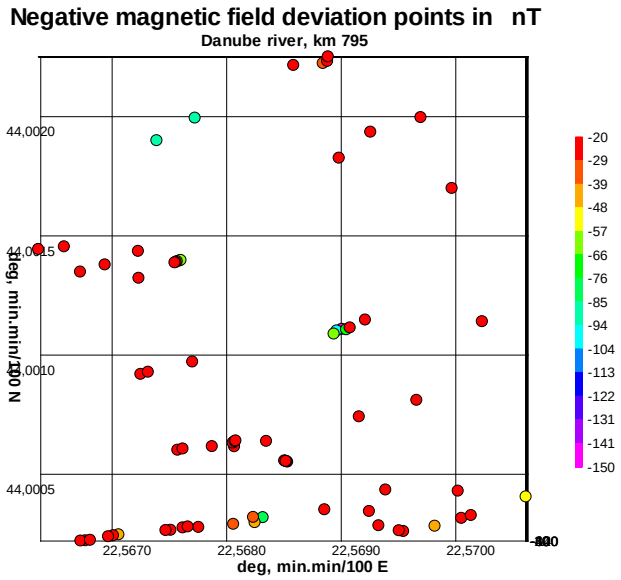
After application of the optimization procedure for obtaining of areas with anomalous magnetic field values the next plot was draw. All spots on this picture are areas with disturbed magnetic field caused the eventually disturbers which can be on the river-bed and under the river-bed surface.



Through data processing was derived 73 points with anomalous geomagnetic field which are containing in the areas with anomalous magnetic field. These points are shown in the next scatter plot:



The places in the magnetic field deviation points in the investigated area can be see on the next plot:



The coordinates of these negative magnetic field deviation points are described further down. These coordinates can use for planning of detailed diver searches in the areas around the points.

Negative magnetic field deviation points

Coordinates deg, min.min/100		deviation nT	Coordinates deg, min.min/100		deviation nT
22.568551	44.000551	-17	22.567683	44.000279	-15
22.568545	44.000553	-14	22.569265	44.000344	-17
22.568538	44.000554	-12	22.570629	44.000405	-48
22.568532	44.000555	-16	22.567270	44.000919	-18
22.568525	44.000556	-15	22.567335	44.000928	-16
22.568100	44.000640	-11	22.567722	44.000971	-17
22.568093	44.000637	-14	22.568970	44.001101	-103
22.568087	44.000635	-19	22.569008	44.001108	-154
22.568076	44.000631	-15	22.569230	44.001147	-19
22.567614	44.001397	-62	22.569277	44.001935	-15
22.567604	44.001395	-65	22.566377	44.001443	-16
22.567584	44.001392	-44	22.566602	44.001454	-15
22.567577	44.001389	-26	22.569987	44.001699	-15
22.567568	44.001387	-15	22.566746	44.000220	-17
22.567253	44.001322	-16	22.566787	44.000221	-18
22.568860	44.002223	-32	22.566830	44.000223	-15
22.568900	44.002232	-18	22.566988	44.000238	-16
22.569347	44.000284	-20	22.567031	44.000242	-18
22.569525	44.000263	-18	22.567075	44.000246	-39
22.569563	44.000260	-19	22.567489	44.000264	-18
22.569834	44.000282	-47	22.567532	44.000265	-20
22.570070	44.000315	-22	22.567775	44.000277	-19
22.570154	44.000327	-21	22.568077	44.000290	-37
22.570251	44.001140	-18	22.568263	44.000297	-46
22.568951	44.001088	-61	22.568875	44.000351	-21
22.569058	44.001106	-70	22.569408	44.000434	-17
22.569097	44.001114	-18	22.567593	44.000601	-16
22.566743	44.001348	-16	22.567638	44.000606	-16
22.566958	44.001378	-16	22.567893	44.000616	-17
22.567248	44.001435	-17	22.568088	44.000615	-16
22.569002	44.001826	-14	22.568367	44.000638	-16
22.569715	44.001996	-17	22.569177	44.000741	-16
22.567400	44.001899	-91	22.569679	44.000810	-16
22.567734	44.001994	-88			
22.568604	44.002215	-17			
22.568906	44.002251	-18			
22.568251	44.000319	-34			
22.568328	44.000318	-83			
22.570040	44.000429	-17			
22.567638	44.000275	-18			

References:

1. IAGA Guide for Magnetic Measurements and Observatory Practice by J. Jankowski and C. Sucksdorff, 1996.
2. IAGA Guide for Repeat Station Surveys by L.R. Newitt, C.F. Barton and J. Bitterly, 1997.
3. Quality Assurance Certificate for Proton - 4 magnetometer.