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Review Article

EUNAseis: A seismic model for Moho and crustal structure in Europe, Greenland, and the North Atlantic region

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ABSTRACT

We present a new digital crustal model for Moho depth and crustal structure in Europe, Greenland, Iceland, Svalbard, European Arctic shelf, and the North Atlantic Ocean (72W–62E, 30N–84N). Our compilation is based on digitization of original seismic profiles and Receiver Functions from ca. 650 publications which provides a dense regional data coverage. Exclusion of non-seismic data allows application of the database to potential field modeling. EUNAseis model includes Vp velocity and thickness of five crustal layers, including the sedimentary cover, and Pn velocity. For each parameter we discuss uncertainties associated with theoretical limitations, regional data quality, and interpolation.

By analyzing regional trends in crustal structure and links to tectonic evolution illustrated by a new tectonic map, we conclude that: (1) Each tectonic setting shows significant variation in depth to Moho and crustal structure, essentially controlled by the age of latest tectono-thermal processes; (2) Published global averages of crustal parameters are outside of observed ranges for any tectonic setting in Europe; (3) Variation of Vp with depth in the sedimentary cover does not follow commonly accepted trends; (4) The thickness ratio between upper-middle (Vp < 6.8 km/s) and lower (Vp > 6.8 km/s) crystalline crust is indicative of crustal origin: oceanic, transitional, platform, or extended crust; (5) Continental rifting generally thins the upper-middle crust significantly without changing Vp. Lower crust experiences less thinning, also without changing Vp, suggesting a complex interplay of magmatic underplating, gabbro-eclogite phase transition and delamination; (6) Crustal structure of the Barents Sea shelf differs from rifted continental crust; and (7) Most of the North Atlantic Ocean north of 55°N has anomalously shallow bathymetry and anomalously thick oceanic crust. A belt of exceptionally thick crust (ca. 30 km) of probable oceanic origin on both sides of southern Greenland includes the Greenland–Iceland–Faeroe Ridge in the east and a similar "Baffin Ridge" feature in the west.

Contents

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1. Introduction

The crust in most parts of continental Europe has been studied in detail, primarily during the past half a century. Details of the development of crustal studies may be found in Prodehl et al. (2013–this volume). The first controlled source seismological experiment was carried out near Dublin in the mid 19th century by Mallet (1852), who determined the velocity of granites in the upper crust. The refraction seismic method came into use following *Mintrop's* developments in the 1920s and the first observations of normal-incidence reflections from the Moho were published by Beloussov et al. (1962), Kosminskaya and Riznichenko (1964), Liebscher (1964), Dohr and Fuchs (1967), Meissner (1967) and Clowes et al. (1968). During the late 20th century, several large scale seismic experiments provided the dense data coverage of the structure of the European crust, e.g. a series of EGT sub-projects, BABEL, POLONAISE and the Celebration'2000/Alps2000 projects, as well as the extensive activities by various national seismic programs (e.g. DEKORP, ECORP, and BIRPS).

The results have earlier been summarized as maps of the depth to Moho for specific areas of Europe (e.g. Behm et al., 2007; Beloussov et al., 1991; Burollet, 1986; Dezes et al., 2004; Garkalenko, 1970; Neprochnov et al., 1970; Pavlenkova, 1996; Sollogub, 1970; Thybo, 1997; Volvovski, 1973; Volvovsky and Volvovsky, 1975), and for the whole of western Europe (Artemieva and Meissner, 2012; Grad et al., 2009; Meissner et al., 1987a,b; Tesauro et al., 2008; Ziegler and Dezes, 2006). Two of them (Grad et al., 2009; Tesauro et al., 2008) additionally cover substantial areas outside of western Europe (Fig. 1) and are available in digital form, which makes them a useful tool for many geophysical studies. The models differ by the spatial coverage and include significantly different information on the crustal structure (Table 1): Grad et al. (2009) published a map of depth to the Moho in the European plate, whereas EuCRUST-07 model (Tesauro et al., 2008) includes information on the internal structure of the crust. Methodologically, both models are based on an extensive selection of original interpretations of seismic profiles, published maps and also use gravity data, tectonic regionalization, and interpolation to fill-in gaps between incorporated compilations. For example, gravity models, tectonic considerations and interpolations, such as often used in the crustal models of Russian geophysical organizations GEON (1979-1994), are inherited in the crustal model by Grad et al. (2009), where the Russian compilations (Erinchek and Milstein, 2006; Kostyuchenko, 1999) form an integral part.