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Paleostress reconstruction from calcite twin and fault–slip data using the multiple inverse method in the East Walanae fault zone: Implications for the Neogene contraction in South Sulawesi, Indonesia

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ABSTRACT

A new approach for paleostress analysis using the multiple inverse method with calcite twin data including untwinned *e*-plane was performed in the East Walanae fault (EWF) zone in South Sulawesi, Indonesia. Application of untwinned *e*-plane data of calcite grain to constrain paleostress determination is the first attempt for this method. Stress states caused by the collision of the south-east margin of Sundaland with the Australian microcontinents during the Pliocene were successfully detected from a combination of calcite-twin data and fault–slip data. This Pliocene NE–SW-to-E–W-directed maximum compression activated the EWF as a reverse fault with a dextral component of slip with pervasive development of secondary structures in the narrow zone between Bone Mountain and Walanae Depression.

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1. Introduction

Sulawesi Island is located in a complex tectonic setting involving three large lithospheric plates: the Eurasian Plate to the west, the Pacific Plate to the east, and the Indian–Australian Plate to the south (Fig. 1a). The Neogene tectonic history of Sulawesi is characterized by a continent–continent collision that occurred between Sundaland (Western arc) and Australian Craton-derived blocks (Eastern arc) (Hamilton, 1979; Yuwono et al., 1988; Coffield et al., 1993; Priadi et al., 1994; Bergman et al., 1996; Polvé et al., 1997; Elburg and Foden, 1999; Hall and Wilson, 2000; Hall, 2002; Elburg et al., 2003), resulting in the development of large-scale strike–slip faults, fold and thrust belts, and magmatism related to extensive lithospheric melting (Bergman et al., 1996). A number of N–S-to-NW–SE-trending large-scale faults occur in Sulawesi Island, including the Palu-Koro fault in Central Sulawesi and the Matano fault in the eastern arm of the island. The Walanae fault zone is also a major structure with prominent linear landform features that is traceable over 150 km through the southern arm of Sulawesi (Fig. 1b; Van Leeuwen, 1981; Sukamto, 1982; Berry and Grady, 1987; Van Leeuwen et al., 2010).

The Walanae fault system comprises two parallel faults, the West Walanae fault (WWF) and the East Walanae fault (EWF), with a narrow topography depression in between. The two faults purportedly formed during the end of the Middle Miocene (Van Bemmelen, 1949; Van Leeuwen, 1981; Sukamto, 1982) along the eastern margin of the western mountain range and the western margin of the Bone Mountains, respectively. The geomorphic trace of the EWF can be recognized as a distinct line between the Bone Mountains and the Walanae Depression, around which an intensive deformation zone characterised by various scales of faults, folds and related structures has developed (Van Leeuwen et al., 2010). Therefore, the EWF is thought to have played a major role in the structural and landform developments in this region during the Neogene. The predominance of a sinistral strike–slip motion in the EWF has been assumed on the basis of its linear topographic feature and the shear sense of its neighboring major faults, including the Masupu fault in the northern area (Hamilton, 1979; Coffield et al., 1993; Guritno et al., 1996; Van Leeuwen et al., 2010). However, the timing and sense of fault motion plus associated deformation

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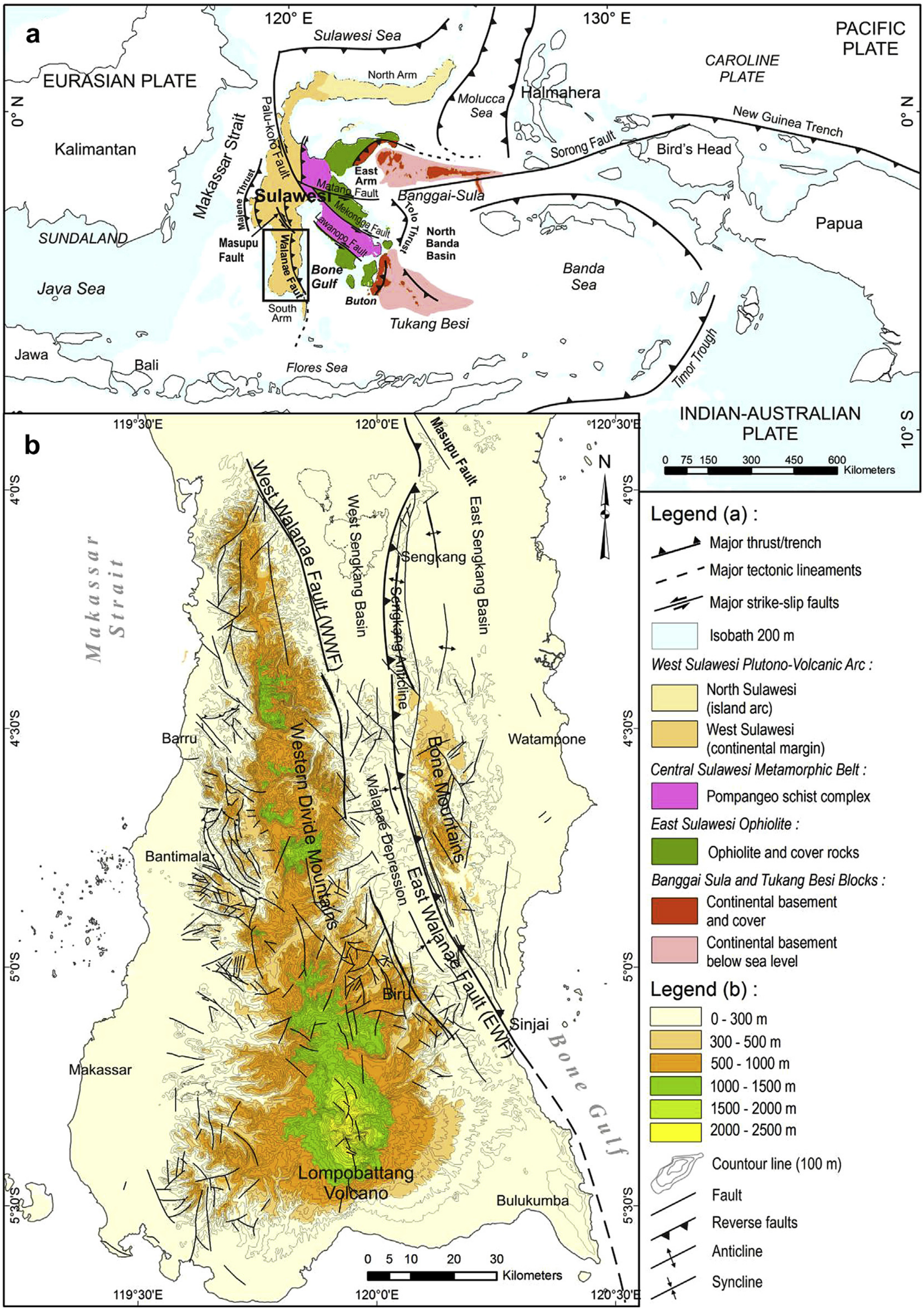

Fig. 1. (a) Tectonic map showing the distribution of plates, continents and island arcs in the eastern part of Indonesia (modified after Hamilton, 1979; Hall and Wilson, 2000; Watkinson, 2011). The area of the rectangle corresponds to South Sulawesi shown in (b). (b) Structural and topographic map of South Sulawesi (modified after Sukamto, 1982; Sukamto and Supriatna, 1982; Berry and Grady, 1987).

have not been sufficiently investigated (Hall and Wilson, 2000; Van Leeuwen et al., 2010).

Determination of the paleostress state is an important approach for reconstructing the tectonic history of an area because fault activity, related structures and the geomorphology can be strongly controlled by the orientation, ratio and magnitude of regional stress. Paleostress tensors can be determined by inverse methods from fault–slip data (e.g., Angelier, 1979, 1984, 1990, 1994; Etchecopar et al., 1981; Armijo et al., 1982; Gephart and Forsyth, 1984; Michael, 1984; Reches, 1987; Gephart, 1990; Hardcastle and

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