Institute of Geodynamics
Romanian Academy

Scientific report on the project

"**The geomagnetic field under the heliospheric forcing. Determination of the internal structure of the Earth and evaluation of the geophysical hazard produced by solar eruptive phenomena**"

IDEI Program, Contract 93/5.10.2011
Stage II, January – December 2012
December 15, 2012

Synthesis

The proposed research aims at achieving an understanding of the space weather effects on conducting structures inside the Earth and on the surface electric field, with applications to a better knowledge of the internal structure of the Earth at continental (Europe) and country scales, on one hand, and to estimating the geophysical hazard of space weather at midlatitudes, on the other. The main objectives are:

- To derive the magnetic and electrical properties of the terrestrial lithosphere and mantle at continental and Romanian territory scales;

- To analyze solar eruptive processes and solar wind components responsible for geomagnetic hazardeous activity (geomagnetic storms and substorms) in the time interval 1964-2014;

- To model the geoelectrical field at the Earth's surface as produced by various magnetospheric and ionospheric current systems;

- To evaluate the geophysical hazard for technological networks, associated to variations of the geolectric field during geomagnetic disturbances linked to the interaction of coronal mass ejections and high speed solar streams with the magnetosphere.

The stage report, entitled „**Modeling the magnetic and electric structure of the interior at European and Romanian territory scales**" is structured as follows, according to the working plan of the project.

In Chapter 1, entitled „**New geomagnetic and magneto-telluric measurements in Romania**", the results of the stage 2012 obtained by geomagnetic and magneto-telluric measurements on the Romanian territory are reported.

The **geomagnetic measurements** were taken in the 26 repeat stations of the so-called National network of secular variation, as well as at the Surlari Geomagnetic Observatory. Two field campaigns were undertaken, in the time intervals 26.06 – 17.07.2012 and 27.08 – 19.09.2012.

Measurements of the horizontal component H, total field F, magnetic declination D, and magnetic inclination were done. They were performed by means of a DI-Flux LEMI 024 theodolite, two QHM magnetometers, of a Geometrics G-856 proton magnetometer and of a flux-gate recording magnetometer LEMI-018. The determined values were corrected for the diurnal variation and brought to the time of the first reading of the measurements series established in the determination protocols, by means of continuous recordings provided by the Surlari Geomagnetic Observatory. The results are presented in tables. The data will be processed in the next stages of the contract, to obtain values corresponding to the middle of the year 2012 (geomagnetic epoch 2012.5), taking into account the delay of about one year for the annual means from the observatory. In Fig.1 preliminary maps of the distribution of geomagnetic elements H, Z, D and F, brought to the epoch 2010.5, for which necessary data could be provided by the Surlari Geomagnetic Observatory are presented.

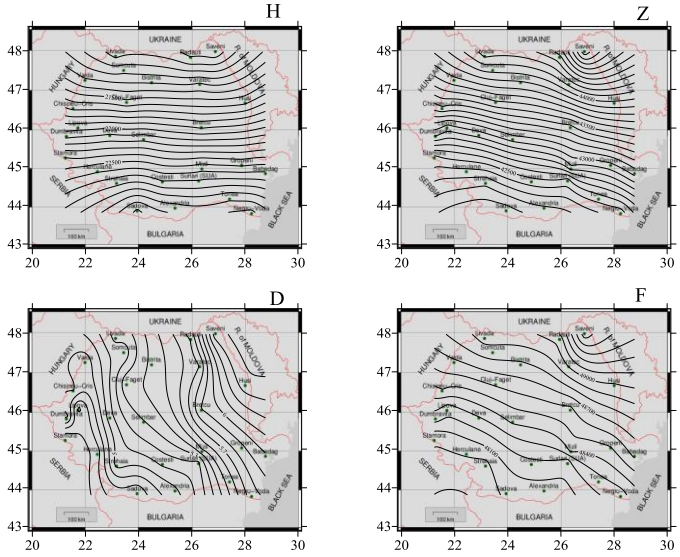

Fig. 1 – Geographical distribution on the Romanian territory of the geomagnetic elements H, Z, D and F at 2010.5

In parallel with the absolute measurements, in all 26 stations of the National network of secular variation, **recordings of the field evolution** (components X, Y, Z and F) were performed. The equipment Bartington MAG-03, purchased in 2012 was tested by recordings done in parallel with those of LEMI (X, Y, Z) and Geometrics (F).

Magneto-telluric measurements were experimentally performed at the Provita de Sus observatory of the Institute of Geodynamics. In the detailed scientific report both the measurement method as well as the first obtained results are presented.

In *Chapter 2*, entitled „**Modeling the distribution of magnetic and electric properties of the Earth's interior at the European continent and Romanian territory scales based on geomagnetic measurements. Magnetic induction model stage II**" the results of using a so-called induction model that takes into account that the geomagnetic measurements at the Earth's surface are affected, besides by the electromagnetic induction in the conductive layers of the interior, also by magnetic induction in the crustal rocks, produced by the same variable magnetospheric and ionospheric external sources. At the present stage models of the distribution of magnetic properties of the crust were elaborated, both for the Romanian

territory and at the scale of the European continent. In the first case, field data recorded during the field campaigns of the year 2010 (results illustrated in Fig. 2), while in the second case, data recorded at European geomagnetic observatories during a geomagnetic storm were used. The European-scale model based on rapid variations associated to the magnetic storm, at time-scale of hours, confirm some of previous conclusions of the research team, obtained for much larger time-scales (decadal and interdecadal).

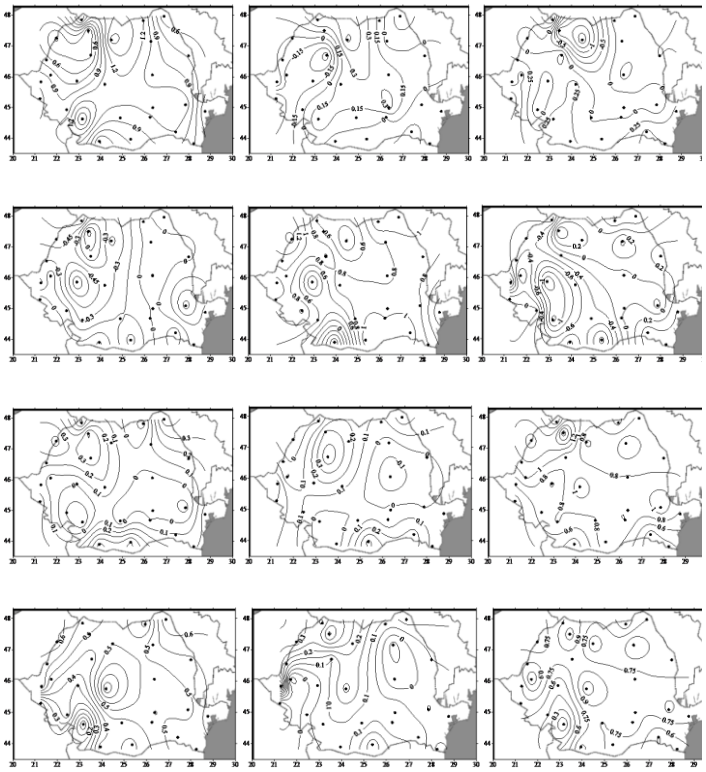

Fig. 2 – Lateral variation of the induction model coefficients for the Romanian territory

In *Chapter 3*, entitled „**Modeling the electrical resistivity structure of the Romanian territory based on magneto-telluric measurements**", a detailed model of the distribution of the deep electric resistivity on the Romanian territory is presented. The electric resistivity and the corresponding electric conductivity, which values can be determined by modeling and inversion of magneto-telluric soundings, are basic parameters necessary in modeling the induction effect produced by the variation of magnetospheric and ionospheric current systems during strong geomagnetic disturbances.

The determination of the distribution of resistivity values on the Romanian territory was achived by performing numerous magneto-telluric soundings (Stănică, Stănică, 1993; 1998; Stănică et al., 1999; 2000), located on magneto-telluric (MT) profiles (geotraverses) that cross major geological units in Romania, marked in Fig. 3.

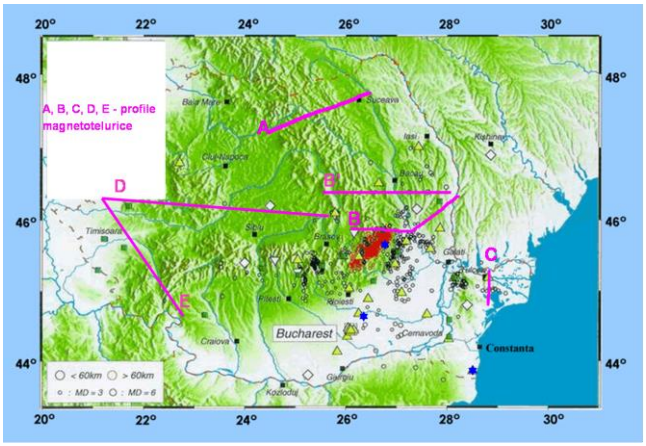

Fig. 3 – Magneto-telluric geotraverses on the Romanian territory

In the detailed scientific report the way of obtaining the resistivity curves and of characterizing the structure type is presented. A detailed analysis of electric resistivity values that characterize the various crustal formations crossed by the mentioned profiles is also done. The model of the distribution of the crustal electrical properties obtained in the present stage will be used in later stages of the project to estimate the effects produced by the currents induced under the action of variations in magnetospheric and ionospheric current systems during major geomagnetic disturbances of geomagnetic storm and/or geomagnetic substorms.

In *Chapter 4*, entitled „**Comparative analysis of the geoeffectivity of some solar and heliospheric processes**", the results obtained by analyzing effects that variations of the interplanetary electric field Em, called the geoeffective electric field, formed as a consequence of the movements of charged particles of the solar wind in the presence of the interplanetary (heliospheric) magnetic field, have on the ionospheric and magnetospheric current systems, with hazardous consequences. The geomagnetic PC index was used in the analysis, in relation with other geomagnetic indices, such as Dst, AE and aa. The PC index is a measure of the interplanetary electric field in the vicinity of Earth. Dst and AE indices describe the temporal evolution of the current systems, namely of the magnetospheric ring current and, respectively, the ionospheric auroral electrojet. The aa index describes the general disturbed state of the ionosphere and magnetosphere. The PC index has recently been defined (1980), and is constructed based on geomagnetic recordings taken permanently at the Thule Geomagnetic Observatory of the Denmark Space Sciences Institute, located in the North polar area; following statistical processing of geomagnetic recordings, solar wind and heliospheric magnetic field data, the PC index reflects the evolution of the geoeffective interplanetary electric field Em, $PC \sim Em = V_{SW} * B_T * (\sin(q/2))^2$, where $q = \arccos(Bz/B_T)$.

In the present stage, we explored the way the PC index represents the geoeffective interplanetary electric field Em at various time-scales from 15 minutes (the PC definition time-interval), to diurnal, monthly and annual values, and studied the correlation of this index with the

three geomagnetic indices mentioned above. The main conclusion, namely that PC, Dst, AE and aa indices correlate well with one another at the interannual time-scale, and this correlation improves if the effect of the 11-year solar cycle is eliminated, allowed the reconstruction of the PC index evolution in the past, to the year 1868 (Fig. 4).

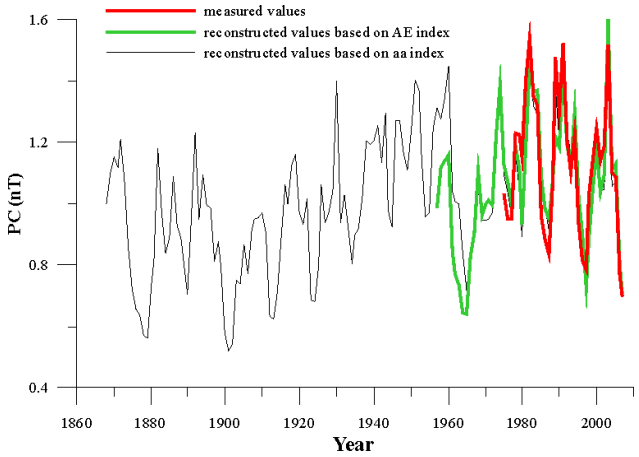

Fig. 4 – Reconstrution of the PC index based on AE and aa

In *Chapter 5*, entitled „**Dissemination of results**", the participation at international scientific meetings and published papers during 2012 are presented as follows:

A. Presentations at conferences

1. Demetrescu C., Dobrică V., Ştefan C., On the evolution of high-frequency ingredients of the secular variation and of their expression at core surface, as inferred from observatory data and main field models, *European Geosciences Union (EGU) General Assembly*, Vienna, Austria, 22-27 April 2012.
2. Dobrică V., Demetrescu C., Greculeasa R., On the crustal bias of repeat stations in Romania, *European Geosciences Union (EGU) General Assembly*, Vienna, Austria, 22-27 April 2012.
3. Greculeasa R., Dobrică V., Demetrescu C., The Romanian network of repeat stations. Methodological aspects 2009-2011. *European Geosciences Union (EGU) General Assembly*, Vienna, Austria, 22-27 April 2012.
4. Ştefan C., Dobrică V., Demetrescu C., On the ~80-year variation of the core surface geomagnetic field. Derivation and characteristics, *European Geosciences Union (EGU) General Assembly*, Vienna, Austria, 22-27 April 2012.
   Demetrescu C., Dobrică V., On the long-term evolution of the PC index, *European Geosciences Union (EGU) General Assembly*, Vienna, Austria, 22-27 April 2012.
5. Demetrescu C., Dobrică V., Space climate characterization of the heliosphere-magnetosphere environment, *First International Conference on Moldavian Risks – From Global to Local scale*, Bacău, Romania, 16-19 May 2012.
6. Maris G., Maris O., Mierla M., Oprea C., Stere O., Geomagnetic super-storms during the maximum phase of solar cycle 23, *The Fourth Workshop on Solar Influences on Magnetosphere, Ionosphere and Atmosphere*, Sozopol, Bulgaria, 4-8 June 2012.
7. Demetrescu C., Dobrică V., Features of space climate seen in the solar system -heliospheric-magnetosphere, *The Fourth Workshop on Solar Influences on Magnetosphere, Ionosphere and Atmosphere*, Sozopol, Bulgaria, 4-8 June 2012.
8. Demetrescu C., Dobrică V., On the magnetosphere response to heliospheric activity, *Asia Oceania Geosciences Society (AOGS) Assembly*, Singapore, 13-17 August 2012 (**invited**).
9. Stanică, D. Stanică, D. A., Pre-seismic ULF Geomagnetic Signature Related to the M9 Great Tohoku Earthquake on March 11, 2011, *Asia Oceania Geosciences Society (AOGS) Assembly*, Singapore, 13-17 August 2012.

10. Demetrescu, C. Dobrică V., Mariş G., On the climate of the solar – terrestrial space, *International Conference on Solar and Heliospheric Influences on the Geospace*, Bucharest, Romania, 1-5 October 2012 (**invited**).
11. Greculeasa R., Dobrică V., Demetrescu C., Sources of geomagnetic activity at local scale. Case study – European observatory, *International Conference on Solar and Heliospheric Influences on the Geospace*, Bucharest, Romania, 1-5 October 2012.
12. Ştefan C., Dobrică V., Demetrescu C., The evolution of the Earth's magnetic moment in the last 400 years. Consequences on the magnetopause standoff distance, I*nternational Conference on Solar and Heliospheric Influences on the Geospace*, Bucharest, Romania, 1-5 October 2012.
13. Besliu-Ionescu D., Maris G., Mierla M., Progress in understanding the complex solar event of September 13, 2005, *9th European Space Weather Week*, Brussels, Belgium, 5-9 November 2012.
14. Demetrescu C., Dobrică V., Ştefan C., Long-term evolution of high-frequency ingredients of ingredients of the core surface field, *Fall Meeting of the American Geophysical Union (AGU)*, San Francisco, 3-7 December 2012.

B. Peer-reviwed papers

1. Dobrică V., Demetrescu C., Greculeasa R., Isac A., On the crustal bias of repeat stations in Romania, *Annals of Geophysics*, 55 (6), 1145-1154, 2012, .
2. Dobrică V., Demetrescu C., Mariş G., Solar wind dynamic pressure and magnetopause stand-off distance before the instrumental era, *Sun and Geosphere*, 7 (1), 45-48, 2012.

In the end, we mention that the web page of the project http://www.geodin.ro/IDEI2011/engl/index.html is being updated.

Project Director,

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