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Journal of Asian Earth Sciences 29 (2007) 751–777
Journal of Asian Earth Sciences
www.elsevier.com/locate/jaes

# Petrologic, isotopic, and radiometric age constraints on the origin and tectonic history of the Malino Metamorphic Complex, NW Sulawesi, Indonesia

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Received 3 February 2005; accepted 30 May 2006

**Abstract**

The Malino Metamorphic Complex (MMC) is located at the western end of the north arm of Sulawesi. It consists of mica schists and gneisses (derived from proximal turbidite and granitoid protoliths), with intercalations of greenschist, amphibolite, marble, and quartzite, forming an E-W elongated dome-like structure bounded on all sides by faults. The age of the MMC is constrained between Devonian and Early Carboniferous. This Paleozoic age, the presence of Archean and Proterozoic inherited zircons, and the isotopic signature of the mica schists and gneisses indicate that the terrane was derived from the New Guinea-Australian margin of Gondwana. Similarities with basement rocks in the Bird's Head suggests a common origin. Greenschists forming a discontinuous selvage (metamorphic carapace) around the complex were derived from adjacent autochthonous Paleogene formations. The rocks of the MMC show a Barrovian-type progression from greenschist through epidote-amphibolite to amphibolite facies. P–T estimations suggest a depth of burial of up to 27–30 km. K/Ar and 40Ar/39Ar cooling ages of 23–11 Ma, and a 7 Ma age for unconformably overlying volcanic rocks, indicate that the complex was exhumed during the Miocene. Two tectonic scenarios are considered: 1. the continental fragment docked with Sulawesi during the Mesozoic and was exhumed as a metamorphic core complex during the Miocene; 2. it was subducted beneath the north arm during the late Oligocene and then rapidly returned back to the surface.


*Keywords:* Metamorphic rocks; Radiometric age dating; Radiogenic isotopes; Sulawesi

## 1. Introduction

The Indonesian region comprises a complex assemblage of continental fragments of Gondwanan origin, which are interspersed with island arcs, accretionary complexes, dismembered ophiolite terranes, and marginal basins. It can be divided into two main tectonic entities (Fig. 1A) based on the time of accretion of the continental fragments: Sundaland (mainland SE Asia and western Indonesia), which had become a stable craton by the end of the Mesozoic (e.g., Metcalfe, 1996 and references therein), and eastern Indonesia (east Sulawesi and islands to the east and southeast), where the first microcontinents began to arrive during the late Oligocene/early Miocene (e.g., Audley-Charles et al., 1972; Katili, 1978; Hamilton, 1979; Milsom, 2000; Hall and Wilson, 2000).

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doi:10.1016/j.jseaes.2006.05.002

Located between these two domains is the Western Sulawesi Province (Fig. 1B), which began to develop at the southeastern margin of Sundaland in the late Mesozoic. A number of authors have suggested that a microcontinent is incorporated in its basement, now (largely) covered by Cenozoic deposits, but opinions differ as to whether it accreted to Sundaland during the late Mesozoic (Audley-Charles et al., 1988; Metcalfe, 1990, 1996; Priadi et al., 1993; Longley, 1997; Elburg et al., 2003a), or Miocene (Priadi et al., 1994; Bergman et al., 1996; Polvé et al., 1997, 2001; Elburg et al., 2003a). The main evidence published to date in support of the presence of old crustal rocks in Western Sulawesi is provided by the results of radiogenic isotope analyses (Sr, Nd, and Pb) of Middle Miocene to Pliocene

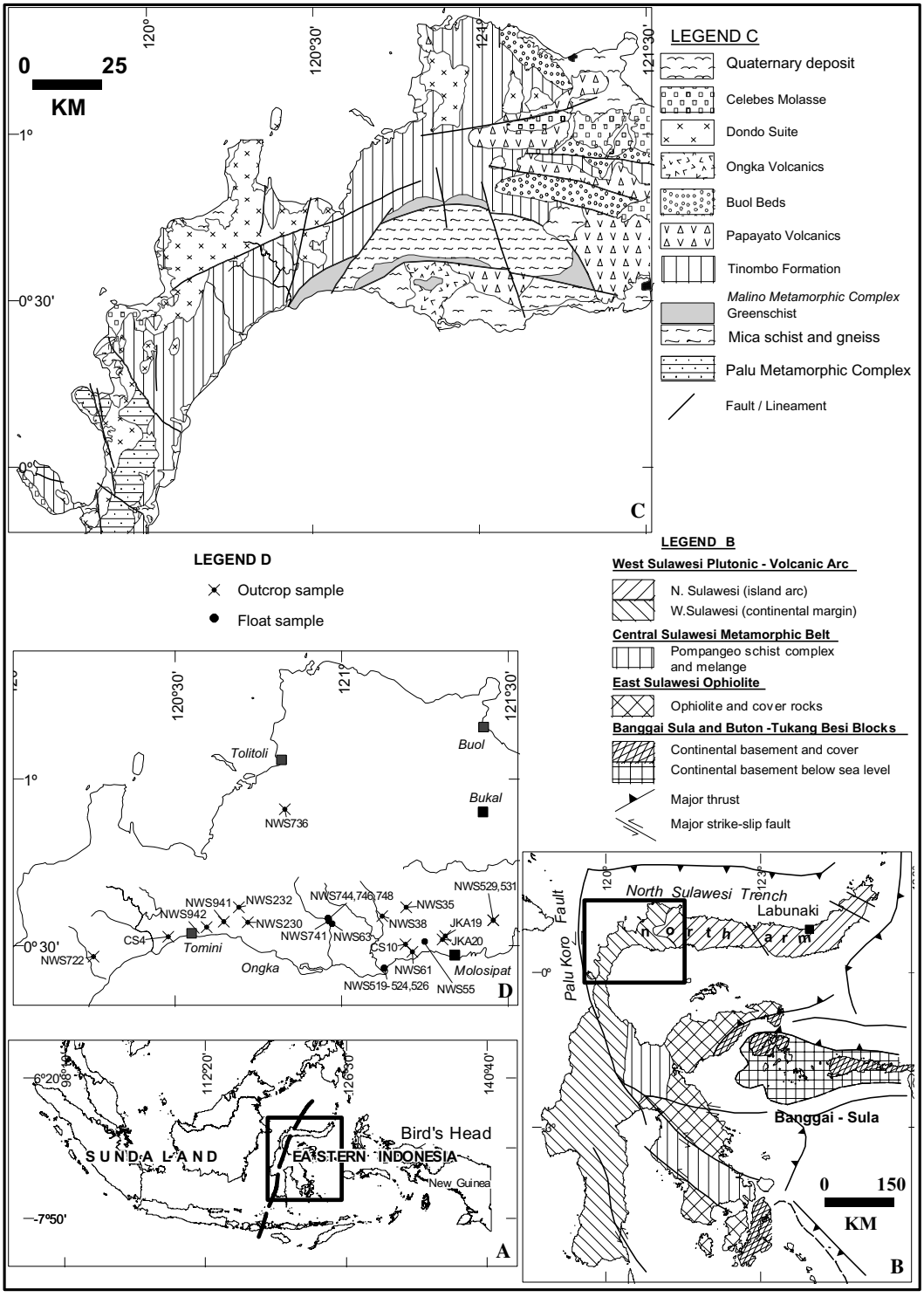


Fig. 1. (A) Geology of NW Sulawesi (modified after Ratman, 1976); (B) Sample locations; (C) Map of Indonesia showing the location of Sulawesi (boxed), boundary between Sundaland and Eastern Indonesia, and the Bird's Head; (D) Tectonic framework of Sulawesi; (A) is boxed.