Tectonophysics 609 (2013) 217–233

Contents lists available at ScienceDirect

Tectonophysics

journal homepage: www.elsevier.com/locate/tecto

Review Article

Seismic images of the continental Moho of the Indian shield

P.R. Reddy, V. Vijaya Rao *

CSIR-National Geophysical Research Institute, Hyderabad-500007, India

ARTICLE INFO

Article history:
Received 14 January 2012
Received in revised form 31 October 2012
Accepted 22 November 2012
Available online 5 December 2012

Keywords:
Continental Moho
Seismic reflection profiling
Orogeny
Delamination
Extension
Crustal thickness

ABSTRACT

Deep seismic reflection profiling has imaged different patterns of the Moho across the Indian shield with a variety of tectonic environments from Archean to Recent. The character of the Moho varies from a discrete strong event, the base of strong coherent lower crustal sub-horizontal reflections, the base of dipping lower crustal reflections into mantle, to no clear reflection boundary. The seismic reflection data suggest a laminated lower crust in several places and offsets in the Moho at others. Kinematic and dynamic modeling of wide-angle reflection data across the Mesoproterozoic South Delhi Fold Belt and the Central Indian Tectonic zone suggests a laminated lower crust for these regions. In general, the lower crust of the Indian shield is heterogeneous. A clear Moho is identified in some of the Precambrian orogenic belts and sedimentary basins along with reflective lower-crust, whereas the cratonic areas exhibit a diffused Moho. Post-collisional extensional process, such as orogenic collapse, delamination, magmatic intrusions, low-viscosity ordering and underplating might have played a role in the generation of lower crustal laminated zone and formation of a younger Moho. The termination of lower-crustal reflectivity at the Moho with a transparent upper mantle need not necessarily indicate homogeneous upper mantle.

Contents

1. Introduction . . . 217
2. Deep crustal seismic data . . . 218
 2.1. Seismic reflection data . . . 219
 2.2. Seismic refraction data . . . 220
3. Structure and tectonic significance of reflection Moho . . . 220
 3.1. Reflection Moho patterns . . . 220
 3.2. Tectonic significance of reflection Moho patterns . . . 220
4. Discussion . . . 227
 4.1. Seismic characteristics of Moho . . . 227
 4.2. Moho depths . . . 232
5. Conclusions . . . 232
Acknowledgments . . . 232
References . . . 232

1. Introduction

The Moho, the Mohorovičić discontinuity, separates the crust from the mantle with differences in velocity, density, composition and rheology. In seismic refraction studies, the Moho is observed as a velocity discontinuity, where the P velocity changes from (6.8–7.4) km/s to (7.6–8.6) km/s representing compositional changes from predominantly mafic crustal facies to ultramafic upper mantle facies (Jarchow and Thompson, 1989; Meissner, 1973). In contrast, the basic information determined from reflection data is the detailed geometry of reflectors, and the Moho is represented by the termination of bright sub-horizontal lower-crustal reflection band with a transparent upper mantle (Barton et al., 1985; Klemperer et al., 1986).

Traditionally, the Moho was believed to be a static first-order boundary remaining relatively undisturbed subsequent to its formation. High-resolution seismic images of the deep crust and uppermost

* Corresponding author. Tel.: +91 40 23434686.
E-mail addresses: paravata@yahoo.com (P.R. Reddy), vijayraov@yahoo.co.in (V. Vijaya Rao).

0040-1951/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.tecto.2012.11.022

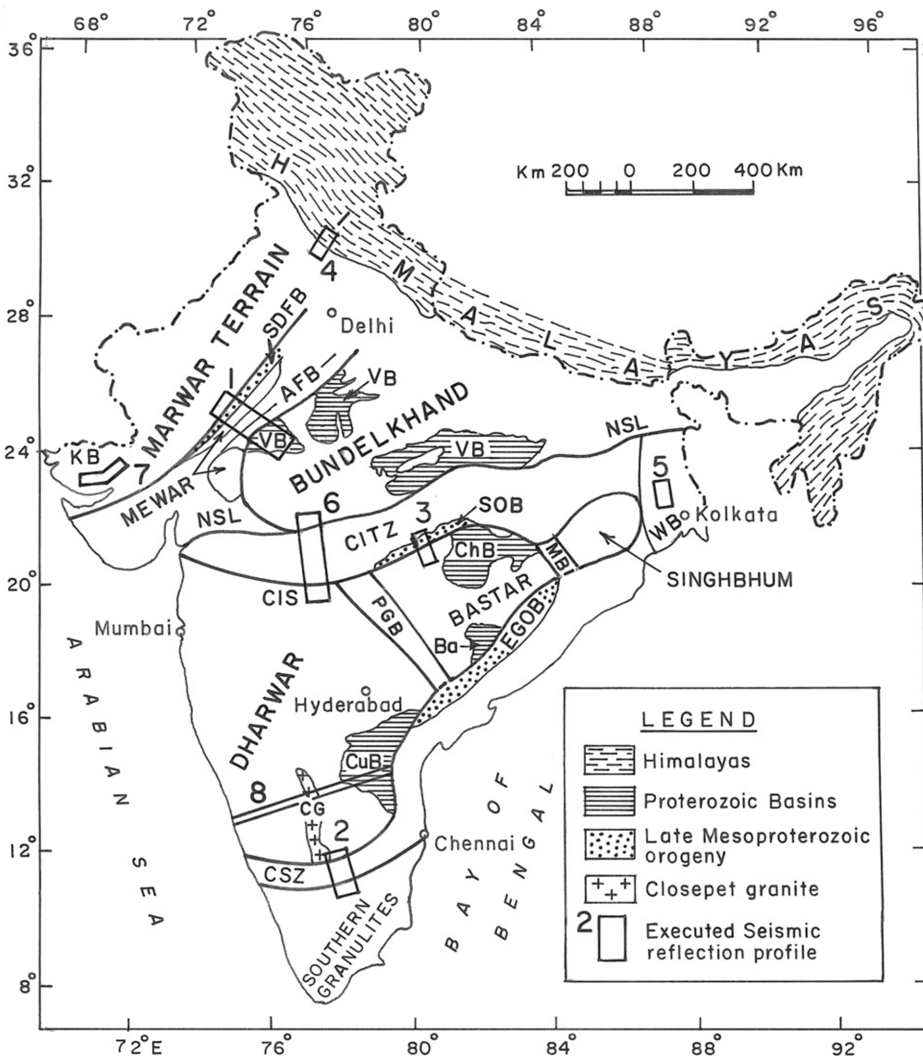

Fig. 1. Geological map of India, along with the seismic reflection/refraction profiles (1–8) marked. 1) Nagaur–Kunjer reflection profile across the Paleo-Mesoproterozoic Aravalli–Delhi fold belts, 2) Kuppam–Palani profile in the late Archean granulite terrain, 3) Seismic reflection profile across the Proterozoic Sausar orogeny of the Central Indian Suture, 4) HIMPROBE profile across the NW Sub-Himalaya, 5) Reflection profile in the Cenozoic West Bengal sedimentary basin, 6) Ujjain–Mahan refraction profile across the Central Indian Tectonic Zone (CITZ), 7) Shallow refraction study in the Kutch sedimentary basin, and 8) Kavali–Udipi refraction profile in the Dharwar craton. AFB — Aravalli Fold Belt; SDFB — South Delhi Fold Belt; SOB — Sausar Orogenic Belt; EGOB — Eastern Ghat Orogenic Belt; CITZ — Central Indian Tectonic Zone; NSL — Narmada Son lineament; CIS — Central Indian Suture; WB — West Bengal Basin; and KB — Kutch Basin.

mantle derived from deep crustal reflection profiling have revolutionized our understanding of the Moho (Brown, 1987; Cook et al., 2010; Klemperer and Hobbs, 1991; Meissner and Rabbel, 1999; Mooney and Meissner, 1992). Studies of exposed crustal cross sections and xenoliths have further changed the traditional concepts of the Moho (Fountain and Salisbury, 1981).

The Indian shield is a mosaic of Archean cratonic blocks of ~3.6 Ga rocks accreted and sutured together with the formation of fold belts between them during the 3.6 Ga long geological history (Radhakrishna, 1989). The Proterozoic Aravalli, Satpura, South Delhi, Eastern Ghat and Sausar fold belts, the Pan-African Kuunga–Malagasy orogeny and the Cenozoic Himalayan orogeny are the major orogens associated with the various accretionary episodes. The lithospheric evolution of the Indian shield is related to these orogenic episodes (Vijaya Rao, 2008). Some of the accretionary boundaries/suture zones are now represented by rifts, such as the Narmada–Tapi (CITZ), Mahanadi and Pranahita–Godavari rifts (Fig. 1). Additionally, a large number of sedimentary basins were also formed, with ages spanning the Proterozoic to Recent period.

Deep probing of the Indian continental crust was started in 1972 by refraction/wide-angle reflection studies and they were subsequently complemented by deep seismic reflection profiling from 1991 (Kaila and Krishna, 1992; Rajendra Prasad and Vijaya Rao, 2005; Reddy et al., 1999). The purpose of the present paper is to understand the dynamic nature of Moho under the Indian shield. In this context, seismic reflection data that provide high-resolution deep crustal images are integrated with selected refraction/wide-angle reflection data from the Indian shield to understand the nature of the Moho and its relationship to the tectonic regime. Seismic wave field patterns identified from reflection profiling are analyzed to understand the geological processes, as seismic images are manifestations of tectonic and magmatic processes of the Earth.

2. Deep crustal seismic data

Different geophysical methods have different spatial resolution and measure different physical properties. Among the various methods, seismic profiling provides the highest resolution of the subsurface. The seismic refraction method provides indications of the state of chemical differentiation (composition) of the Earth and the metamorphic condition at depth, whereas the reflection method provides