Available online at www.sciencedirect.com
ScienceDirect
Gondwana Research 10 (2006) 207–231
www.elsevier.com/locate/gr

GR Focus

Rise and fall of the Eastern Great Indonesian arc recorded by the assembly, dispersion and accretion of the Banda Terrane, Timor

Ron Harris

Department of Geological Sciences, Brigham Young University, Provo, Utah, 84602-4606 USA

Received 23 February 2006; received in revised form 20 May 2006; accepted 28 May 2006
Available online 28 August 2006

Abstract

New age, petrochemical and structural data indicate that the Banda Terrane is a remnant of a Jurassic to Eocene arc–trench system that formed the eastern part of the Great Indonesian arc. The arc system rifted apart during Eocene to Miocene supra-subduction zone sea floor spreading, which dispersed ridges of Banda Terrane embedded in young oceanic crust as far south as Sumba and Timor. In Timor the Banda Terrane is well exposed as high-level thrust sheets that were detached from the edge of the Banda Sea upper plate and uplifted by collision with the passive margin of NW Australia. The thrust sheets contain a distinctive assemblage of medium grade metamorphic rocks overlain by Cretaceous to Miocene forearc basin deposits. New U/Pb age data presented here indicate igneous zircons are less than 162 Ma with a cluster of ages at 83 Ma and 35 Ma. $^{40}Ar/^{39}Ar$ plateau ages of various mineral phases from metamorphic units all cluster at between 32–38 Ma. These data yield a cooling curve that shows exhumation from around 550 °C to the surface between 36–28 Ma. After this time there is no evidence of metamorphism of the Banda Terrane, including its accretion to the edge of the Australian continental margin during the Pliocene. These data link the Banda Terrane to similar rocks and events documented throughout the eastern edge of the Sunda Shelf and the Banda Sea floor.

Keywords: Banda Terrane; Timor; Banda Arc; Banda Sea; Indonesia; SE Asia; Forearc; Orogenic collapse; Slab rollback; Suprasubduction zone spreading; Arc–continent collision; Terrane accretion; Tectonics; Geochronology; Metamorphism; Structure

Contents

E-mail address: rharris@byu.edu.

1342-937X/$ - see front matter © 2006 International Association for Gondwana Research. Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.gr.2006.05.010

1. Introduction

Most volcanic arcs are retreating due to slab rollback of subducting plates (i.e. Dewey, 1980). If the upper plate of the subduction zone cannot keep pace with the retreating trench, it is extended (Elsasser, 1971), and may even form a new supra-subduction zone oceanic basin with embedded fragments of the collapsed arc–forearc system. Extensional collapse of an arc is driven by its high potential energy and thermal weakening (Molnar and Atwater, 1978). The extension direction is commonly normal to the orientation of the trench, which can form trench parallel, highly attenuated ridges of arc and forearc units embedded in newly formed supra-subduction zone oceanic crust (Schellart et al., 2002). Examples of this process are well documented in the Izu–Bonin–Mariana, Mediterranean and Caribbean arc–trench systems. In these regions shortening at the trench was simultaneous with extension in the arc and backarc regions (i.e. Malinverno and Ryan, 1986).

The Banda Arc region of eastern Indonesia (Fig. 1), which is the focus of this paper, also provides a classic example of how arcs evolve by multiple phases of fragmentation and accretion. The unique aspect of the Banda Arc region is that its outer edge is currently colliding with the northern continental margin of Australia. The collision has uplifted and exposed large sections of forearc basement and cover, which provide a rare opportunity to investigate the make-up and complex origin of a forearc slab still attached to an active arc (Fig. 1). These rocks are collectively named the Banda Terrane (Audley-Charles and Harris, 1990).

Discussion in this paper will mainly focus on the age petrology and metamorphic history of basement rocks of the Banda Terrane, and the paleogeographic origins of associated sedimentary and volcanic cover units. These new data from Banda Terrane units in Timor strengthen correlations already made between similar units from different parts of the Banda Sea region (Tappenbeck, 1939; van West, 1941; Haile et al., 1979; Earle, 1983). I will also show how the stratigraphic and age relations of Banda Terrane upper plate units contrast with structurally underlying lower plate units of the Australian continental margin (Fig. 1).

Due to the obliquity of the active Banda arc–continent collision, Banda Terrane thrust sheets in Timor can be traced laterally along orogenic strike to autochthonous units in the present forearc of the western most Banda Arc (Harris, 1991). For example, exposures of autochthonous forearc basement in Sumba are traceable eastward along the submarine Sumba Ridge (Reed et al., 1986) to thin, flat-lying thrust sheets of Banda Terrane up to 2000 km^2 in size and 1–3 km thick in Timor (Fig. 1d). Various stages of roof thrust emplacement and deformation are found along orogenic strike, and provide a rare glimpse of progressive modes of forearc nappe emplacement during an active arc–continent collision (Fig. 1b).

The purpose of this paper is to integrate earlier studies with new data collected throughout the Banda Arc region that focus on the well-exposed Banda Terrane thrust sheets in both West and East Timor. These data include the first U/Pb and ^{40}Ar/^{39}Ar age analyses and petrologic and structural studies of Banda Terrane klippen in East Timor, which are critical in addressing various models for the origin of metamorphic rocks in the Timor region.

2. Banda Terrane

The Banda Terrane consists of three distinctive components (Fig. 2): 1) crystalline schist and gneiss, 2) meta-mafic and ultramafic bodies, and 3) arc affinity igneous rocks interlayered with and intruding high-energy forearc basin deposits and volcanogenic and carbonate cover sequences. Various parts of the Banda Terrane are found in Sulawesi, the islands between Sulawesi and Flores, the Banda Ridges, which separate the north and south Banda Sea ocean basins, Sumba and in high-level thrust sheets of the Timor fold and thrust belt (Fig. 1d). The lithotectonic assemblage is interpreted as remnants of a continental arc terrane fringing the southeastern edge of the Sunda Shelf, which has been fragmented and dispersed mostly by opening of the Banda Sea, and is presently partially accreted to the leading edge of the Australian plate (Carter et al., 1976; Haile et al., 1979; Earle, 1983).

Another view of the metamorphic rocks associated with the Banda Terrane of East Timor is that they represent pre-Permian basement from the Australian continental margin exposed as autochthonous horst blocks (Grady, 1975; Chamalaun and Grady, 1978) or basement involved thrusts (Charlton, 2002). The purpose of this section of the paper is to provide a comprehensive overview of the geology and age of various Banda Terrane units in an effort to distinguish between these various models and establish their tectonic affinity.

2.1. Sumba

The westernmost occurrences of the Banda Terrane are exposed on the island of Sumba. Most of the island is covered with Late Neogene chalk and marl, which is characteristic of the oldest forearc basin deposits found throughout the islands of the outer Banda Arc (Audley-Charles, 1986). To the east of Sumba, in Savu, Rote and Timor, the chalk and marl unit is known as the Batu Putih (rock white) Formation (Kenyon, 1974), which