MOLA: 3D lithospheric-scale structural model of the European Molasse basin

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Contents

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Abstract

We provide data that collectively allow recreating MOLA – the 3D structural subsurface model of the European Molasse basin introduced in Przybycin et al. (2015). The lithospheric-scale model that covers an area of 450 km in E–W direction and 500 km in N–S direction in North Alpine Foreland Basin, has originally been developed to understand the deep structure, balance, and load distribution of the Molasse basin and nearby Alpine area.

The data consist of 11 ASCII grid files corresponding to 11 lithostratigraphic model layers. The files include information on spatial variation of depth and thickness of these geological units and are mapped onto a grid with nodes spaced 2.5 km apart. The contents and structure of the grid files are described in the Technical Information section.

Model area

In model CRS (UTM32N):

X: 4450000 to 905000

Y: 5200000 to 5700000

Methods

To construct the 3D model, depth data for each lithostratigraphic unit was compiled using Petrel software (Schlumberger, version 2011.1). Where depth data was missing, thickness or seismic data was utilized if available. The compiled data was interpolated using a minimum tension gridding algorithm in Earth Vision software (Dynamic Graphics Ltd., version 8.0.1), with known faults considered as interpolation barriers. Inconsistencies from interpolation and extrapolation in data-sparse areas were corrected using the top Upper Jurassic (Malm) and top Paleozoic surfaces as references, due to their extensive coverage and reliable data constraints. After correcting all inconsistencies, the thicknesses of the top 8 lithostratigraphic units (from the Nördlinger Ries to the Tauern body, see Table 1) were calculated by subtracting the depths of successive units.

To extend the model further downward, we implemented the Moho (Grad et al., 2009) as the next deeper depth level of the model and calculated the thickness of the crystalline crust as the difference between the top of the crystalline basement and the Moho. Afterwards, each unit of the sedimentary part was parameterized with an average bulk density according to its dominant lithology. To obtain a density configuration for crystalline layer, the lateral density distribution was calculated following the approach of isostatic equilibrium of Pratt (1855).

The model was extended even further downward by introducing a seismologically constrained lithosphere–asthenosphere boundary (LAB). The LAB reaching the depth of 145 km b.s.l. has been constructed by integrating results of Tesauro (2009), Geissler et al. (2010), Karousová et al. (2013), Seiberlich et al. (2013) and Bianchi et al. (2014).

More details on the integration process and original input datasets can be found in Przybycin et al. (2015), in particular see tables and references there.

Technical Information

The model grids, the top surface elevations and thicknesses of corresponding layers of the 3-D model are provided as ASCII files, one file for each individual layer of the model.

The MOLA model consists of the layers shown in Table 1.

Number	Layer name	File name
1	Nördlinger Ries impact structure	*2024-MOLA_01_Ries.txt*
2	Alpine Body	*2024-MOLA_02_AlpineBody.txt*
3	Folded Molasse	*2024-MOLA_03_FoldedMolasse.txt*
4	Foreland Molasse	*2024-MOLA_04_ForelandMolasse.txt*
5	Cretaceous	*2024-MOLA_05_Cretaceous.txt*
6	Upper Jurassic Malm	*2024-MOLA_06_Malm.txt*
7	PreMalm Sediments (Jurassic and Triassic)	*2024-MOLA_07_PreMalm.txt*
8	Tauern Body	*2024-MOLA_08_TauernBody.txt*
9	Upper crystalline crust	*2024-MOLA_09_UpperCrust.txt*
10	Lower crystalline crust	*2024-MOLA_10_LowerCrust.txt*
11	Lithospheric Mantle	*2024-MOLA_11_LithosphericMantle.txt*

Table 1. MOLA model layers and corresponding filenames

The header of each ASCII file contains License, citation and column names. Header lines with license and citation are started with the # symbol, followed by a header line with column names.

The columns in each file are identical:

- column 1 contains the easting (X coordinate, in UTM 32N)
- column 2 contains the northing (Y coordinate, in UTM 32N)
- column 3 contains TOP (elevation, meters above the mean sea level)
- column 4 contains THICKNESS (layer thickness in m).

Values for 4 columns in each row are separated by a space.

The model has a lateral grid resolution of 2.5 km and 185 x 201 grid points (37185 points in total) for all model units. The vertical resolution of the final 3D model is heterogeneous due to the variable thickness of units.

Related Works

Przybycin, A. M., Scheck-Wenderoth, M., & Schneider, M. (2015). Assessment of the isostatic state and the load distribution of the European Molasse basin by means of lithospheric-scale 3D structural and 3D gravity modelling. *International Journal of Earth Sciences*, *104*(5), 1405-1424. https://doi.org/10.1007/s00531-014-1132-4

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Geissler, W. H., Sodoudi, F., & Kind, R. (2010). Thickness of the central and eastern European lithosphere as seen by receiver functions. *Geophysical journal international*, *181*(2), 604-634. https://doi.org/10.1111/j.1365-246X.2010.04548.x

Grad, M., Tiira, T., & Grp, E. W. (2009). The Moho depth map of the European Plate. *Geophysical journal international*, *176*(1), 279-292. https://doi.org/10.1111/j.1365-246X.2008.03919.x

Karousová, H., Plomerová, J., & Babuska, V. (2013). Upper-mantle structure beneath the southern Bohemian Massif and its surroundings imaged by high-resolution tomography. *Geophysical journal international*, *194*(2), 1203-1215. https://doi.org/10.1093/gji/ggt159

Pratt, J. H. (1855). On the Attraction of the Himalaya Mountains and of the elevated Regions beyond them, upon the Plumb-line in India. *Philosophical Transactions of the Royal Society of London*, *145 (1855)*, 53-100. https://www.jstor.org/stable/pdf/108510.pdf

Seiberlich, C. K. A., Ritter, J. R. R., & Wawerzinek, B. (2013). Topography of the lithosphere-asthenosphere boundary below the Upper Rhine Graben Rift and the volcanic Eifel region, Central Europe. *Tectonophysics*, *603*, 222-236. https://doi.org/10.1016/j.tecto.2013.05.034

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