

3D GIS-MODELLING FOR EVOLUTION AND METALLOGENY OF EUROPEAN EARTH CRUST: JOINT RUSSIAN-FRENCH PROJECT

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A lot of newly obtained information on deep structure of Europe in last decades makes it necessary to integrate the new multi-disciplinary data into Earth crust model. The project is based on synthesis of geological, geophysical, and geochemical information using GIS technologies and statistics as for data compilation so for reprocessing and interdisciplinary interpretation along with analyzing the evolution and geodynamics of crust units. The fact, that the Europe could be characterized by the most detailed studies of the deep crust structure by seismic methods in comparison with other parts of the World, presents the best opportunity to extend our knowledge on the Earth crust through development of interpretation methods using experience obtained during the work on such projects as 4D Geodynamic Model of Australia (authors), GeoFrance 3D (Ledru, 1999), GIS Andes (Cassard, 1999 ; BRGM, 2001), World Atlas of Precambrian Metallogenic Zoning (Rundqvist et al., 2002), Geodynamic Globe (Rundqvist et al., in progress), etc.

Generalizations made for crust structure in continent scale earlier usually describe one- to maximum two-layers crust model. More detailed interpretation has been done for cross-sections along seismic geotraverses or for restricted isolated regions only. GIS-technologies would allow us to intra-/extrapolate such interpretation for the whole continent.

The area under study includes Western, Central, and Eastern Europe (Kostyuchenko, et al., 1999) excluding (?) Urals, shelf of Atlantic Ocean, Mediterranean and Caspian Sea, Asia Minor, and Caucasus.

The goal of the project is to interrelate metallogenic pattern with evolution of the European Earth crust. It requests:

- synthesis of multi-disciplinary data, methods, and technologies on the basis of GIS-technologies
- creation of 3D tectonic/geological model for European Earth crust at 1:5,000,000 scale
- 3D-modeling in more detailed scale (up to 1:1,000,000) for key structures and geoblocks

- engineering of evolutionary models for most important in terms of understanding the crust evolution regions

- verifying of database for European mineral deposits

- concluding analysis

I. Initial data.

For Western Europe, from published literature detailing the results of seismic refraction and reflection profiles, earthquake studies, and surface wave analyses (results from ECORS, CROP, BIRPS, SWAT, DEKORP, EGT, EUROPROBE, TRANSALP, etc.), it will be possible to extract 1-D seismic velocity model for a specific latitude and longitude. As in CRUST 5.1 and CRUST 2.0 global models (Mooney et al., 1998), the European 1-D model database, could then include the thickness and seismic velocity for each crustal layer : sedimentary layer, crystalline upper crust, middle crust, lower crust, uppermost mantle, etc. Compressional and shear wave velocities in each layer will be based on field measurements, and shear wave velocity and density will be estimated using published Vp-Vs and Vp-density relationships. It is necessary to note that shear velocities were obtained on the geotranssects carried out by GEON Center (Egorkin, 1998). Starting from this 1-D data base, 2-D and 3-D models could be elaborated locally on specific areas by interpolation on an appropriate profile or grid (5' × 5' to 0.5° × 0.5°):

- cross-sections along some characteristic geotraverses,

- 3-D models in area of metallogenic interest and / or where detailed information are available (e.g. French Massif Central, Armorican Massif, Rhein graben).

Interpolation procedure will have to take into account the main limits of crustal domains (craton, orogen, variscides, etc.) assumed from geology, gravity, magnetic, heat flow data, etc.

At the same time, gravimetric maps at 1 : 1,000,000 scale are available for all the territory under study. As it was shown for Yeniseiskii Ridge in Central Siberia (Cherkasov, 1999, 2000, Fig.1), integration of seismic data obtained along the geotranssects with such gravimetric maps allows us to define a detailed pattern of deep crust structure for the whole geoblock extrapolating the geotranssect data to quite large (up to few hundreds kilometers) area.

The Tectonic map of Europe at 1:5,000,000 scale (Khain, Yu. Leonov (eds.), 1996) will be taken as the basis for 2D surface modeling.

II. Methods

At the first stage, compilation of multi-disciplinary data will result with the legend developed for the whole project and series of 2D models (as for the surface, so for sections along the seismic lines/geotraverses. Re-interpretation of seismic will include analysis of seismically transparent zones and V_p/V_s ratio, which is important for metallogenic characteristics (Egorkin, Bulin, 1998, Konstantinov, et al., 1999). Authors do not addict the project methodology neither to plate tectonic nor to plum tectonic or traditional theories understanding possibility of different mechanisms' action at different stages of the Earth crust evolution. Preliminary analysis demonstrates the difference in evolution of the Earth crust on sides of Tonquist line. The East European and Uralian provinces (Fig. 2) are characterized by higher crust density and correlation of the density with the crust thickness. On the contrary, at Mediterranean and Western European provinces, we observe a wide range of the crust thickness and densities with inverse correlation of these parameters, which is typical for areas of basification.

Also, more detailed interpretation and 2D modeling will be executed for Fennoscandian shield, Rhein graben, Russian plate, Aegean Sea, and Central French Massif with special attention to areas where large mineral deposits are located. Fennoscandian shield is being considered as a first area for the study as one of the most interesting in terms of metallogeny and well studied region (Fig. 3).

Second stage will be based on 3D-modeling techniques developed in BRGM (see Courrioux et al., this volume). These techniques involve 3D direct geometric volumic modeling using direct data contained in geological databases (maps, sections and drill holes) and inverse methods using gravity, magnetic data and seismic data, which are used to adjust the geometric model.

The third stage includes evolutionary modeling and metallogenic analysis. In contrast to most published studies, our studies will focus on the distribution of deposits on a continental scale. Side effects arising from this approach are the loss of detailed phenomena by homogenisation of the thematic layers, scale differences in resolution of the GIS and the scale at which individual deposits are controlled. In return by combining the scale at which the crust responds to geodynamic evolution and the observation scale of individual ore deposits, the continent-scale 3-D view aspires to identify and further quantify the continental-scale controls beyond the controls of individual deposits. Data processing and modeling will imply "knowledge-driven" techniques based on in-house expertise and "data-driven" techniques such as weight of evidence modeling and new approaches (at least in the Geosciences domain) such as Data Mining (Salleb, 1999) and Artificial Neural Networking (Bougrain et al., 2002; see also Lips et al., this volume).

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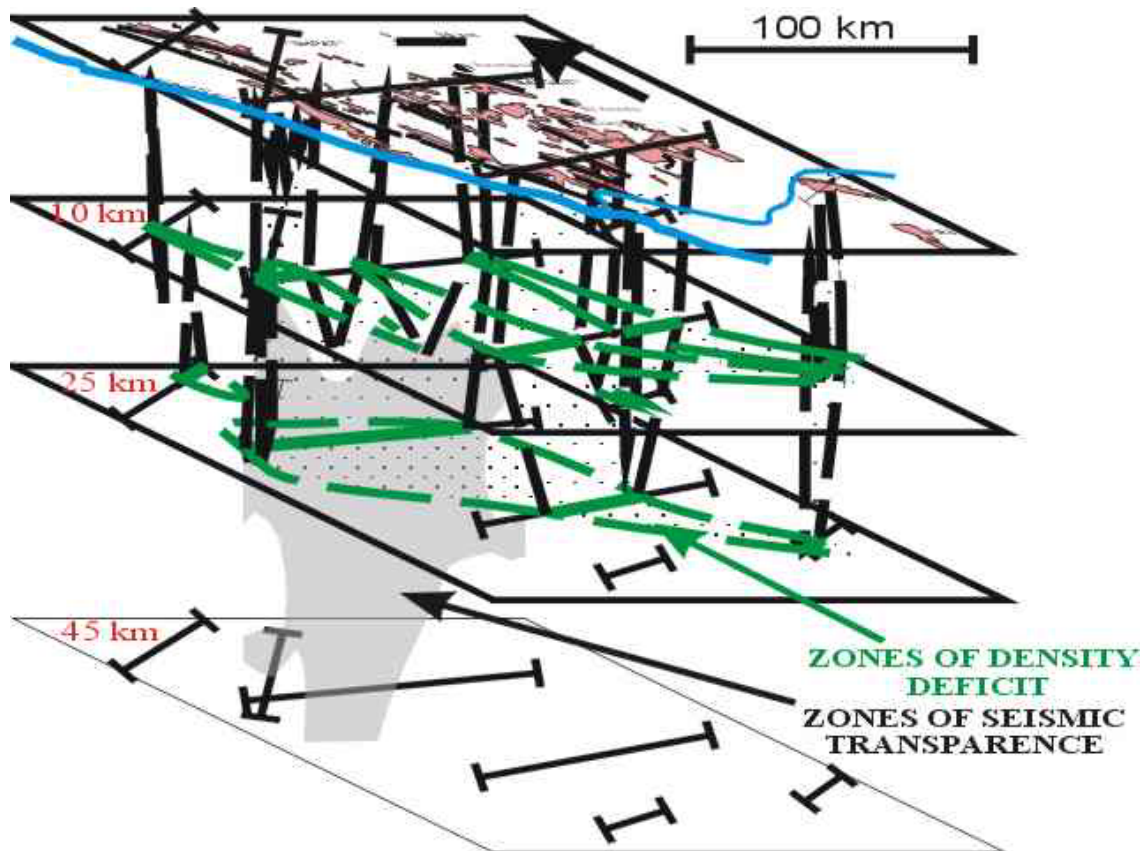
CROP project (Italia, 85-95) : <http://dssol.mi.ingv.it/DOL2000mappe.htm>

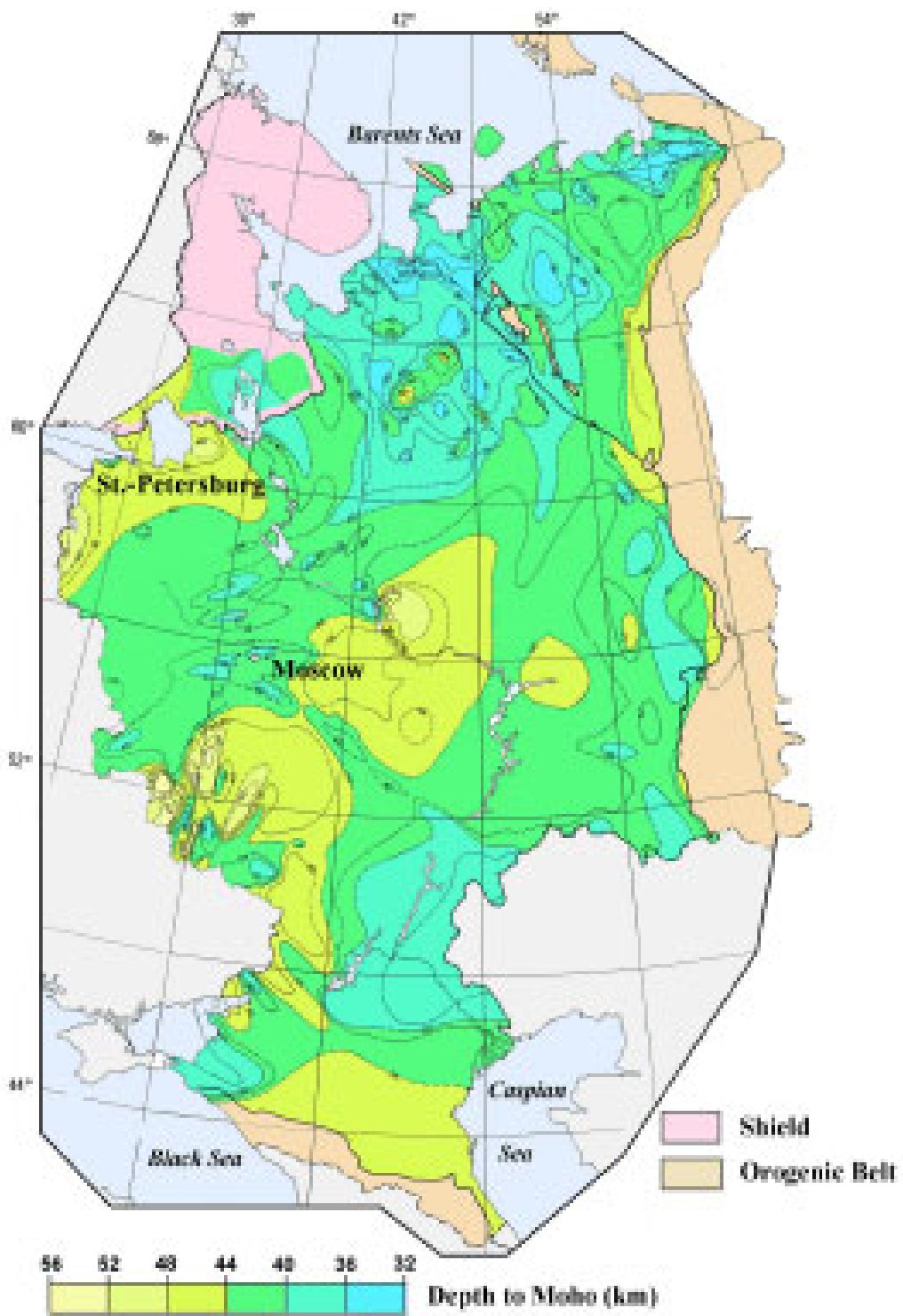
DOL project (Deep Seismic Sounding on line, Italia, 1968 - 1991, includes also Central and southern segments of EGT) : <http://dssol.mi.ingv.it/DOL2000mappe.htm>

NARS (1983-1999) : <http://www.geof.ruu.nl/~nars/>

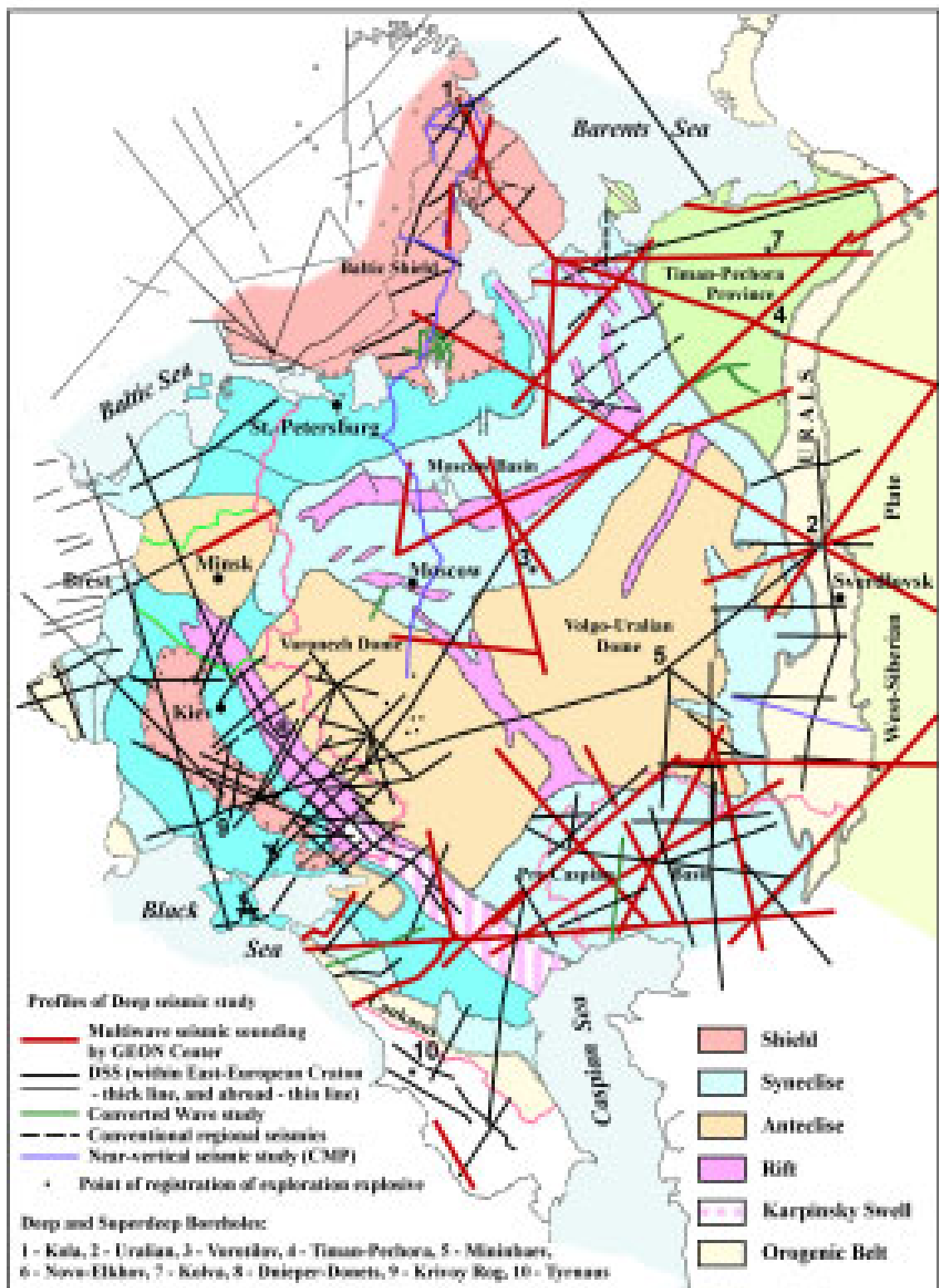
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Depth to Moho within East-European Craton in Russia



Location Map of deep seismic study within East-European Craton