JOURNAL OF THE BALKAN GEOPHYSICAL SOCIETY, Vol. 3, No 3, August 2000, p. 45-52, 7 figs.

Maglodan Project: The first step in merging the national geomagnetic maps of Romania, Ukraine and the Republic of Moldova

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(Received 3 January 2000; accepted 13 March 2000)

Abstract: *This paper deals with the compilation of large-scale composite geomagnetic maps. A joint venture between the Geological Institute of Romania and the Institute of Geophysics of the National Academy of Sciences of Ukraine started in 1998 in order to join the national geomagnetic maps of Romania and Ukraine (UKROMM project). Later on, the Institute of Geophysics and Geology of the Moldavian Academy of Sciences joined the project by providing data for the Moldavian territory. As a first step in merging the national geomagnetic maps, some pilot-maps have been constructed for a small area, in the Low Danube region. This area encompasses parts of the territories of the three co-operative countries (MAGLODAN sub-project). Secular variation distortions have been reduced and data were brought to a common datum by employing a common geomagnetic reference network. Based on the consistent geomagnetic data set some geomagnetic images for the Low Danube area are finally presented.*

Key Words: *Geomagnetism, Secular Variation, Composite Maps, Romania, Ukraine, Republic of Moldova.*

INTRODUCTION

There is a general tendency in the Earth's sciences world to merge geophysical images over the state borders to solve large-scale geological problems. At the beginning of 1998 a joint venture of the Geological Institute of Romania and the Institute of Geophysics of the National Academy of Sciences of Ukraine was initiated. Later on, the Institute of Geophysics and Geology of the Moldavian Academy of Sciences joined the project. The basic aim of the project is to merge the national geomagnetic maps of the three neighboring countries: Romania, the Republic of Moldova and Ukraine.

The main project was scheduled in two phases. The first step was the construction of a pilot geomagnetic map for the Low Danube area that encompasses small regions belonging to the participant countries (Fig. 1). The operation was named MAGLODAN (**MAG**netic **LO**w **DAN**ube) sub-project and it was aimed to solve some basic problems that would be faced in the overall merging operation:

- comparing national geomagnetic standards;
- providing a common reference level;
- removing the secular variation effect;
- overcoming administrative problems;
- training scientists from the participant countries for the next more developed phase of research, etc.

The final stage of the project is scheduled for the year 2000 and its final product will be the construction of a common geomagnetic map of the three participant countries.

COMPARING THE NATIONAL GEOMAGNETIC STANDARDS

The first problem that should be examined in an attempt to merge national geomagnetic maps is represented by the possible differences between the geomagnetic standards used. Usually, the national geomagnetic observatories of each country provide these standards. The Republic of Moldova has no geomagnetic observatory and actually all determinations used for the geomagnetic mapping of its territory were carried out by a Ukrainian team.

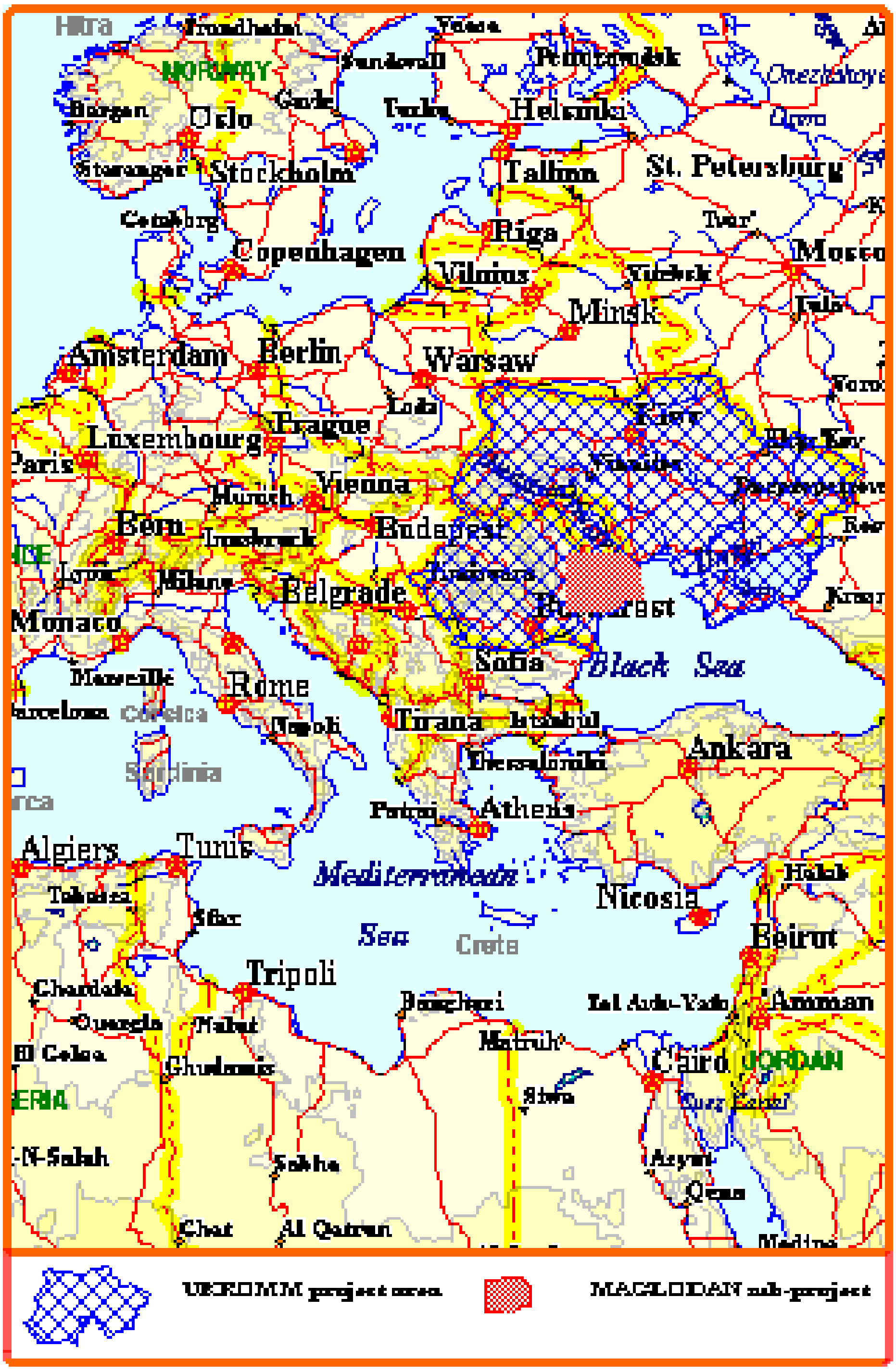

FIG. 1. Study area location.

As it was expected, the analysis of the records made at the Surlari Geomagnetic Observatory (Romania) and Stepanovka-Odessa Geomagnetic Observatory (Ukraine) showed both similar aspects and lack of connection. The differences could be explained by the large distance between the two observatories, but discrepancies between instrument standards could not be *a priori* denied.

In order to compare the geomagnetic standards used for the construction of the national geomagnetic maps, a Romanian-Ukrainian group worked jointly at the above-mentioned observatories. A GEOMETRICS and an MP-01 (USSR made) proton magnetometers were used to compare their reference level. No systematic difference was found except for a small scattering (± 1 nT), that can be fully justified by the instrumental accuracy.

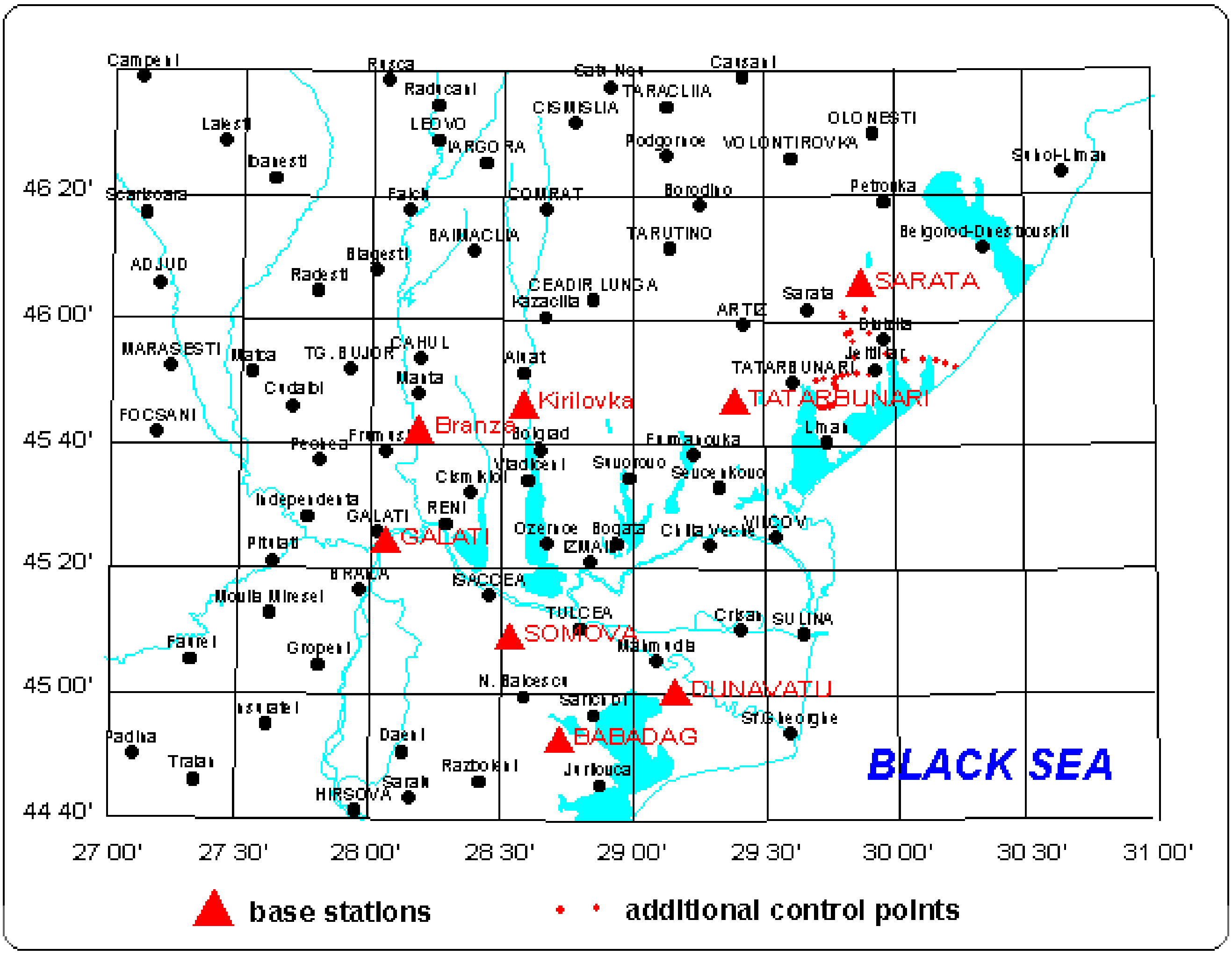

FIG. 2. The MAGLODAN geomagnetic reference network design

SETTING UP THE GEOMAGNETIC DATUM

As in the case of any composite geomagnetic map, one of the main problems was to assess a common datum for the various data sets acquired during surveys carried out at various epochs, with different instruments and reference levels. Such discrepancies could cause severe problems and made it the object of a thorough analysis for US aeromagnetic data (Grauch, 1993).

It has been shown (Beşuţiu and Beşuţiu, 1994) that a control network for the whole area of the composite map could solve this problem. Therefore, a common international reference network covering the area of the future pilot-map was established (Fig. 2). It consisted of 8 base stations: 4 in Romania (Dunavăţu, Babadag, Somova and Galaţi), 2 in Ukraine (Sărata and Tatarbunar) and 2 in the Republic of Moldova (Brânza and Kirilovka). In each base station location (usually chosen within areas having no, or weak, geomagnetic anomaly), a micromagnetic survey (about 100 m by 100 m with a stations spacing of 10 m) was conducted in order to avoid man-made geomagnetic noises (see, for instance, Fig. 3). The intricate pattern of the geomagnetic field, with high gradients, on the Ukrainian shield imposed the construction of some control lines located between the network base stations, to add information concerning the geomagnetic datum.

The data collected were then referred to the geomagnetic level of the Surlari observatory by using a previously checked methodology (Beşuţiu and Beşuţiu, 1987). Thus, a consistent data set of the ground total intensity scalar of the geomagnetic field, as annual mean values for the epoch 1998.0 were obtained.

To compare and correct the datum of the various geomagnetic surveys used in the construction of the composite pilot-map, according to the geomagnetic level provided by this consistent ground data set, the reference network data were continued upward (Ivan, 1994) to the flight altitude of the airborne measurements.

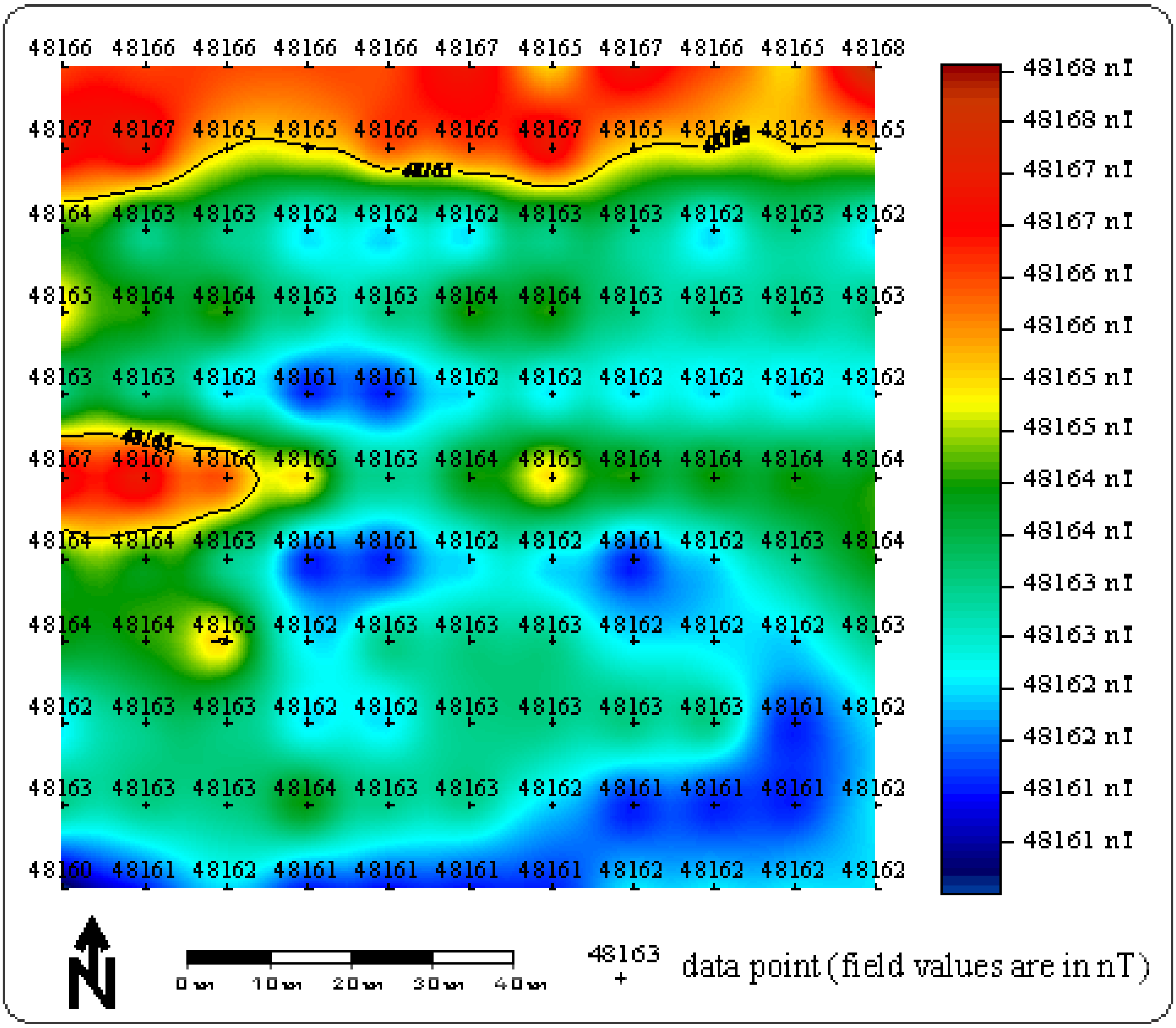

FIG. 3. The ground total intensity of the geomagnetic field in the area of Dunavatu (Romania) base station.

CONSTRUCTION OF THE MAGLODAN GEOMAGNETIC MAPS

Analysis of raw data

The regional airborne magnetic survey of the Romanian territory was carried out between 1962-1968 by SC"Prospectiuni SA" company (Cristescu and Stefanciuc, 1968). Within the study area, constant flight altitude panels of 400 or 600 m and lines spacing of 500 or 1000 m were used. The location of data points along the flight lines and values of the total intensity field have been stored in a computer database. Lower altitude data were continued upward to the 600-meter altitude.

For the whole area of the former Soviet Union (i.e. including the Ukrainian and Moldavian territories) a previous attempt was made to construct a common geomagnetic map (Simonenko and Pashkevich, 1990), but in those days surveys made at various epochs with various instruments, flight altitudes and geomagnetic datum were joined by simple visual fitting that was considerably below the map accuracy.

Within the present attempt all parameters of the geomagnetic surveys carried out within the MAGLODAN area were taken into account.

Airborne measurements for the Moldavian area were conducted during 1980–1985, with a 500-meter line spacing and a terrain clearance of 250 m.

Two sets of airborne geomagnetic data for the Ukrainian territory were used:

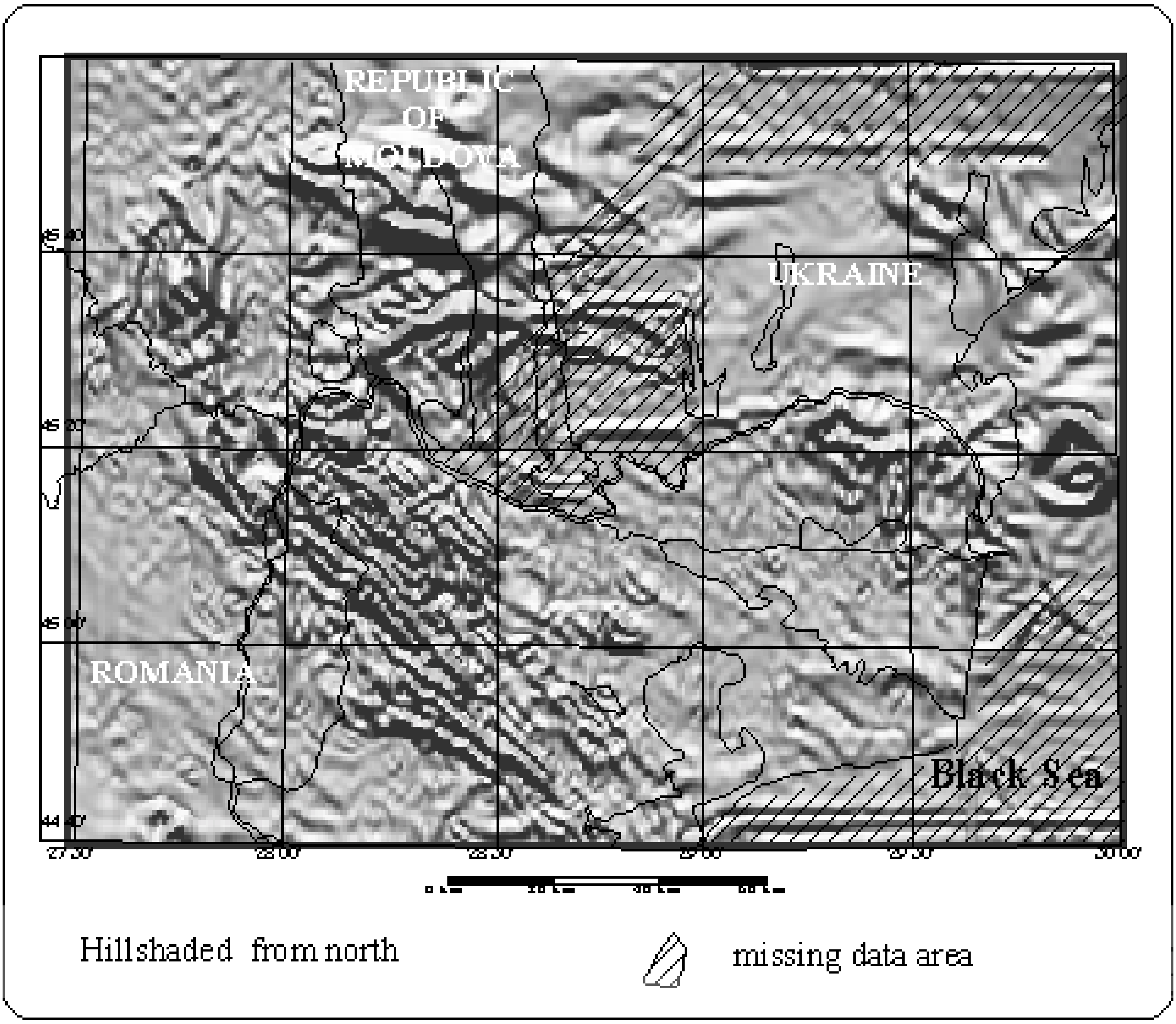

FIG. 4.Horizontal gradient of the total intensity scalar of the geomagnetic field of the Low Donabe area.

- a regional survey at the epoch 1965, with a line spacing of 2000 m and flight altitude of 300 m;
- an airborne survey, at the 1980 epoch, was conducted at a flight altitude of 250 m with a line spacing of 500 or 1000 m.

Unlike the Romanian area of the map, geomagnetic anomaly (ΔTa) contour maps were only available as raw data for the Moldavian and Ukrainian territories. Mentions should be made to the fact that at that time graphical models of the geomagnetic reference field constructed by LO-IZMIRAN (the Sankt Petersburg branch of IZMIRAN) were used to compute the geomagnetic anomaly.

Therefore, such anomalous values of the geomagnetic field were stored as raw data by digitizing those contour maps.

Assessing a common datum level

To compare and correct the various datum of the surveys previously carried out with the common datum provided by the international geomagnetic reference network, absolute values of the normal geomagnetic fields (ngf) had to be added to ΔTa values. Consequently, numerical ngf models had to be first created to substitute the graphical LO-IZMIRAN models for the epochs 1965.0 and 1980.0 (used in the construction of the above mentioned ΔTa maps. Fourth order polynomials successfully approximated graphical models within the range of ± 2.5 nT. They were used to recover absolute values of the geomagnetic field from the geomagnetic anomaly maps at the epochs 1965.0 and 1980.0. Similar data for the Romanian territory were available for the 1965.0 epoch.

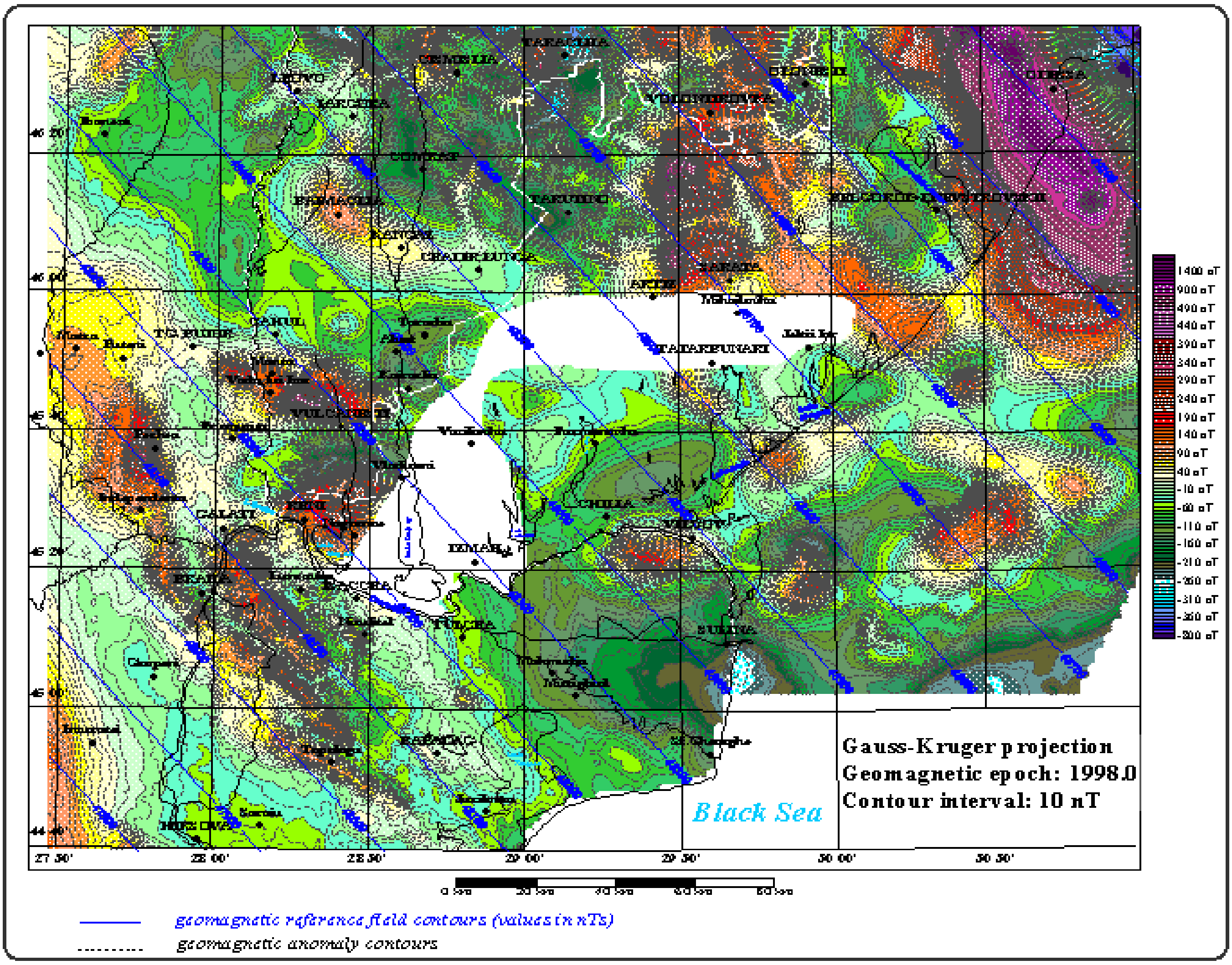

FIG. 5. Geomagnetic anomaly of the total intensity scalar of the Low Danube area as deduced after removing a first order polynomial trend.

The three sets of raw geomagnetic data were then compared to the datum provided by the common geomagnetic reference network and the necessary corrections were found. As MAGLODAN project covers a rather confined area, no isoporic variations were taken into account and constant corrections for every survey were applied.

After the corrections for the datum level were applied, a consistent geomagnetic data set at the epoch 1998.0 was achieved by a total amount of about 60 000 observations.

Checking up the joining accuracy

To check up the quality of the joining operation, horizontal gradient maps of the total intensity scalar of the geomagnetic field were prepared. These derivative maps are well known for their sensitivity to the presence of any discordance within data.

As can be seen from the Fig. 4, no gradient trends within the state border area are pointed out thus proving the consistency of the geomagnetic data set.

Geomagnetic anomaly images

By using the above-mentioned consistent database, a map of the total intensity scalar of the geomagnetic field at the epoch 1998.0 was first prepared. In order to get more intuitive images, regional trends were removed from that total intensity scalar map by using the polynomial regression technique.

Figure 5 presents the residual geomagnetic anomaly after removing the first order polynomial trend. A second residual geomagnetic map was gathered by removing the 5th order polynomial trend as shown in Figure 6. Within it, some local effects become more obvious.

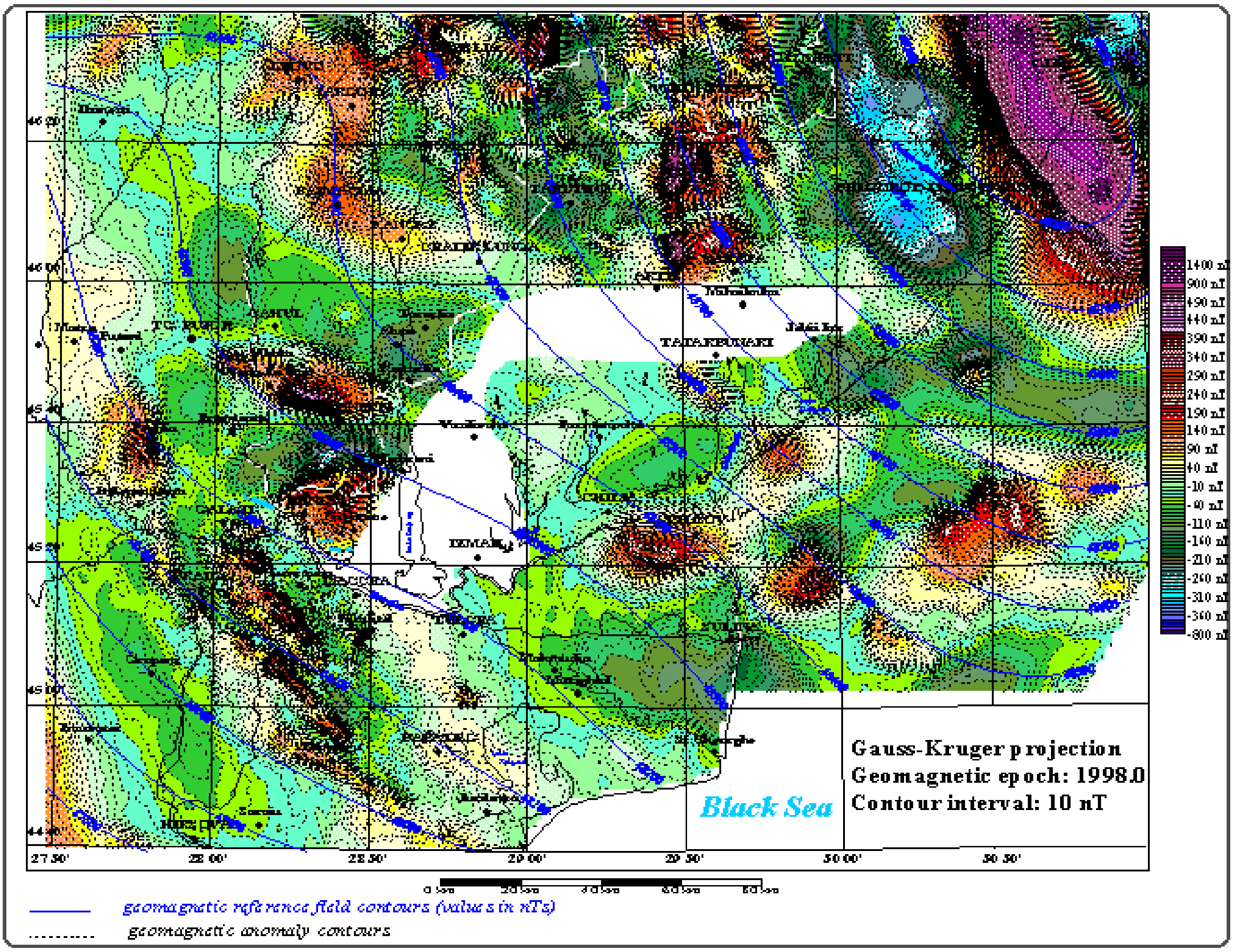

FIG. 6. Geomagnetic anomaly of the total intensity scalar of the Low Danube area as deduced after removing a fifth order polynomial trend.

Closer to the geological background seems to be the image of the horizontal gradient, as visualized by using the shaded relief technique (see Fig. 7). The main geotectonic units within the area (Ukrainian shield, Predobrogean Depression, Northern Dobrogea, etc.) can be discriminated by their distinct geomagnetic behavior.

In fact, at this early stage of joining the national geomagnetic maps of Romania, Ukraine and the Republic of Moldova it is not aimed to get into the geological interpretation of the images obtained. This requires a lot of additional information and will follow after the completion of the whole operation.

CONCLUDING REMARKS

As was previously stated, the MAGLODAN sub-project represents the first step in joining the national geomagnetic maps of Romania, Ukraine and the Republic of Moldova. The use of an international control network was the key for the success of the cooperative efforts of the specialists of three countries. Based on that network, a consistent geomagnetic data set for its epoch could be obtained and accurate pilot-maps were constructed. The quality of the pilot-maps is the best evidence for the correct algorithm used and a guarantee for the final success of the integration of the national maps.

The main aim of this paper to inform the scientific world about our projects and consequently to invite any partner interested in extending the cooperation within Balkan area and even further away.

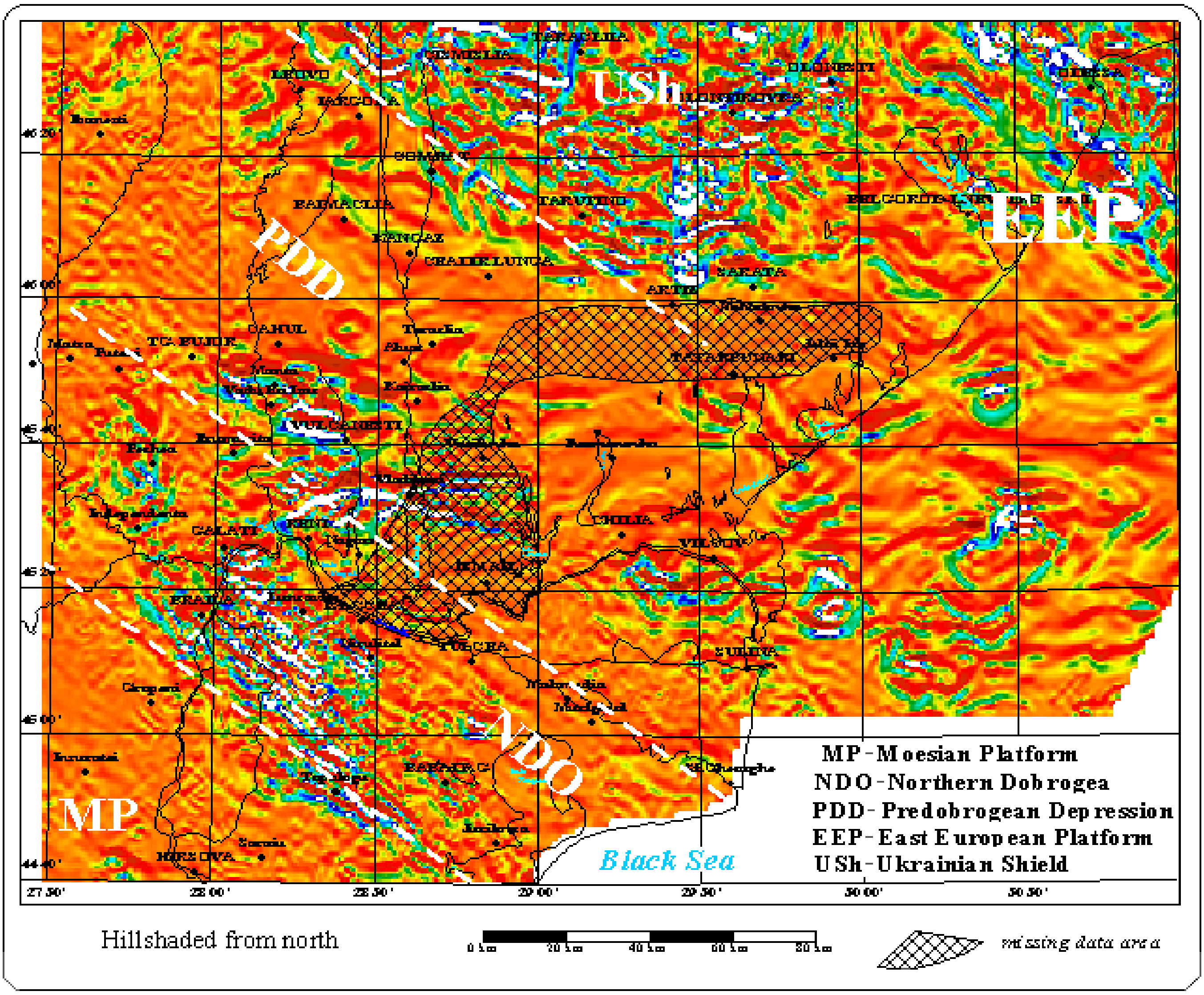

FIG. 7. Total horizontal gradient of the residual magnetic anomaly (as deduced after removing a first order polynomial trend) and the main geotectonic units within the study area.

ACKNOWLEDGMENTS

This work could not be done without the essential support of the Romanian Academy grant no. 82/1998/AR. The authors also wish to thank the management of the three institutions involved in this joint venture project for their invaluable help. Special thanks are due to Prof. Dr. Marius Visarion, C.M. of the Romanian Academy for his permanent support of the project.

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