Available online at www.sciencedirect.com
SCIENCE DIRECT
ELSEVIER
Tectonophysics 410 (2005) 325–336
TECTONOPHYSICS
www.elsevier.com/locate/tecto

The Vrancea seismic zone and its analogue in the Banda Arc, eastern Indonesia

John Milsom *

Department of Earth Sciences, University of Hong Kong, Pokfulam Road, Hong Kong, China

Received 24 October 2004; received in revised form 6 March 2005; accepted 6 June 2005
Available online 28 September 2005

Abstract

It is now widely, although not universally, accepted that the Carpathian orogen marks the site of an arc–continent collision that followed the subduction of a now vanished small ocean basin. Seismic tomography has defined a high-velocity anomaly in the upper mantle similar to those associated with subduction zones worldwide. There is, however, no recognisable Wadati–Benioff Zone (WBZ), and intermediate-depth seismicity is confined to a relatively small, roughly cylindrical and vertically elongated region beneath the extreme southeastern corner of the mountain chain. There is no consensus in the published studies as to the origin of this 'Vrancea Zone'.

The Banda Sea region of eastern Indonesia has sometimes been cited as an analogue for the Pannonian/Transylvanian basin and the enclosing Carpathian orocline, but at first sight the patterns of seismicity appear very different. Intermediate depth seismic activity defines a subducted slab that dips north, south and west beneath the Banda Sea, a configuration explained as a consequence of the rapid expansion of the sea during roll-back subduction. If the similar scenario proposed for the Carpathians is correct, then it is the absence of a Carpathian WBZ that is actually anomalous. Closer examination of Banda Arc seismicity shows that it can be divided into two parts, these being a scoop-shaped WBZ and an adjacent 'Damar Zone' of much more intense intermediate-depth activity. At its eastern end the Damar Zone merges with the WBZ, but in the west there is evidence for separation from it. A plausible explanation of this pattern is that a lower layer of the downgoing slab is peeling away from the remainder.

The Banda/Australia collision is now almost complete and the activity in the WBZ proper can be expected to decrease. Damar Zone activity, on the other hand, may persist for a much longer period, migrating towards the foreland as the detaching layer separates from the remainder of the subducted lithosphere. In a few million years the seismicity of the Banda region could well resemble the present day seismicity of the Carpathian orogen.

Keywords: Vrancea; Banda arc; Subduction roll-back; Arc–continent collision

1. Introduction

The Vrancea intermediate depth seismic zone of eastern Romania (Fig. 1) has been discussed by numerous authors, (e.g., Wenzel et al., 1999; Raileanu et al., this volume; Popa et al.; this volume). Some consider it to be a relic of a Wadati–Benioff Zone (WBZ) associated with subduction that involved rapid roll-back of the Carpathian arc into a small oceanic embayment. However, a significant number (e.g., Knapp et al., this volume) reject this view as incompatible with the evidence, citing in particular

* The Camp, Gladestry, Kington, Herefordshire HR5 3NY, UK. Tel./fax: +44 1544 370 607.
E-mail address: john@kinnersley.com.

0040-1951/$ - see front matter © 2005 Published by Elsevier B.V.
doi:10.1016/j.tecto.2005.06.011

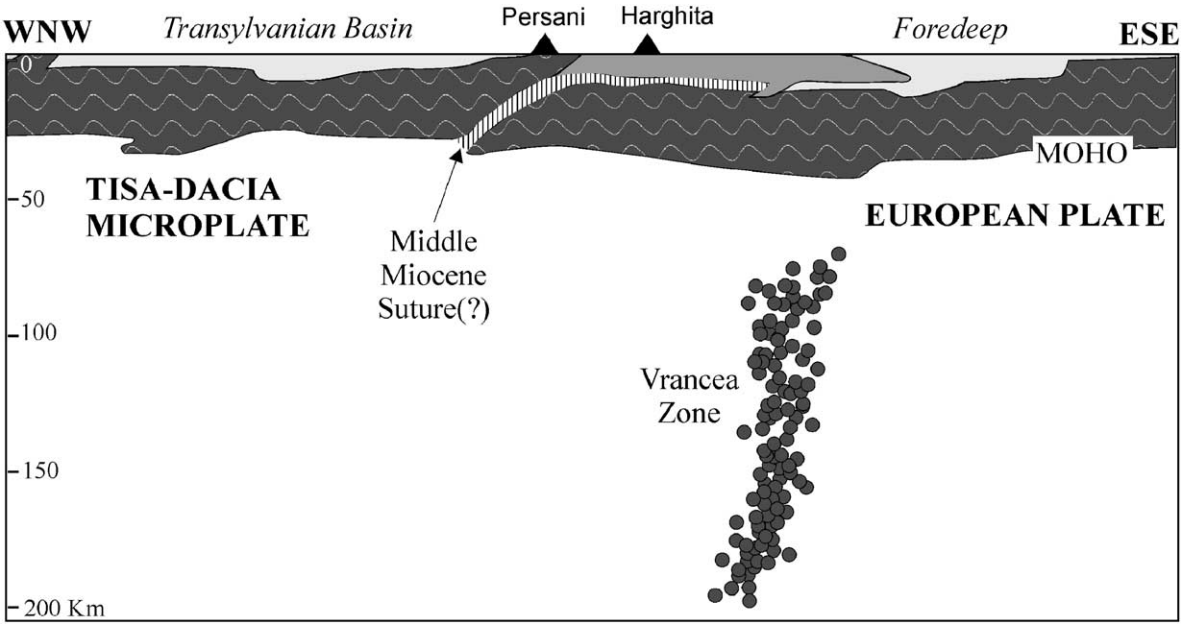

Fig. 1. The Vrancea seismic zone, after Girbacea and Frisch (1998). Profile location shown on Fig. 2.

the displacement of the seismically active region towards the foreland and away from the location expected for a subducted slab (see Bala et al., 2003; Girbacea and Frisch, 1998; Oncescu, 1984; Oncescu and Bonjer, 1997). The lack of any direct evidence for the incorporation of oceanic crust into the supposed collision complex has also been widely noted (e.g., Sandulescu, 1988). In terms of this controversy, the most important aspects of the Vrancea Zone are that:

1) It is the site of the deepest earthquakes in the entire Carpathian area and, in fact, of the only intermediate depth earthquakes (Oncescu, 1984).
2) It is situated close to the region of maximum curvature in the Carpathian arc (Fig. 2a).

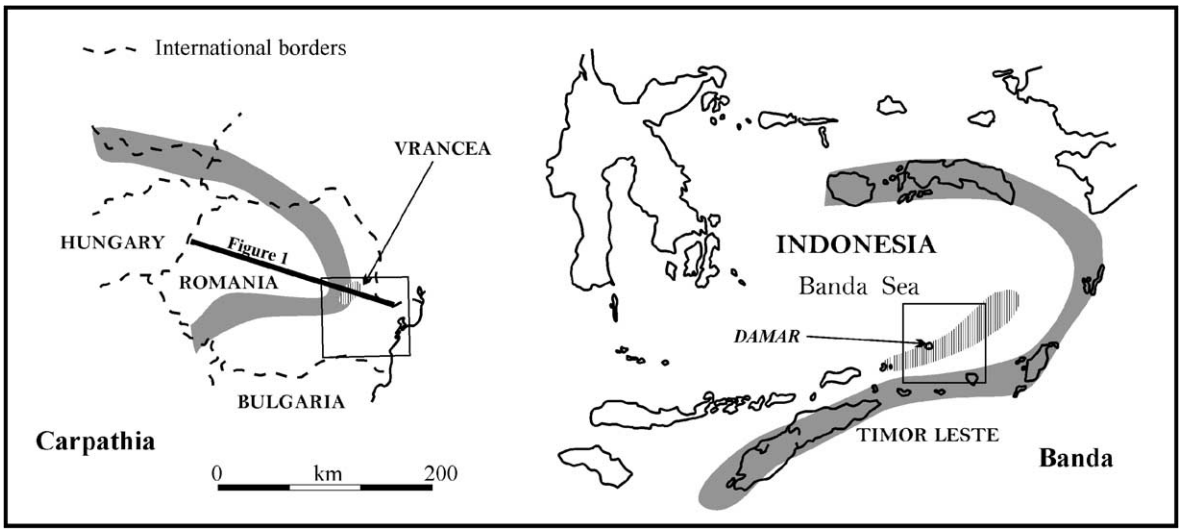

Fig. 2. The Carpathian and Banda oroclines. The location of the cross-section in Fig. 1 is indicated by the thick black line. Stipple indicates the locations of the orogenic belts and vertical striping the locations of the zones of intermediate depth seismic activity. Rectangles define areas where focal mechanisms are shown in Fig. 8. The scale is the same for both sketches.