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Preface

Moho: 100 years after Andrija Mohorovičić

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1. Introduction

In October 1909 an earthquake near Pokupsko, about 40 km to the southeast of Zagreb in Croatia, sparked the interest of the meteorologist and seismologist Andrija Mohorovičić. He secured copies of seismograms from many European stations and inferred the presence of a jump in seismic wavespeeds at a depth near 50 km by careful analysis of the character and times of arrival of both P and S phases. This work was published in the yearbook of the Zagreb Meteorological Institute in 1910, and was brought to wider attention by a digest in Gerlands Beiträge zur Geophysik published in 1911 that included a summary representation of his results.

The crust is relatively thick in this part of the Dinarides and so the cross-over between crustal and mantle arrivals occurs at considerable distance from the source. This large offset enabled the change in character to be recognised with the rather sparse set of information available to Mohorovičić. Subsequent work, including significant contributions from Jeffreys and Conrad, pushed forward the analysis of crustal structure using seismic waves, leading to the recognition of the Mohorovičić discontinuity as a ubiquitous feature marking the base of the crust. The name of the discontinuity is now commonly contracted to the "Moho". The nature of the transition between crust and mantle is not always sharp and considerable variety in character and depth has been revealed across the globe.

Although recognised as a first order feature of the lithosphere, observations of the Moho remained geographically sparse for the first 50 years after its discovery. In the sixties there was consensus for a definition of the Moho as "that level in the earth where the compressional wave velocity increases rapidly or discontinuously to a value between 7.6 and 8.6 km/s. In the absence of an identifiable rapid increase in velocity, the Mohorovičić discontinuity is taken to be the level at which the compressional wave velocity first exceeds 7.6 km/s" (Steinhart, 1967). An early regional map of depth to the Moho was published by Morelli et al. (1967) for the European continent (Fig. 1). Soon after maps of depth to Moho were published for the territory of the Soviet Union (Fig. 2; Belyaevsky et al., 1973) and for the United States of America (Fig. 3; Warren and Healy, 1973). A Moho map for Australia (Fig. 4) was published by Collins (1991).

It is remarkable that the main features of these early maps are robust and remain identifiable in the newest maps published in this volume. Resolution and regional coverage have improved considerably, so that the new maps show more details than the early contributions. A major uncertainty for estimation of Moho depth is produced by fast lower crust, with a wavespeed of >7.0 km/s which is close to the wavespeed of the uppermost mantle (>7.6 km/s). It is noteworthy that the early maps often underestimate the true crustal thickness where the top of the lower crust mistakenly is interpreted as the Moho because (1) the high velocity lower crust may be a "hidden layer" for refraction seismic interpretations, (2) it may cause the strongest observed wide-angle reflection in seismic sections, or (3) it may be the strongest converter in receiver function images. The uncertainty arising from these and other methodological and logistic challenges have been reduced with time, as seen in improved resolution and a wider depth range of determined Moho depths.

The Moho is most often the interface between the crust and the mantle, although with variable thickness of the transition zone, depending on the tecto-magmatic setting. However, in some locations the Moho may represent a metamorphic front in a gabbroic sequence which has been subject to high-pressure metamorphosis into eclogite facies. In case of serpentinization of the sub-Moho mantle, the seismic Moho may reside at the base of the serpentinites which petrologically lie inside the mantle.

2. Volume overview

This compilation of papers was initiated during the 100 years anniversary of the publication of the discovery made by Mohorovičić in 1910. Through a series of invited review papers the volume provides an overview of the many facets of the Moho as seen with different geophysical and geochemical tools, supplemented by regional studies covering many parts of the world. It includes five sections covering:

- historical introduction;
- regional models of crustal structure and Moho depth;
- physical-chemical nature of the Moho;
- processes that create and modify the Moho; and
- secular evolution of the Moho.

2.1. Historical introduction

The first 100 years of seismic research on the Moho is reviewed by Prodehl et al. (this volume). After a short introduction to how Mohorovičić in 1909 determined the presence of the Moho discontinuity,

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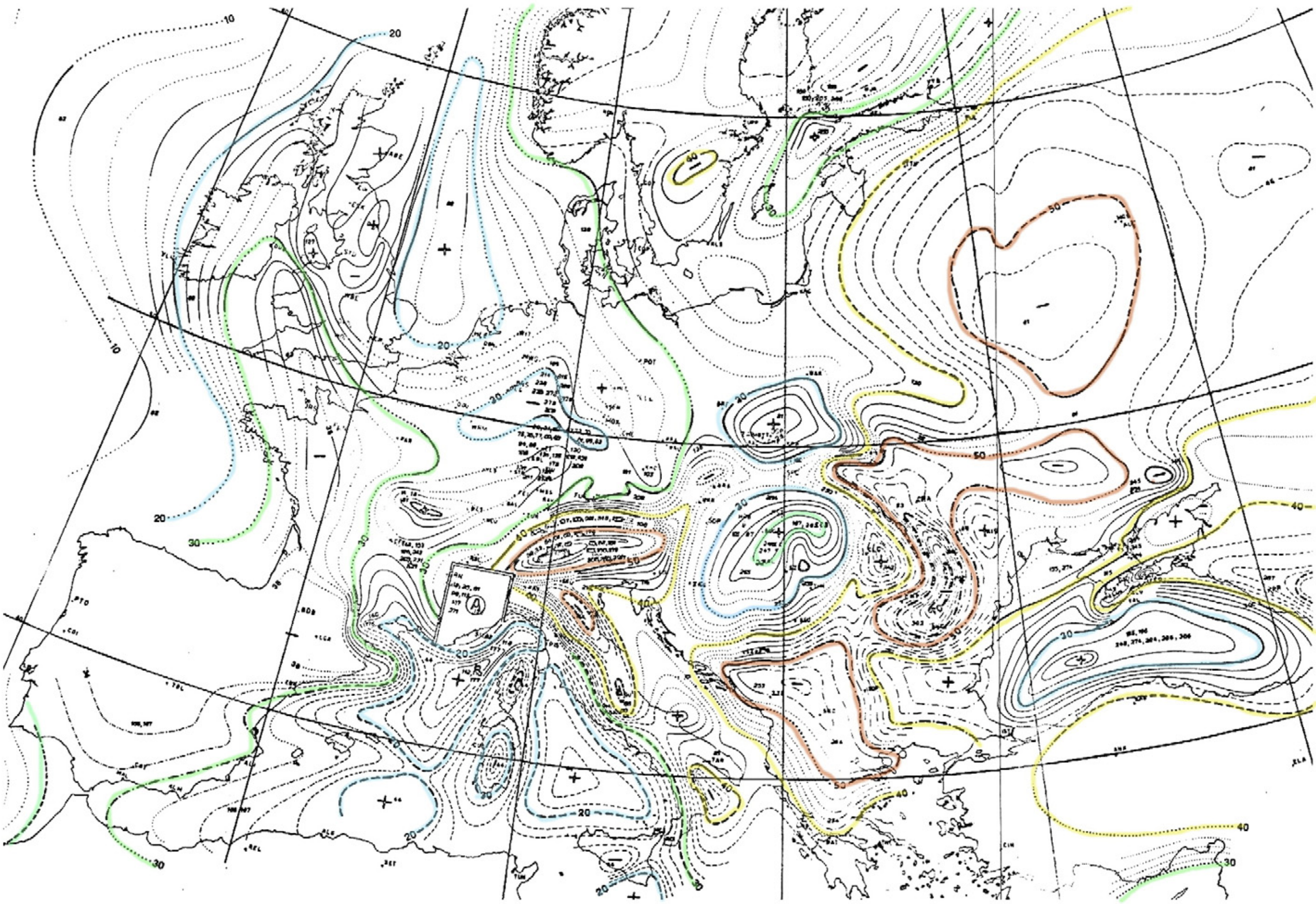

Fig. 1. Depth to Moho in Europe. Isolines with a 2 km step.
After Morelli et al., 1967.

the authors provide an overview of the early techniques that were applied to determinations of crustal structure, which were mainly applying earthquakes as sources although explosion sources were also used for crustal studies. The period after World War II is characterised by increased use of explosive sources which led to higher resolution of seismic images and models, including the determination of intra/crustal velocities. The authors chronologically review the evolution of seismic methods regarding data acquisition methods, processing technology, and interpretation methods. Since the 1980s the earthquake-based receiver function method has become increasingly popular for crustal studies as a supplement to controlled source techniques, not least for providing data on the structure where controlled source profiles are sparse. The integration of the two types of methods has contributed significantly to our current knowledge of crustal structure and depth to Moho.

2.2. Regional models of crustal structure and Moho depth

This large section provides an overview of the current knowledge of crustal structure and Moho in a series of regional reviews with main focus on seismic results. The many new compilations show significant differences to previous global and regional compilations.

The Americas are reviewed in four papers. Keller (this volume) describes the current knowledge of crustal structure and Moho in North America, with focus on results obtained since 2005, and provides a schematic map of depth to Moho for the area. Recent research programmes in Canada and the US have provided large quantities of data on crustal and lithospheric mantle structure. Numerous suture zones, with complex internal structure provide evidence for the Precambrian assembly of the continent. Unusually thick crust with very fast lower crust is interpreted in cratonic regions. Massive magmatic modification has been observed in rift systems and in the Basin and Range province. The highly complex crustal structure in the western part of the continent is related to the interaction between subduction, transform faulting and magmatism. Manea et al. (this volume) provides a geodynamic perspective on the crustal structure in Central America with emphasis on the effects of one of the world's most complex active subduction systems. The main processes controlling the subduction system are discussed based on a review of the tectonics, volcanism, slab geometry and segmentation along the margin. Different evolutionary scenarios for the subduction zone provide background for future modelling. Recent observations of seismic anisotropy provide evidence for mantle flow that may link deep and surface processes. Assumpção et al. (this volume) discuss models of crustal thickness in South America based on the available data from seismic refraction, receiver functions and surface wave tomography. The seismic coverage of the South American continent is highly variable with rather dense coverage along large parts of the Andean Cordillera and extremely sparse coverage in other parts. Two databases have been compiled, one based on controlled source results and the other includes results from surface wave inversion, both will be valuable for *e.g.* gravity interpretations. One of the maps of depth to the Moho is based on the seismic observations and contouring is guided by gravity in the poorly constrained areas. The other map is based on improved data coverage from including surface wave inversion. Not surprisingly, the authors find significant variation in crustal thickness in the Andes Cordillera, ranging from 75 km in Southern Peru and the Bolivian Altiplano, decreasing to the global continental average (~40 km) in Ecuador and southern Colombia, despite high elevation,