



# **CROSS-BORDER GEOPHYSICAL AND GEOLOGICAL MODELS BETWEEN ROMANIA AND UKRAINE IN THE LOW DANUBE AREA**

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Andriy Romenets (2); Ligia Atanasiu (1); Iryna Makarenko (2)**

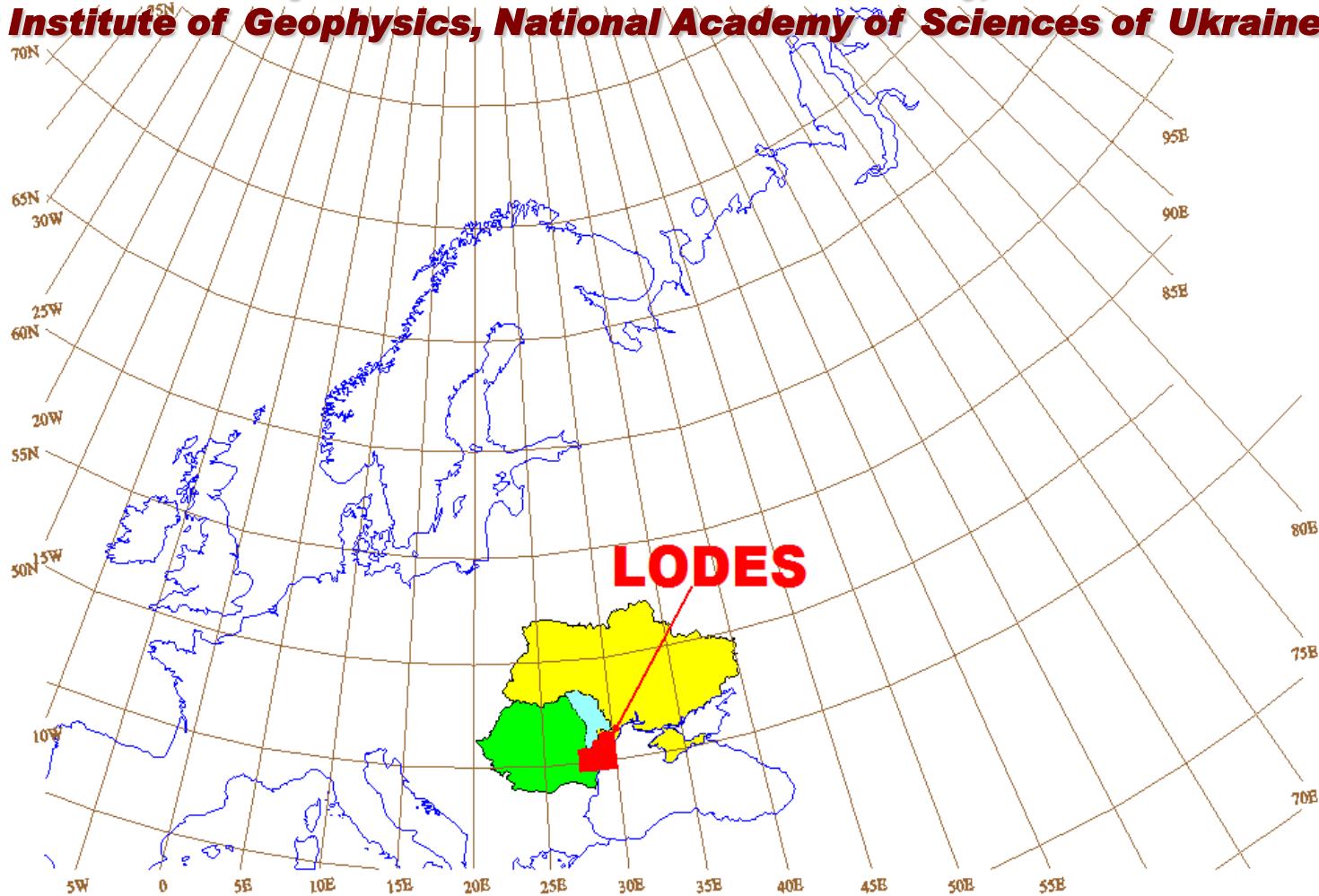


**1) Institute of Geodynamics of the Romanian Academy, Bucharest, Romania;  
2) Institute of Geophysics of the National Academy of Sciences of Ukraine, Kiev, Ukraine**



# LODES: Low Danube area Earth's crust Structure from magnetic and gravitational modelling

**IGAR: Institute of Geodynamics of the Romanian Academy, in Bucharest and  
IGNASU: Institute of Geophysics, National Academy of Sciences of Ukraine, in Kiev**





# **OUTLINE**

- **INTRODUCTORY/RATIONALE**
- **CROSS-BORDER DATABASES AND THEIR (IN)CONSISTENCY**
- **DATA MINING**
  - 2D MODELLING**
  - 3D MODELLING**
- **GEOLOGICAL INTERPRETATION**
  - 3D MODELS FOR NORTH DOBROGEA**
  - 3D MODELS FOR PRE-DOBROGEA**
- **CONCLUDING REMARKS & PERSPECTIVE**

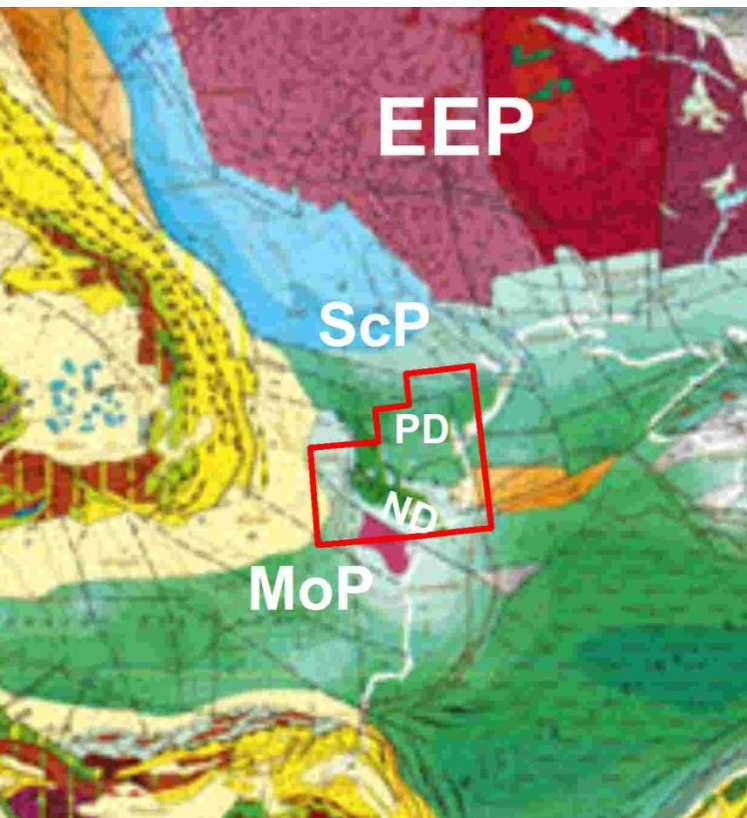




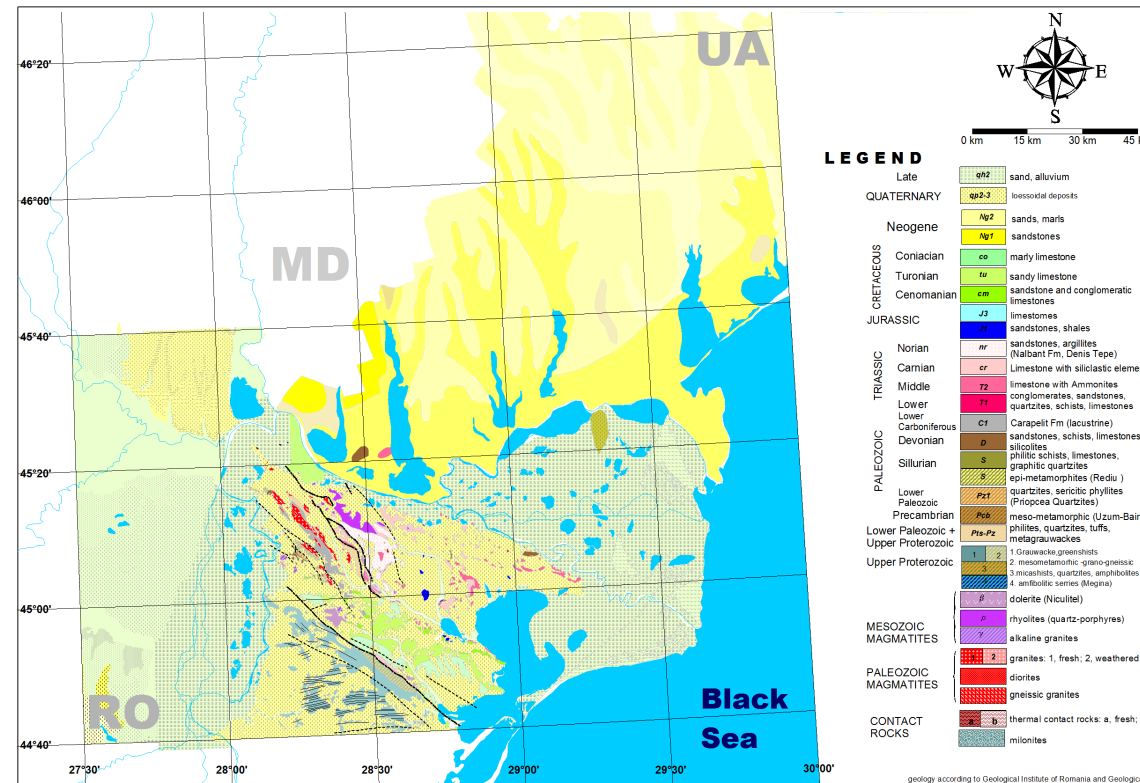
# LOCATION & RATIONALE

**LODES: LOw Danube area Earth's crust Structure from magnetic and gravitational modelling**

## Tectonic setting



## Intense coverage with recent deposits



This map is a product of the LODES project, a joint venture of the Institute of Geodynamics of the Romanian Academy and the Institute of Geophysics of the National Academy of Sciences of Ukraine





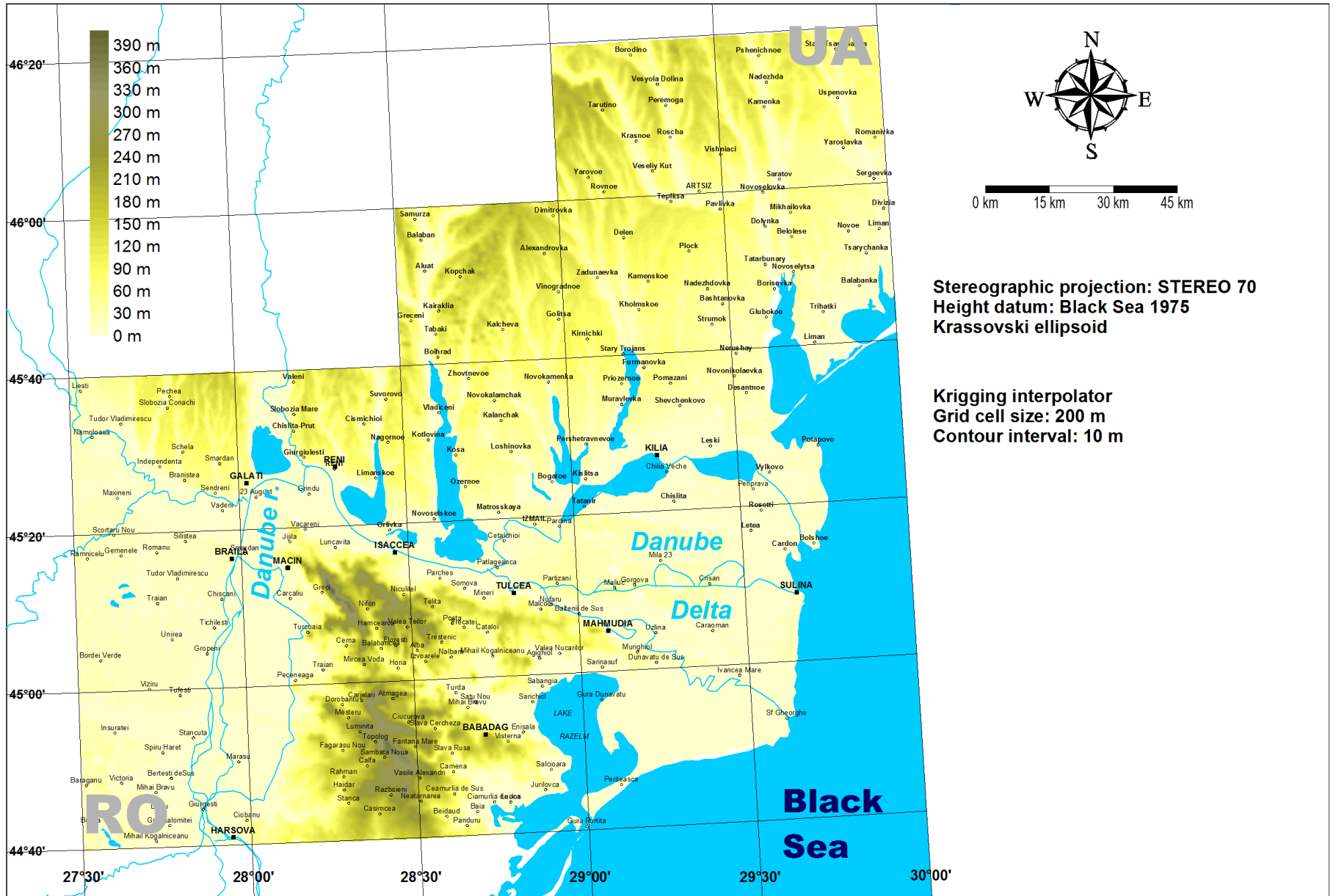
# ***CROSS-BORDER DATABASES***







# TOPOGRAPHY

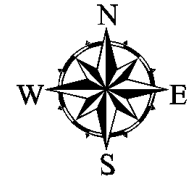
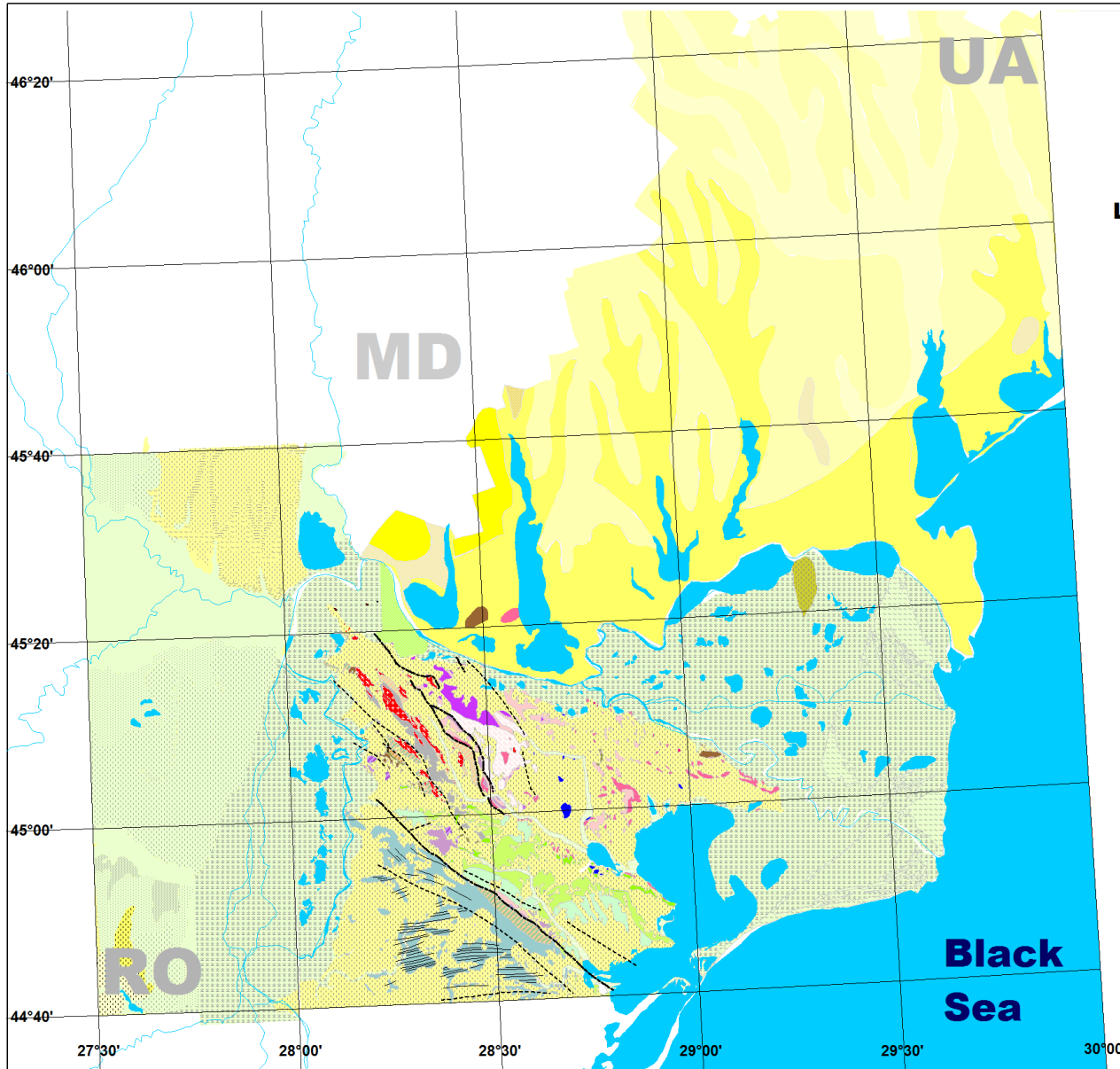


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# GEOLOGICAL MAP



0 km 15 km 30 km 45 km

## LEGEND

|                                     |        |   |
|-------------------------------------|--------|---|
| Late                                | qh2    | sand, alluvium  |
| QUATERNARY                          | qp2-3  | loessoidal deposits   |
| Neogene                             | Ng2    | sands, marls  |
|                                     | Ng1    | sandstones  |
| CRETACEOUS                          | co     | marly limestone   |
| Turonian                            | tu     | sandy limestone   |
| Cenomanian                          | cm     | sandstone and conglomeratic limestones  |
| JURASSIC                            | J3     | limestones  |
|                                     | J1     | sandstones, shales  |
| TRIASSIC                            | nr     | sandstones, argillites (Nalbant Fm, Denis Tepe)                                     |
| Carnian                             | cr     | Limestone with siliclastic elements   |
| Middle                              | T2     | limestone with Ammonites conglomerates, sandstones, quartzites, schists, limestones |
| Lower                               | T1     | quartzites, schists, limestones   |
| Lower Carboniferous                 | C1     | Carapelit Fm (lacustrine)   |
| DEVONIAN                            | D      | sandstones, schists, limestones, silicolites  |
| Sillurian                           | S      | philitic schists, limestones, graphitic quartzites                                  |
|                                     | S      | epi-metamorphites (Rediu )  |
| Lower Paleozoic                     | Px1    | quartzites, sericitic phyllites (Priopcea Quartzites)                               |
| Precambrian                         | Pcb    | meso-metamorphic (Uzum-Bair)  |
| Lower Paleozoic + Upper Proterozoic | Pts-Pz | phillites, quartzites, tuffs, metagrauwackes  |
| Upper Proterozoic                   | 1      | 1. Grauwacke, greenschists  |
|                                     | 2      | 2. mesometamorphic -grano-gneissic  |
|                                     | 3      | 3. micashists, quartzites, amphibolites   |
|                                     | 4      | 4. amphibolitic series (Megna)  |
| MESOZOIC MAGMATITES                 | β      | dolerite (Niculitel)  |
|                                     | β      | rhyolites (quartz-porphyrtes)   |
|                                     | γ      | alkaline granites   |
| PALEOZOIC MAGMATITES                | 1      | granites: 1, fresh; 2, weathered  |
|                                     | 2      | diorites  |
|                                     | 3      | gneissic granites   |
| CONTACT ROCKS                       | a      | thermal contact rocks: a, fresh; b, weathered                                       |
|                                     | b      | milonites   |

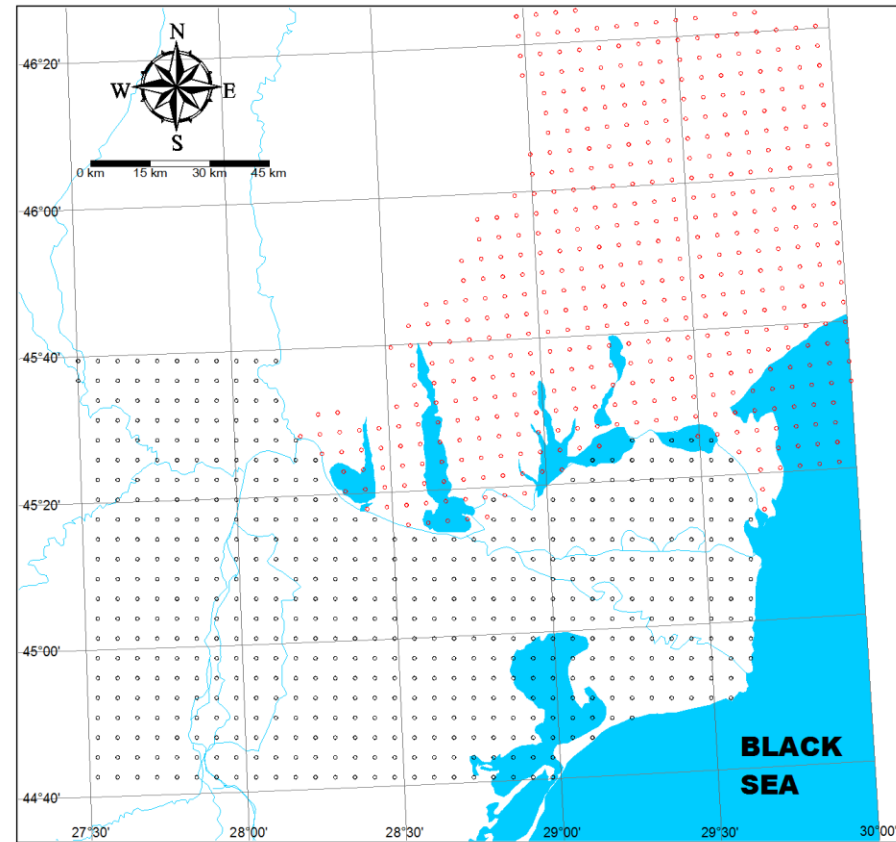
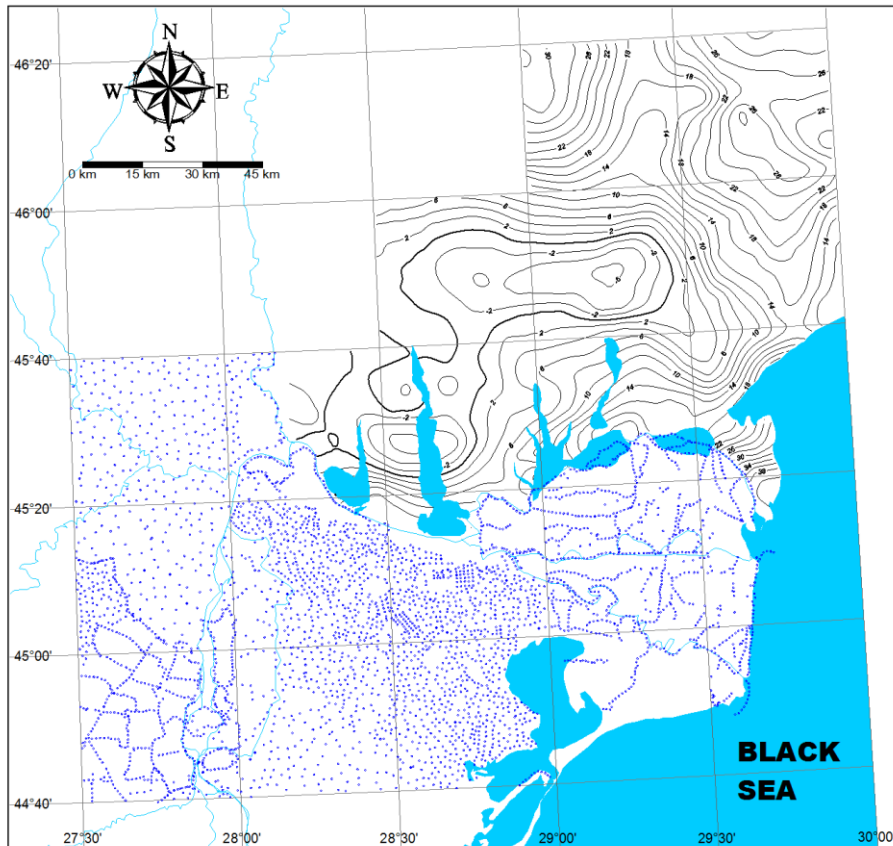
This map is a product of the LODES project, a joint venture of the Institute of Geodynamics of the Romanian Academy and the Institute of Geophysics of the National Academy of Sciences of Ukraine

geology according to Geological Institute of Romania and Geological Institute NAS Ukraine





# GRAVITY FIELD: RAW DATA



## INCONSISTENCIES

RO

Data points

DISTINCT NATIONAL GRAVITY STANDARD

Datum provided within the frame of UNIGRACE

UA

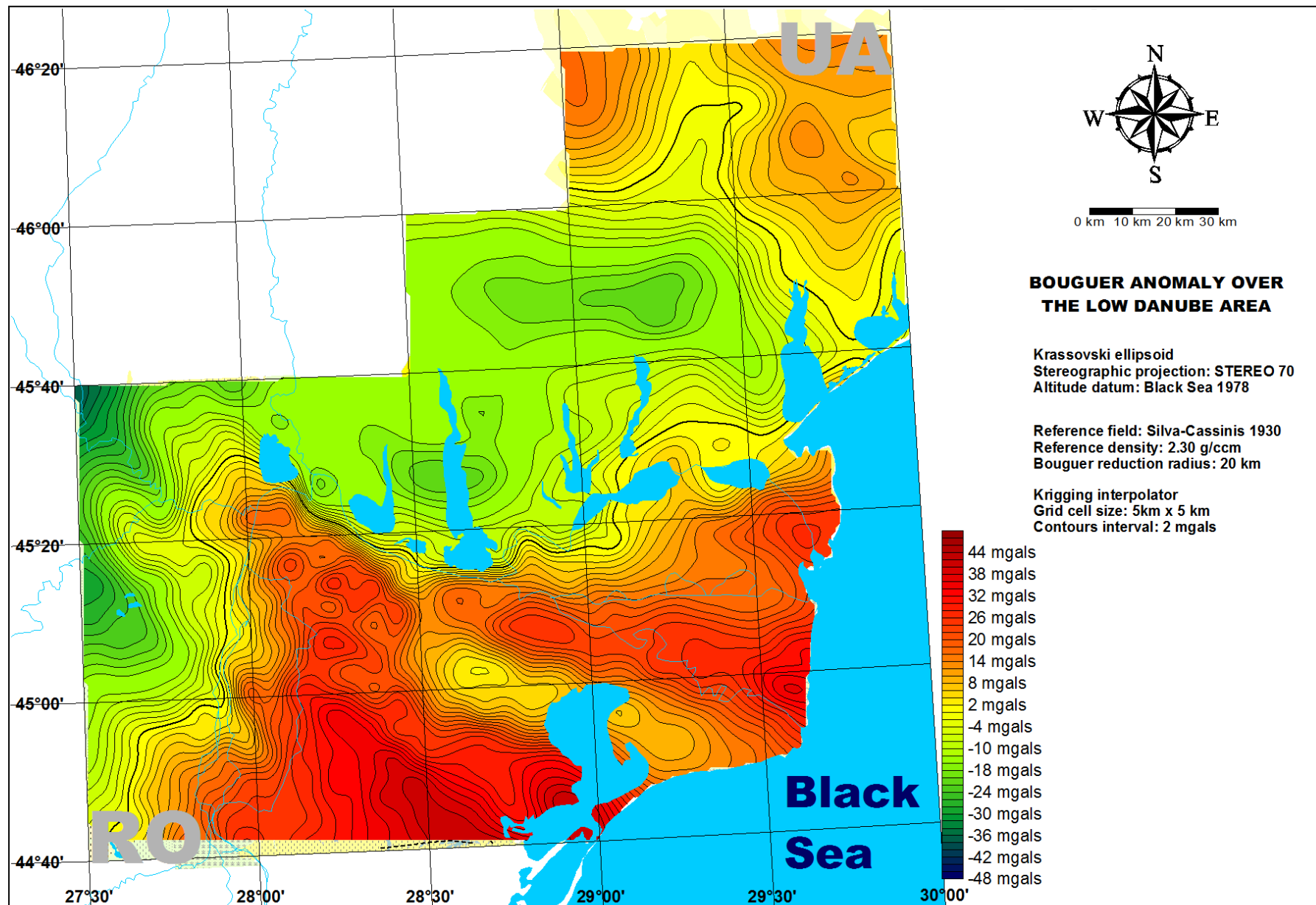
Contour maps for 2.30 g./ccm

Datum provided by old Potsdam





# CONSISTENT GRAVITY FIELD MODEL

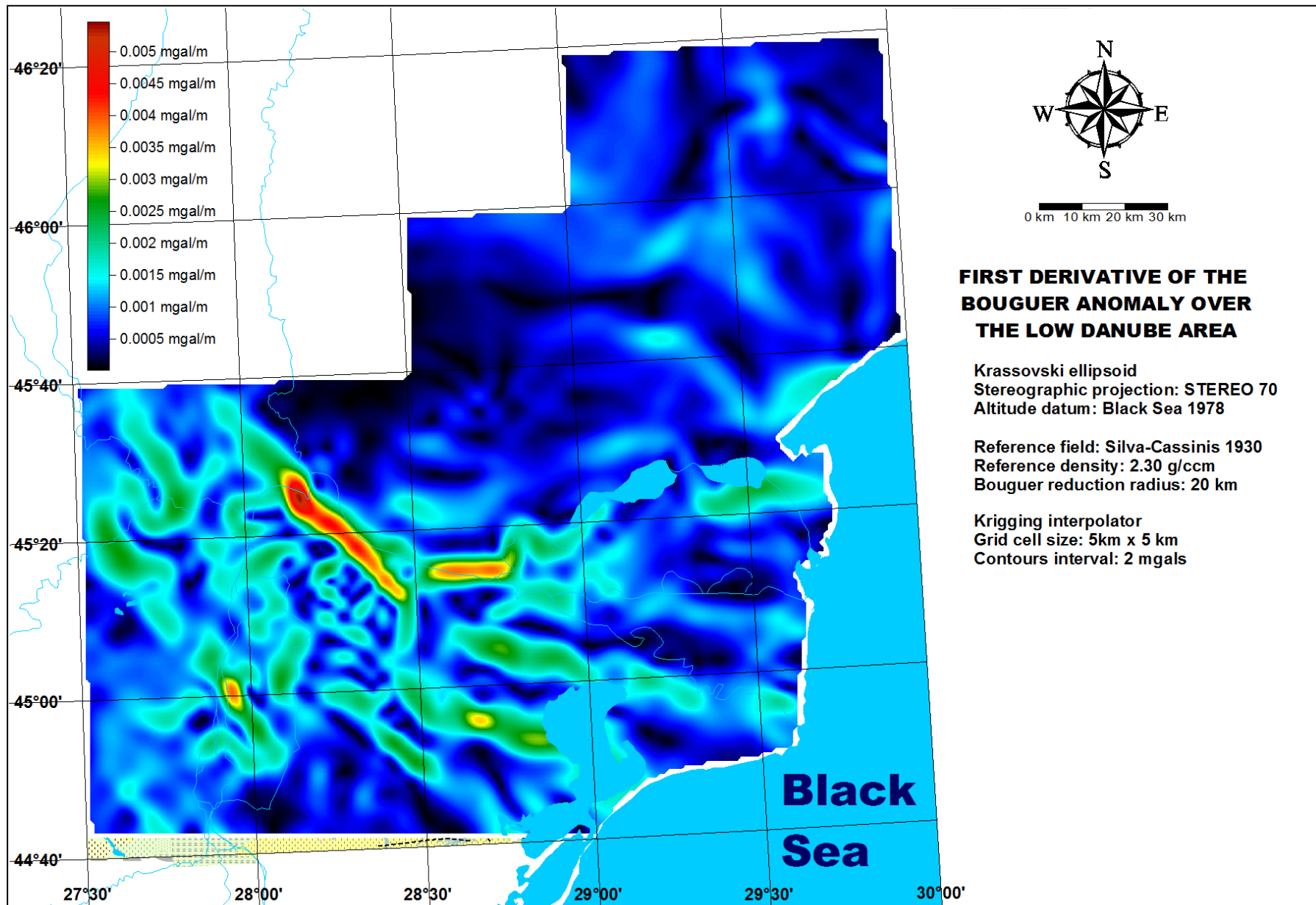


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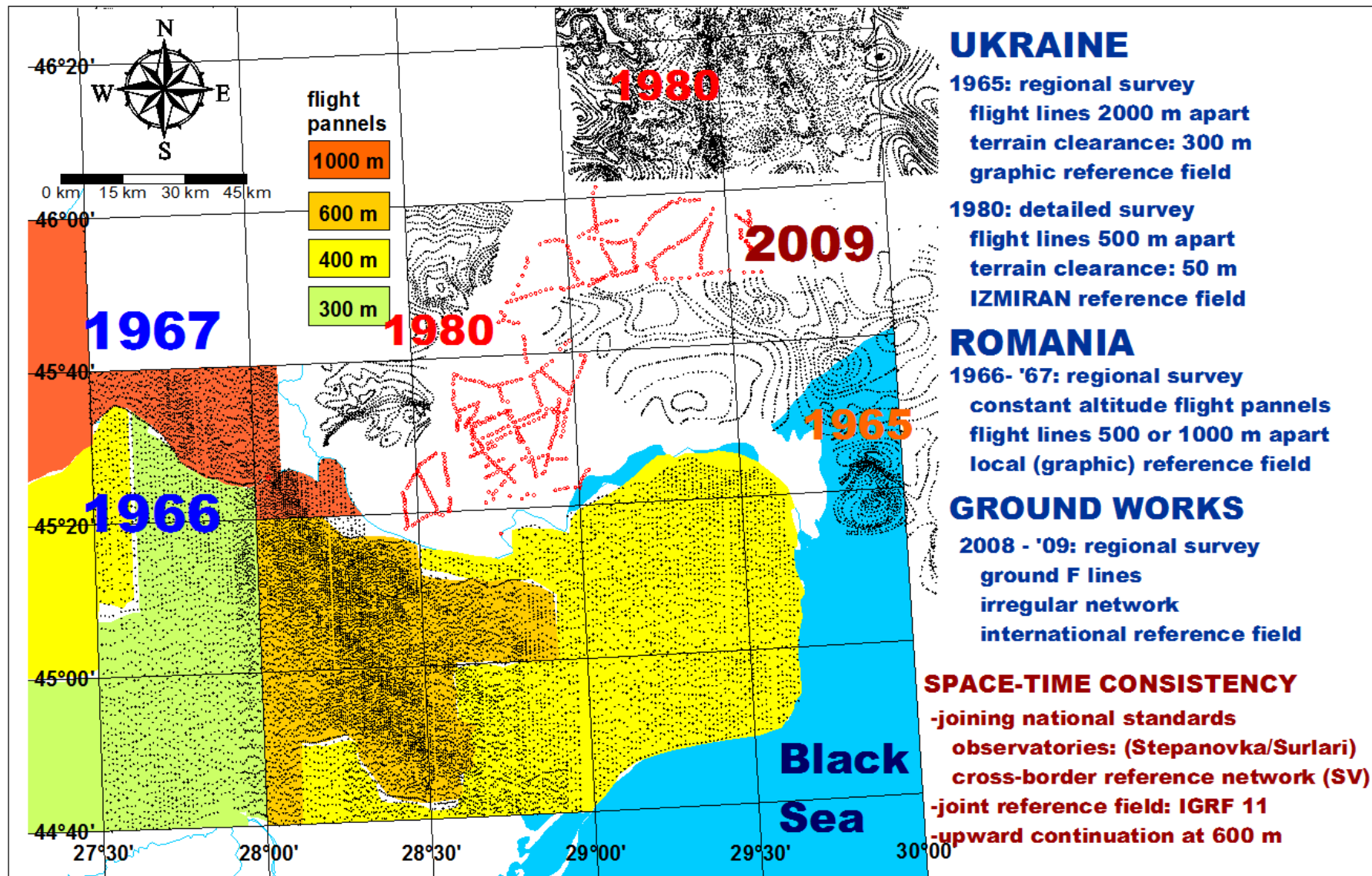
# CONSISTENCY test: FIRST DERIVATIVE OF THE BOUGUER ANOMALY



This map is a product of the LODES project, a joint venture of the Institute of Geodynamics of the Romanian Academy and the Institute of Geophysics of the National Academy of Sciences of Ukraine

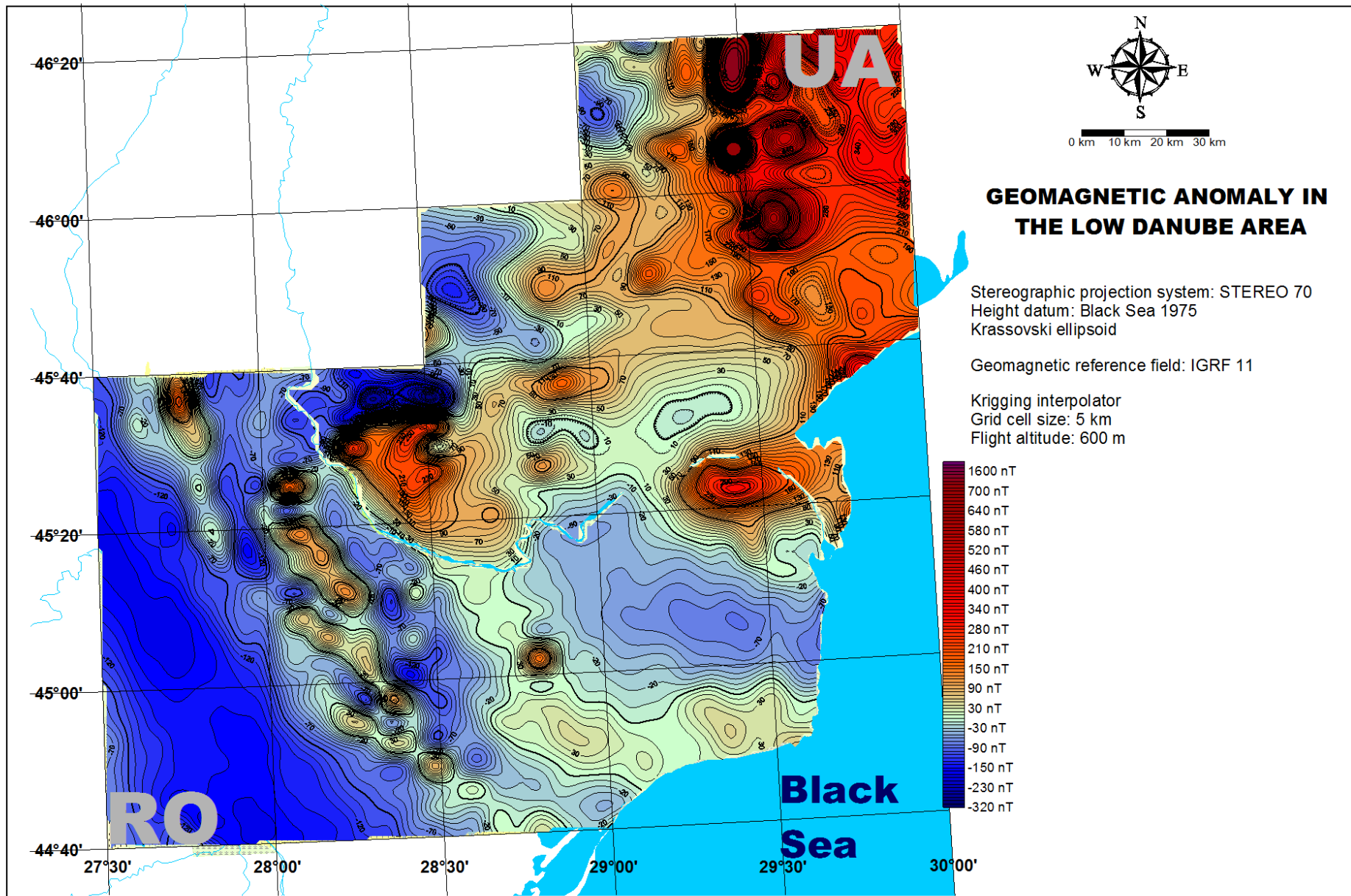


# GEOMAGNETIC FIELD: RAW DATA





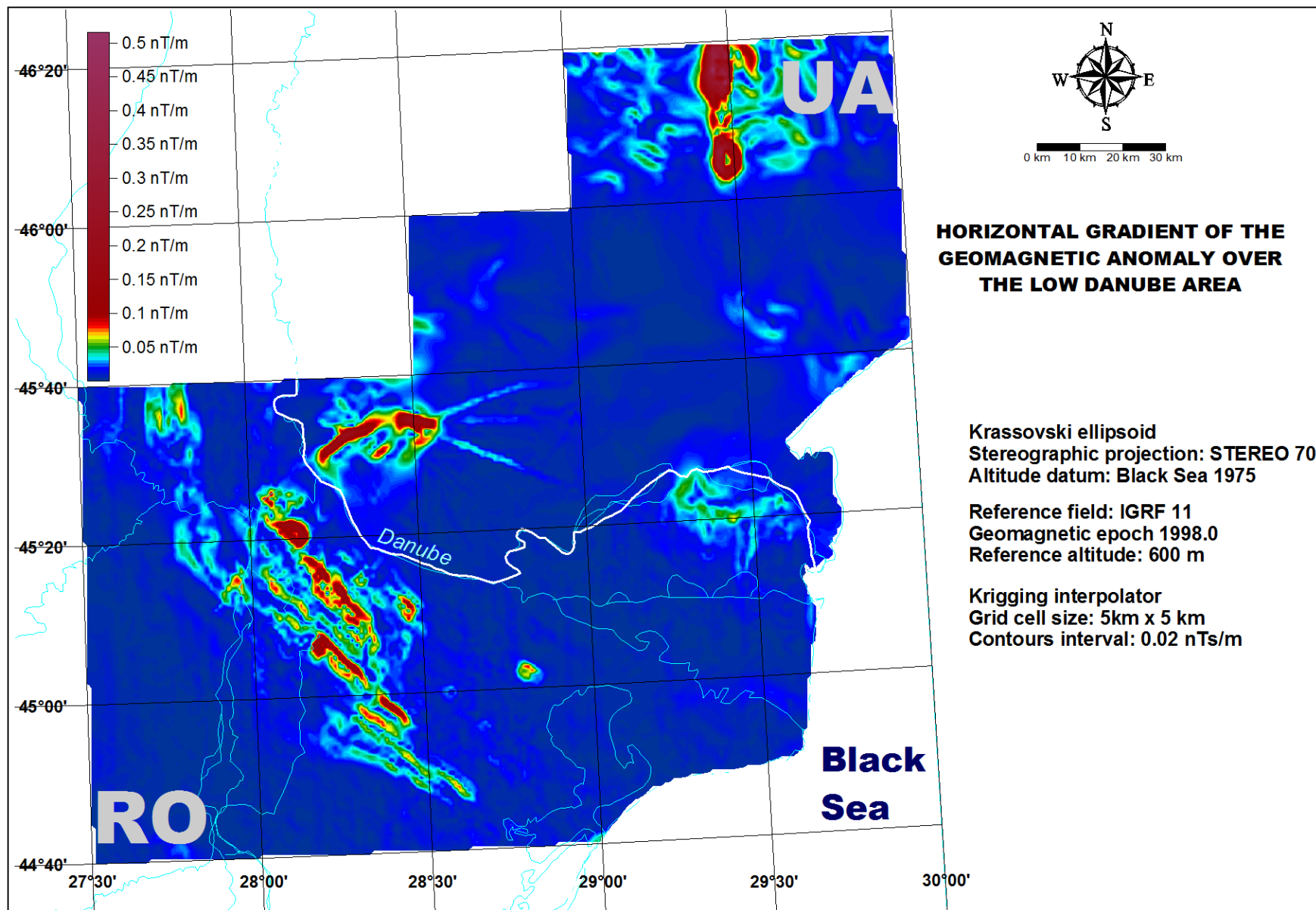
# CONSISTENT GEOMAGNETIC FIELD MODEL



This map is a product of the LODES project, a joint venture of the Institute of Geodynamics of the Romanian Academy and the Institute of Geophysics of the National Academy of Sciences of Ukraine



# CONSISTENCY test: FIRST DEVIVATIVE OF THE GEOMAGNETIC ANOMALY





# ROCK HYSICS DATABASE: stratigraphy and densities for PDD

|            |               |               |               |            |  | Dens. | St.Dev | no.  | Dens. | St.Dev | no.  | Dens. | St.Dev | no.  | Dens. | St.Dev | no.  | Dens. | St.Dev | no.  | Dens. | St.Dev | no.  |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|------------|---------------|---------------|---------------|------------|--|-------|--------|------|-------|--------|------|-------|--------|------|-------|--------|------|-------|--------|------|-------|--------|------|------|---|--|--|--|--|--|--|--|--|--|--|--|--|--|------|------|-----|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|------|------|---|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|------|------|---|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|------|------|----|---|
| CENOZOIC   | QUATERNARY    | Holocene      |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               | Pleistocene   |               | LEVANTIN   |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            | NEOGENE       | PLIOCENE      | upper         | ROMANIAN   |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | lower         | DACIAN     |  |       | 2.31   | 0.19 | 2     |        |      |       |        | 2.3  | 0.2   | 30     |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               | MIOCENE       | upper         | PONTIAN    |  |       |        |      |       | 2.25   | 0.16 | 36    | 2.36   | 0.24 | 43    |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               |               | SARMATIAN  |  |       |        |      | 2.49  | 0.19   | 1103 |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | middle        | BADENIAN   |  |       |        |      |       | 2.60   | 0.15 | 138   |        |      |       | 2.5    | 0.19 | 1472  | 2.5    | 0.2  | 1502  |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            | lower         |               |               |            |  | 2.48  |        | 2    |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            | PALEOGENE     | OLIGOCENE     |               | CHATTIAN   |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               |               | RUPELIAN   |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               | EOCENE        | upper         | PRIABONIAN |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | middle        | BARTONIAN  |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               |               | LUTETIAN   |  |       |        |      | 2.43  | 0.12   | 4    |       |        |      |       |        |      |       |        |      |       |        | 2.39 | 0.13 | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
| lower      |               | YPRESIAN      |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
| PALEOOCENE | THANETIAN     |               |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            | SELANDIAN     |               |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               | DANIAN        |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
| MESOZOIC   | CRETACEOUS    | UPPER         | MAASTRICHTIAN | Senonian   |  |       |        |      | 2.61  |        | 1    |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | CAMPANIAN     |            |  |       |        | 2.58 | 0.16  | 3      |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | CONIACIAN     |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | TURONIAN      |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | CENOMANIAN    |            |  |       |        | 2.52 |       | 1      |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               | LOWER         | ALBIAN        |            |  |       |        | 2.62 | 0.10  | 4      |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | APTIAN        |            |  |       |        | 2.43 | 0.21  | 6      |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | BARREMIAN     |            |  |       |        | 2.60 |       | 1      |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | HAUTERIVIAN   |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | VALANGINIAN   |            |  |       |        | 1.90 |       | 1      |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | BERRIASIAN    | Neocomian  |  |       | 2.65   | 0.19 | 14    |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            | JURASSIC      | Malm          | TITHONIAN     |            |  |       | 2.68   | 0.10 | 4     |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | KIMMERIDGIAN  |            |  |       |        | 2.73 | 0.10  | 3      |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | OXFORDIAN     |            |  |       |        | 2.56 |       | 1      |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | CALLOVIAN     |            |  |       |        | 2.62 | 0.04  | 4      |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               | BATHONIAN     |            |  |       |        | 2.65 | 0.08  | 22     |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               | Dogger        | BAJOCIAN      |            |  |       |        | 2.68 | 0.10  | 65     |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
| ALENIAN    |               |               |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
| Liasic     |               | TOARCIAN      |               |            |  |       | 2.64   | 0.08 | 2     |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               | PLEINSBACHIAN |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               | SINEMURIAN    |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               | HETTANGIAN    |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
| TRIASSIC   |               | RHAETIAN      |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               | NORIAN        |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               | CARNIAN       |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               | LADINIAN      |               |            |  |       | 2.72   | 0.12 | 18    |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               | ANISIAN       |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               | OLENEKIAN     |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
| PALEOZOIC  |               | INDUAN        |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            | PERMIAN       |               |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            | CARBONIFEROUS |               |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            | DEVONIAN      |               |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            | SILURIAN      |               |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
| ORDOVICIAN |               |               |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
| CAMBRIAN   |               |               |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |      |      |    |   |
|            |               |               |               |            |  |       |        |      |       |        |      |       |        |      |       |        |      | 2.49  | 0.2    | 1537 |       |        |      |      |   |  |  |  |  |  |  |  |  |  |  |  |  |  | 2.63 | 0.13 | 288 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 2.61 | 0.14 | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 2.72 | 0.05 | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 2.75 | 0.11 | 62 | 4 |

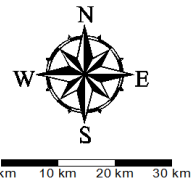
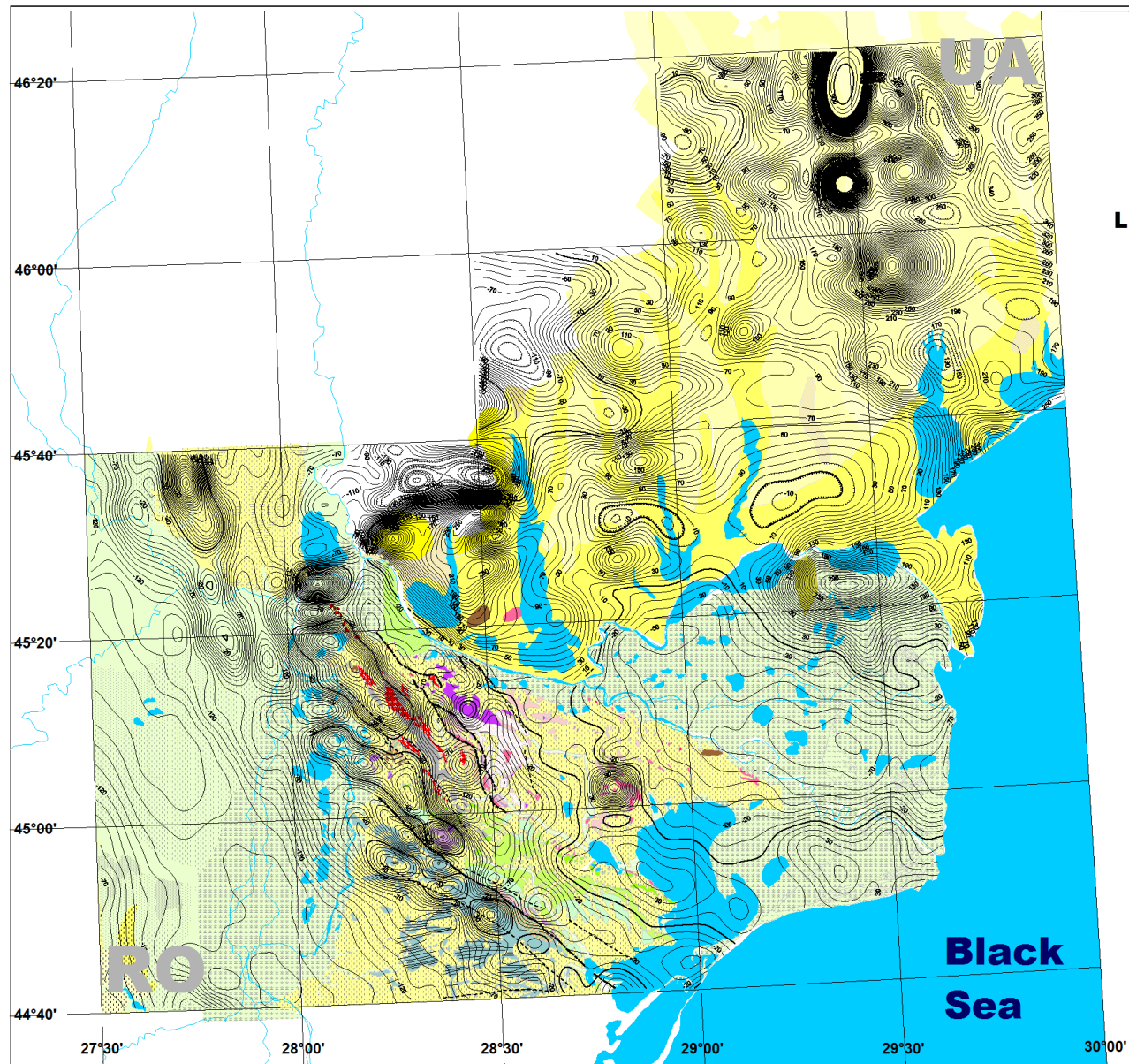


# ***PROCESSING AND INTERPRETING***





# CORRELATION BETWEEN GEOLOGY AND GEOPHYSICAL DATA: GEOMAGNETISM



## LEGEND

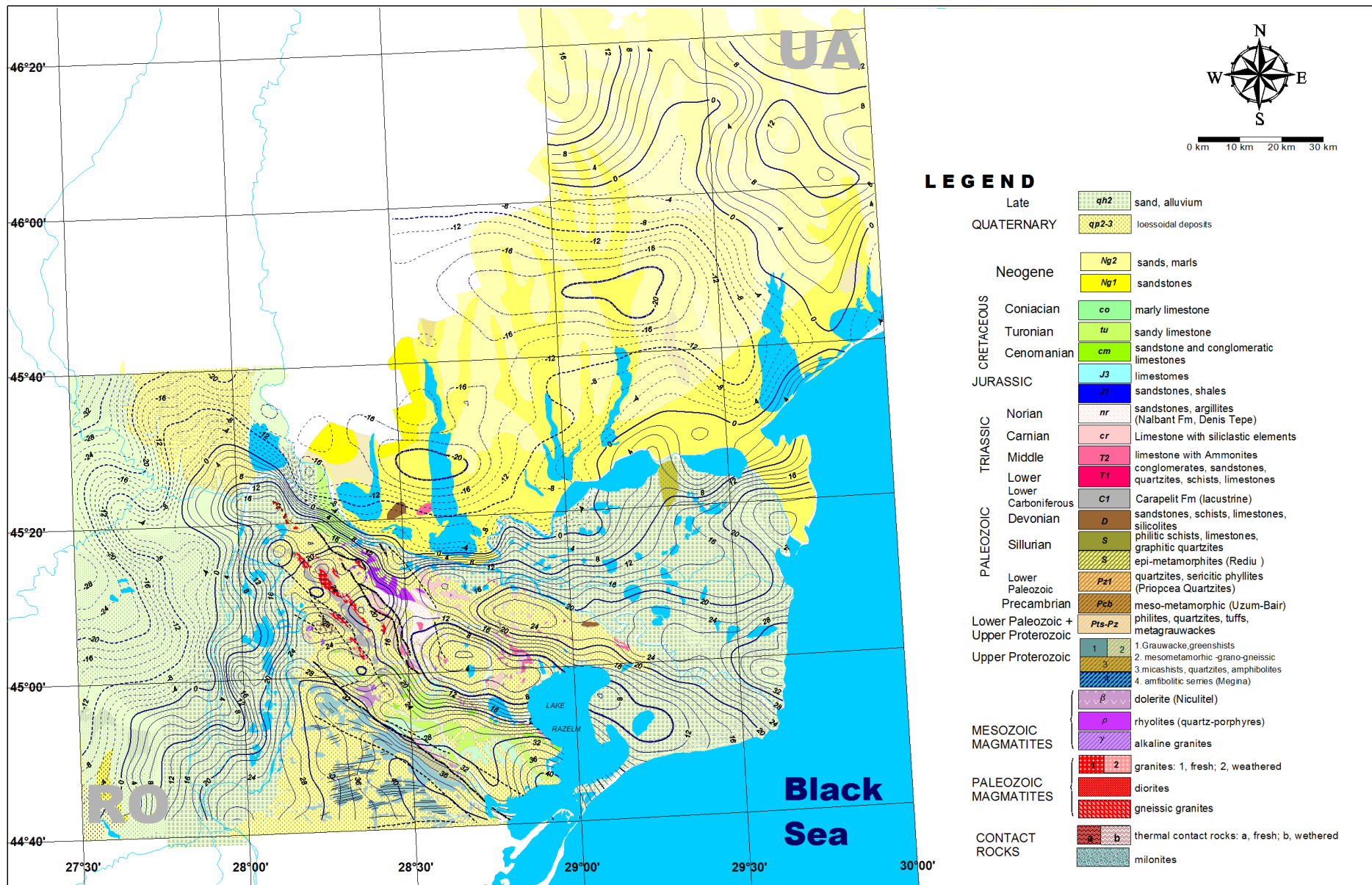
|                                     |        |  |
|-------------------------------------|--------|--|
| Late QUATERNARY                     | qh2    | sand, alluvium   |
| QUATERNARY                          | qp2-3  | loessoidal deposits  |
| Neogene                             | Ng2    | sands, marls   |
|                                     | Ng1    | sandstones   |
| CRETACEOUS                          | co     | marly limestone  |
| Turonian                            | tu     | sandy limestone  |
| Cenomanian                          | cm     | sandstone and conglomeratic limestones                     |
| JURASSIC                            | J3     | limestones   |
|                                     | J1     | sandstones, shales   |
| TRIASSIC                            | nr     | sandstones, argillites (Nalbant Fm, Denis Tepe)            |
| Norian                              | cr     | Limestone with siliclastic elements                        |
| Carnian                             | t2     | limestone with Ammonites                                   |
| Middle                              | T1     | conglomerates, sandstones, quartzites, schists, limestones |
| Lower                               | C1     | Carapelit Fm (lacustrine)                                  |
| Lower Carboniferous                 | D      | sandstones, schists, limestones, silicolites               |
| Devonian                            | S      | philitic schists, limestones, graphitic quartzites         |
| Sillurian                           | S      | epi-metamorphites (Rediu )                                 |
| PALEOZOIC                           | Pz1    | quartzites, sericitic phyllites (Priopcea Quartzites)      |
| Lower Paleozoic                     | Pcb    | meso-metamorphic (Uzum-Bair)                               |
| Precambrian                         | Pts-Pz | phillites, quartzites, tuffs, metagrawackes                |
| Lower Paleozoic + Upper Proterozoic | 1      | 1. Grauwacke greenshists                                   |
| Upper Proterozoic                   | 2      | 2. mesometamorphic -grano-gneissic                         |
|                                     | 3      | 3. micashists, quartzites, amphibolites                    |
|                                     | 4      | 4. amphibolitic series (Megma)                             |
| MESOZOIC MAGMATITES                 | β      | dolerite (Niculitel)                                       |
|                                     | ρ      | rhyolites (quartz-porphyrtes)                              |
|                                     | γ      | alkaline granites  |
| PALEOZOIC MAGMATITES                | 2      | granites: 1, fresh; 2, weathered                           |
|                                     |        | diorites   |
|                                     |        | gneissic granites  |
| CONTACT ROCKS                       | a      | thermal contact rocks: a, fresh; b, wethered               |
|                                     | b      |  |
|                                     |        | milonites  |

This map is a product of the LODES project, a joint venture of the Institute of Geodynamics of the Romanian Academy and the Institute of Geophysics of the National Academy of Sciences of Ukraine





# CORRELATION BETWEEN GEOLOGY AND GEOPHYSICAL DATA: GRAVITY

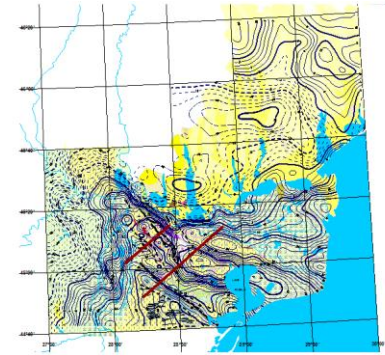


This map is a product of the LODES project, a joint venture of the Institute of Geodynamics of the Romanian Academy and the Institute of Geophysics of the National Academy of Sciences of Ukraine



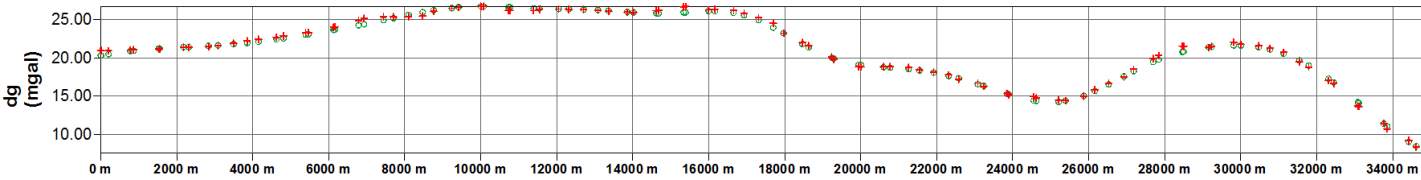


# DATA MINING: 2D FORWARD MODELLING OF GRAVITY DATA

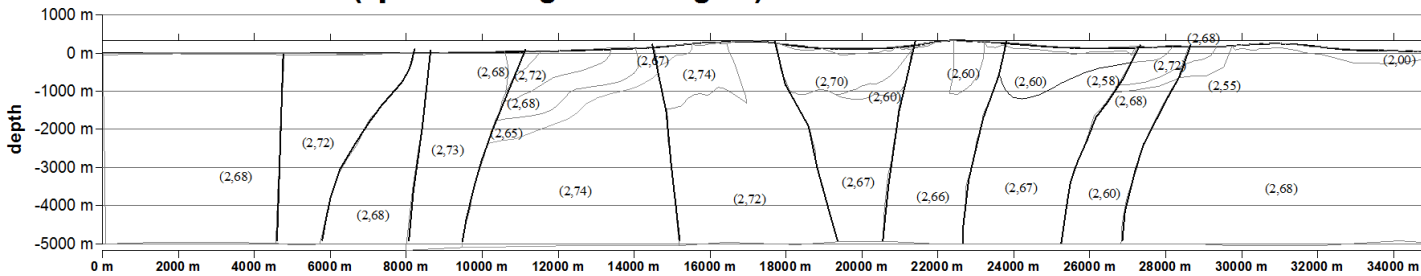


## TENTATIVE INTERPRETATIVE CROSS-SECTION ACROSS THE MACIN MTS

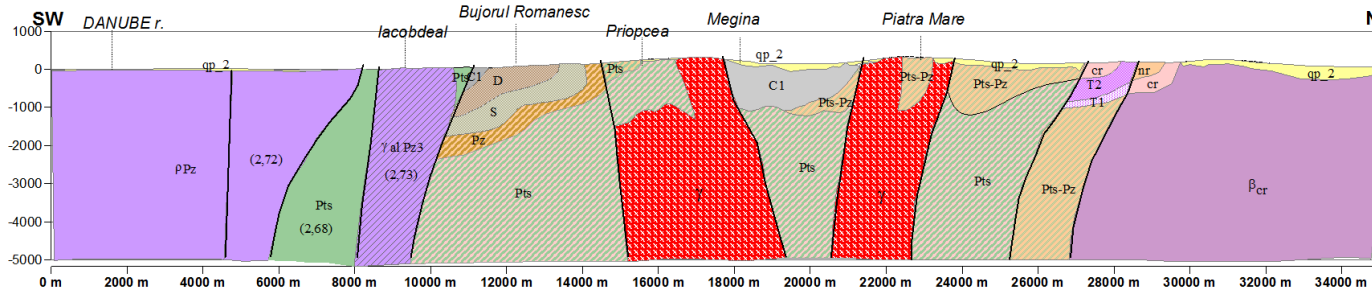
### GRAVITY MODEL



### ROCK-PHYSICS MODEL (specific weight in $10^3 \text{kg/m}^3$ )



### GEOLOGICAL INTERPRETATION



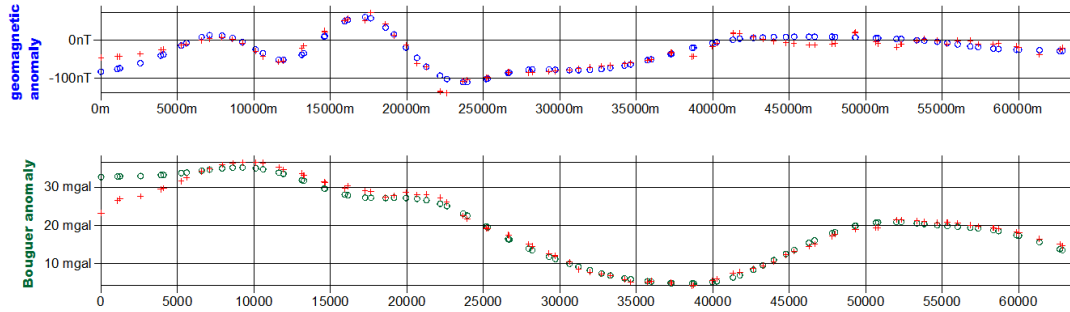
### LEGEND

|  |   |
|--|---|
|  | observed gravity anomaly  |
|  | synthetic gravity   |
|  | qh2 sand, alluvium  |
|  | qp2-3 loessoidal deposits   |
|  | co marly limestone  |
|  | tu sandy limestone  |
|  | cm sandstone and conglomeratic limestones                                   |
|  | J1 sandstones, shales   |
|  | nr sandstones, argillites (Nalbant Fm)                                      |
|  | cr Limestone with siliclastic elements                                      |
|  | T2 limestone with Ammonites   |
|  | T1 conglomerates, sandstones, quartzites, schists, limestones               |
|  | C1 Carapelit Fm (schists, grauwackes, conglomerates)                        |
|  | D sandstones, schists, limestones, silicillites                             |
|  | S philitic schists, limestones, graphitic quartzites                        |
|  | Pz1 quartzites, sericitic phyllites (Priopcea Quartzites)                   |
|  | Pts-Pz phillites, quartzites, tuffs, metagrauwackes                         |
|  | Pts micaschists, quartzites, amphibolites (Ciamurlia series, Orliga series) |
|  | $\beta$ dolerite (Niculitel)  |
|  | $\rho$ rhyolites (quartz-porphyrus)   |
|  | $\gamma$ alkaline granites  |
|  | gneissic granites   |

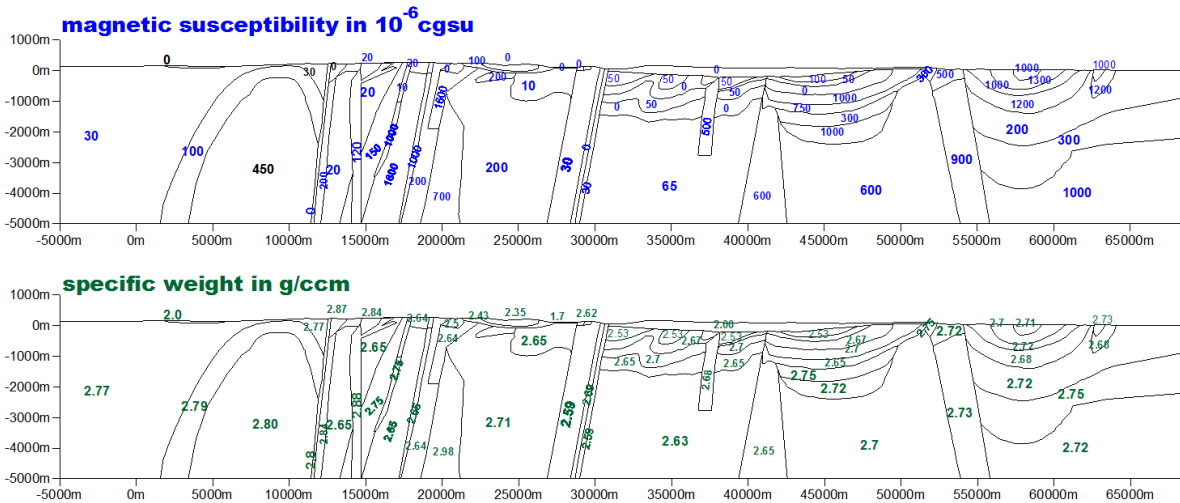


# DATA MINING: 2D JOINTLY MODELLING GRAVITY & GEOMAGNETIC DATA

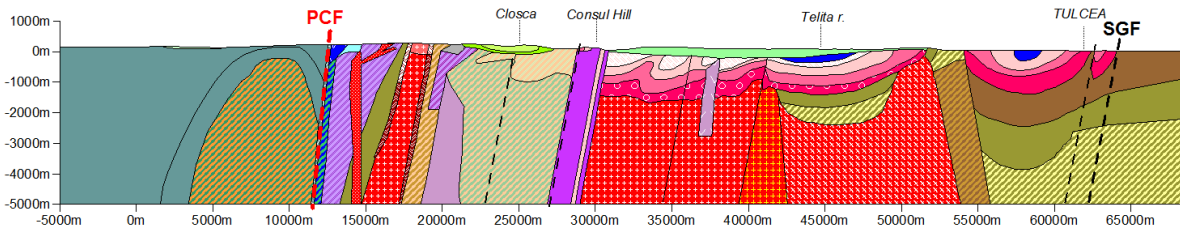
## OBSERVED (red crosses) VERSUS PREDICTED GEOMAGNETIC / GRAVITY FIELDS



## ROCK-PHYSICS MODEL



## TENTATIVE GEOLOGICAL INTERPRETATION



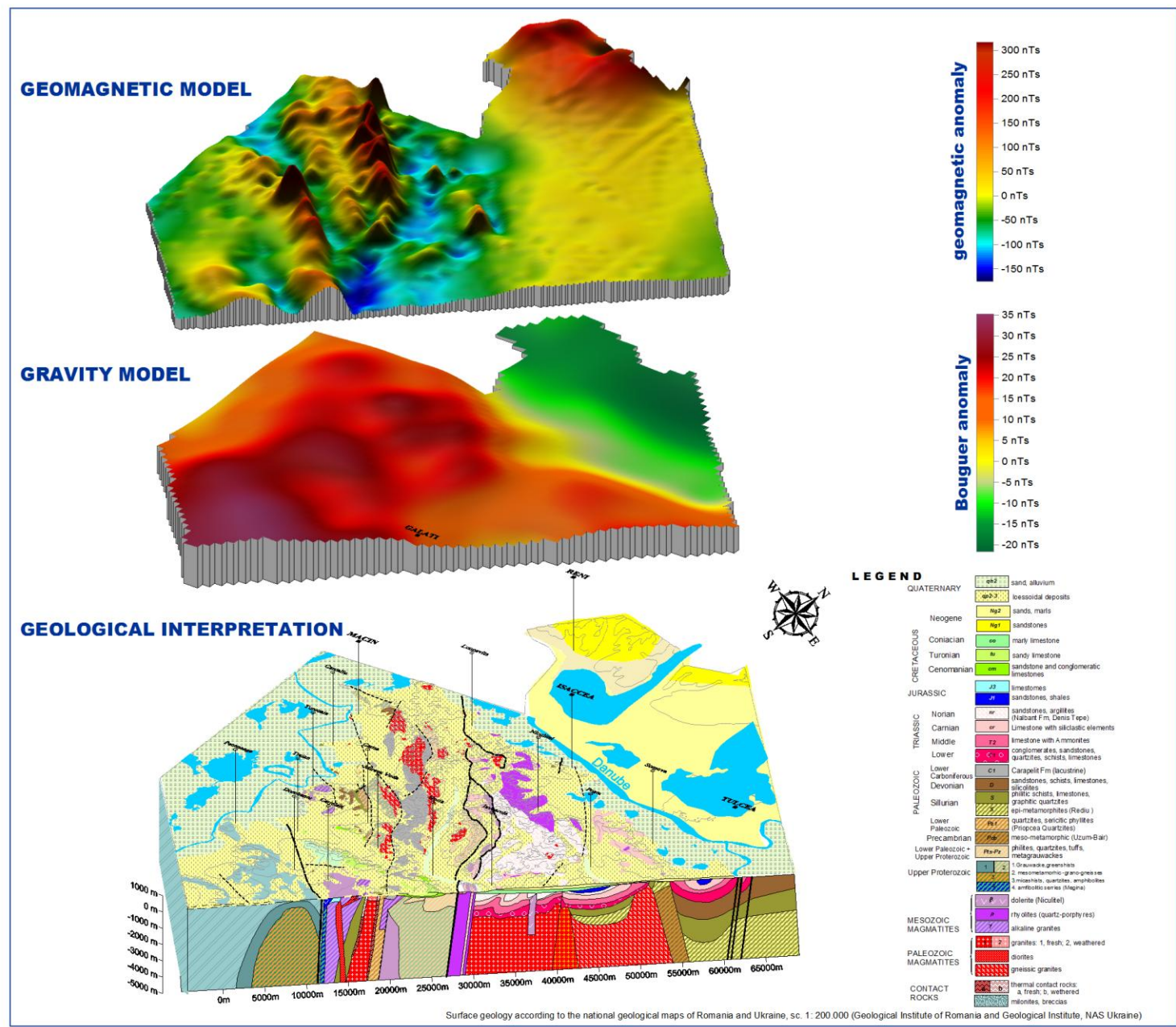
## LEGEND

|                                     |        |  |
|-------------------------------------|--------|--|
| Late Quaternary                     | qh2    | sand, alluvium   |
| Quaternary                          | qp2-3  | loessoidal deposits  |
| CRETACEOUS                          | co     | marly limestone  |
|                                     | tu     | sandy limestone  |
|                                     | cm     | sandstone and conglomeratic limestones                     |
| JURASSIC                            | J3     | limestones   |
|                                     | J1     | sandstones, shales   |
| TRIASSIC                            | nr     | sandstones, argillites (Nalbant Fm, Denis Tepe)            |
|                                     | cr     | Limestone with siliclastic elements                        |
|                                     | T2     | limestone with Ammonites                                   |
|                                     | T1     | conglomerates, sandstones, quartzites, schists, limestones |
| PALEOZOIC                           | C1     | Carapelit Fm (lacustrine)                                  |
|                                     | D      | sandstones, schists, limestones, silicofites               |
|                                     | s      | philitic schists, limestones, graphitic quartzites         |
|                                     | S      | epi-metamorphites (Rediu )                                 |
|                                     | Pz1    | quartzites, sericitic phyllites (Priopcea Quartzites)      |
| Precambrian                         | Pcb    | meso-metamorphic (Uzum-Bair)                               |
| Lower Paleozoic + Upper Proterozoic | Pts-Pz | phillites, quartzites, tuffs, metagrauwackes               |
| Upper Proterozoic                   | 1      | 1. Grauwacke, greenschists                                 |
|                                     | 2      | 2. mesometamorphic -grano-gneissic                         |
|                                     | 3      | 3. micashists, quartzites, amphibolites                    |
|                                     | 4      | 4. amphibolitic series (Megina)                            |
| MESOZOIC MAGMATITES                 | β      | dolerite (Niculitel)                                       |
|                                     | ρ      | rhyolites (quartz-porphyras)                               |
|                                     | γ      | alkaline granites  |
| PALEOZOIC MAGMATITES                | 2      | granites: 1, fresh; 2, weathered                           |
|                                     |        | diorites   |
|                                     |        | gneissic granites  |
| CONTACT ROCKS                       | a b    | thermal contact rocks: a, fresh; b, wethered               |
|                                     |        | milonites  |





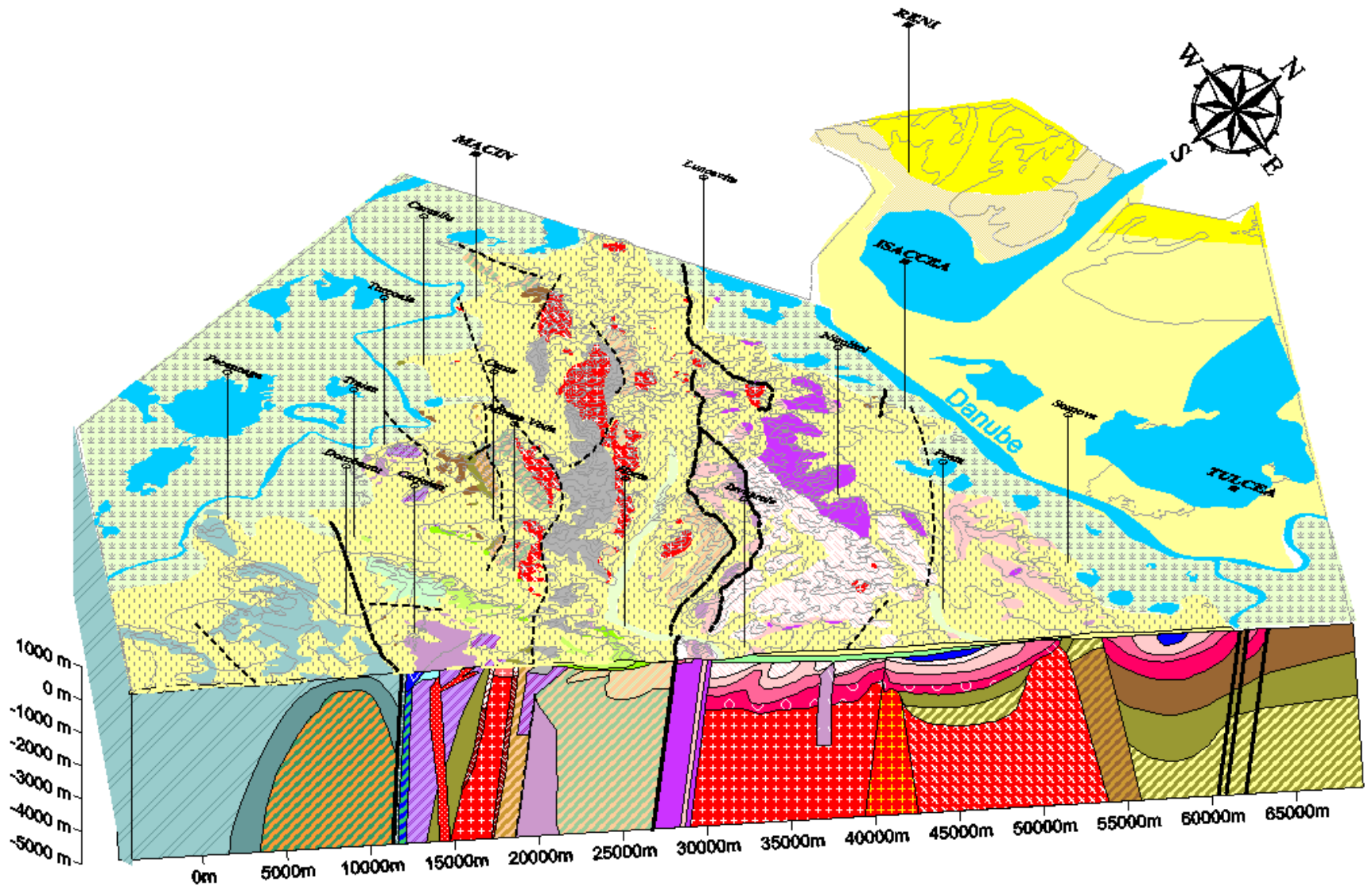
# GM SYS-3D: MODELLING OF THE GRAVITY AND GEOMAGNETIC DATA





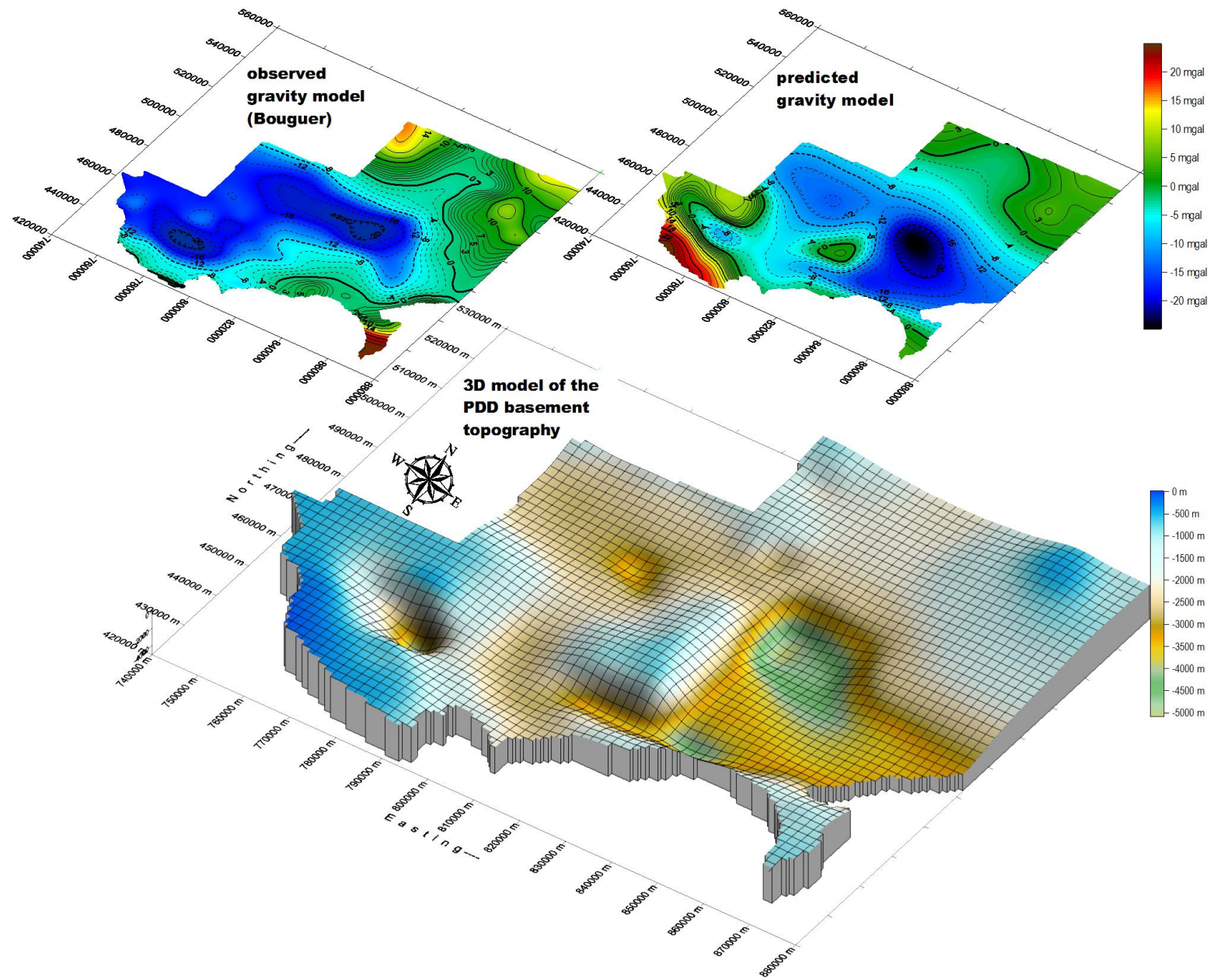


# CONSISTENT 3D MODEL ACROSS THE STATE BORDER BETWEEN ROMANIA AND UKRAINE WITHIN THE LOW DANUBE AREA





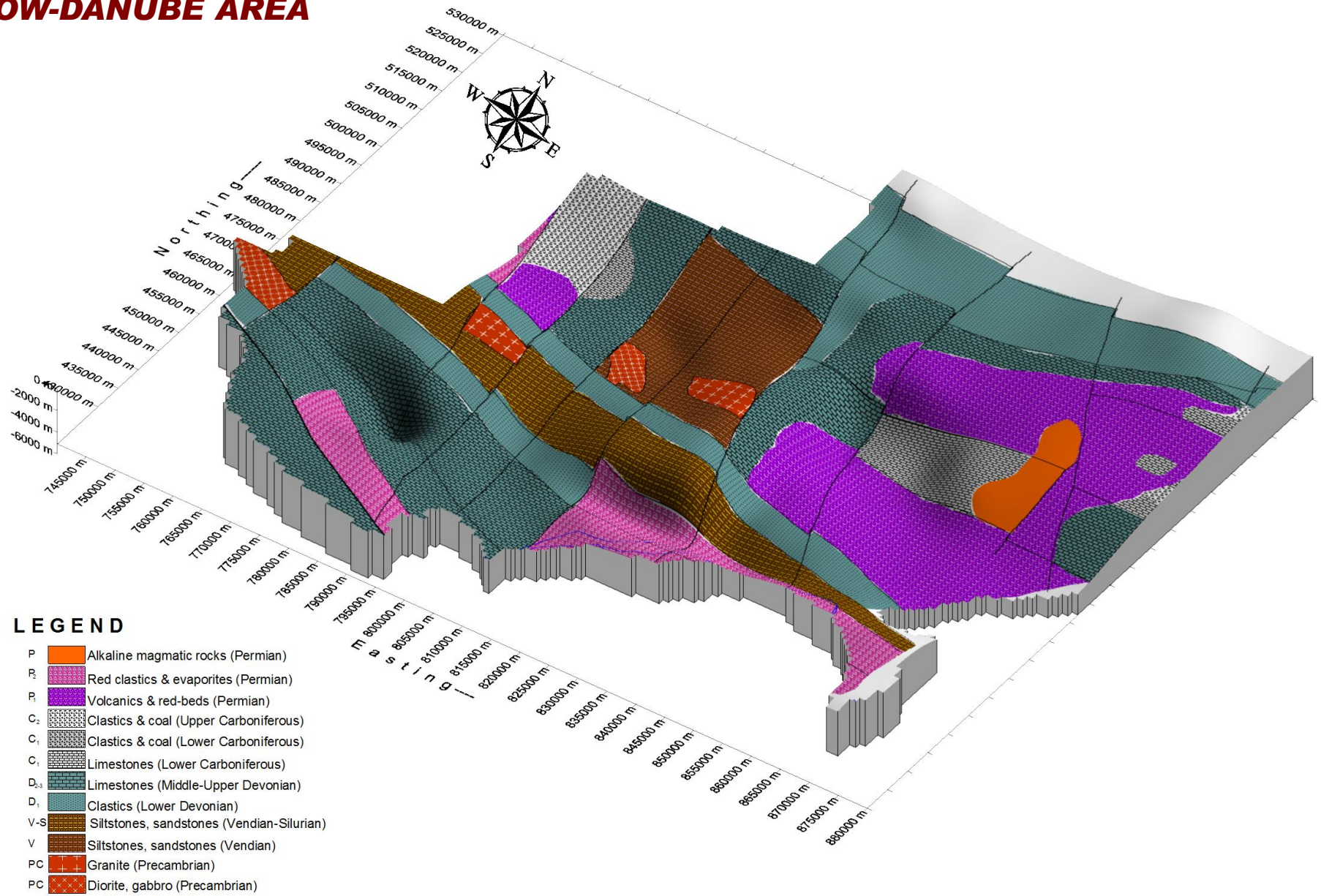
# GRAVITY BASED 3D TENTATIVE MODEL OF PDD BASEMENT TOPO







# 3D MODEL OF THE PRE-DOBROGEA DEPRESSION MESOZOIC SUBCROP WITHIN LOW-DANUBE AREA



## LEGEND

- P Alkaline magmatic rocks (Permian)
- P<sub>2</sub> Red clastics & evaporites (Permian)
- P<sub>1</sub> Volcanics & red-beds (Permian)
- C<sub>2</sub> Clastics & coal (Upper Carboniferous)
- C<sub>1</sub> Clastics & coal (Lower Carboniferous)
- C<sub>1</sub> Limestones (Lower Carboniferous)
- D<sub>2-3</sub> Limestones (Middle-Upper Devonian)
- D<sub>1</sub> Clastics (Lower Devonian)
- V-S Siltstones, sandstones (Vendian-Silurian)
- V Siltstones, sandstones (Vendian)
- PC Granite (Precambrian)
- PC Diorite, gabbro (Precambrian)

Geology compiled after Visarion et al. (1993); and Visarion & Neaga (1997)





# CONCLUDING REMARKS AND PERSPECTIVE

## 1. CONSISTENT DATASETS ACROSS THE STATE BORDER

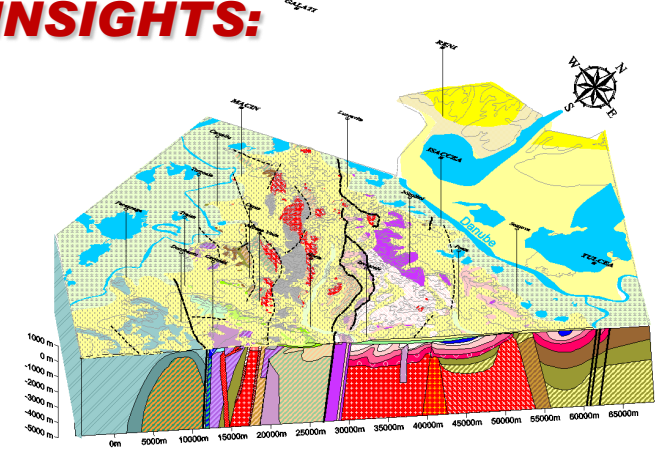
## 2. DATA INTERPRETATION ALLOWED SOME INSIGHTS:

### 2.1. NORTH DOBROGEA FOLDED BELT

**Geomagnetic anomaly sources:**

**Mesozoic bimodal magmatism (mainly effusive) and Paleozoic granites & diorites**

**The lowest gravity low (Nalbant-Randunica) revealed a batholithic granite in the basement of a graben-like structure of the Tulcea unit**



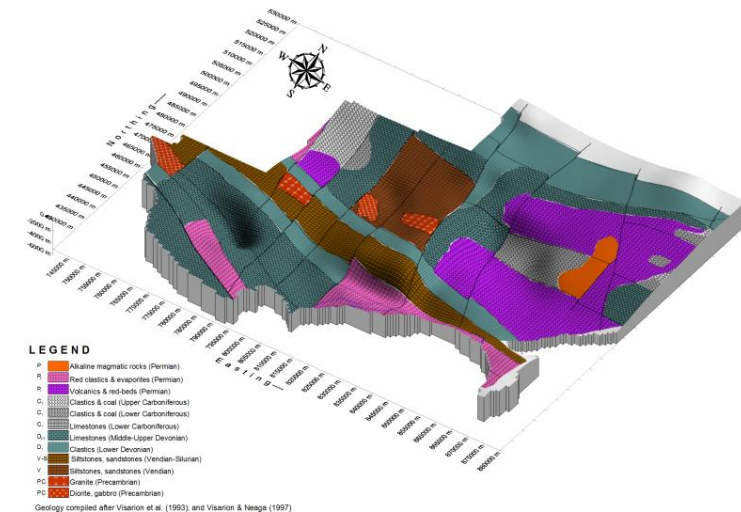
### 2.2. PRE-DOBROGEA (SCYTHIAN PLATFORM)

**Geomagnetic anomalies originate in:**

- Proterozoic crystalline series with magnetite
- Precambrian granites and diorites

**Gravity data outlined the topography of the prior to Mesozoic basement:**

- Aluat & Sarata-Tuzla (E-W) basins separated by
- Orlovka-Suvorov high (N-S)



## 3. PERSPECTIVE:

**Improving consistency of gravity data**

**Refining 3D PDD model by considering lateral variation in rock density**







***Thank you for your patience!***

