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Analysis of the Ragged Basin, Western Australia: Insights into syn-orogenic basin evolution within the Albany–Fraser Orogen

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ABSTRACT

Sedimentary basins occur within a variety of tectonic settings, both within plates and near plate boundaries. We explore the complex history of the Mesoproterozoic Ragged Basin, located in the eastern Nornalup Zone of the Albany–Fraser Orogen, which is part of the West Australian Craton. Sediments of the Ragged Basin were deposited within a shallow basin by a large fluvial system dominated by shifting, sandy braided channels, forming a quartz-rich succession defined as the Mount Ragged Formation. The gradual coarsening upwards sequence indicates a distal fluvial environment characterised by channel migration and abandonment, changing to a proximal fluvial environment characterised by rapid periods of sedimentation and coarser deposits. Ion microprobe (SHRIMP) U–Pb analysis of detrital zircons constrain a maximum depositional age of 1314 ± 19 Ma for the Mount Ragged Formation, so it is feasible that deposition started during the latter part of Stage I (c. 1330–1260 Ma) of the Albany–Fraser Orogeny. The detrital zircon U–Pb data demonstrates that the Mount Ragged Formation contains c. 1810–1320 Ma detritus, most of which appears to be derived locally from the reworked craton margin that forms the Albany–Fraser Orogen basement. However, the smaller c. 1560 and c. 2490 Ma zircon age components have no known source within the West Australian Craton, and were potentially originally sourced from the Gawler Craton or other unknown sources beneath the Eucla and Bight Basins. These exotic ages support the interpretation that outboard accretion occurred prior to Stage II of the Albany–Fraser Orogeny. New structural data, field observations and aeromagnetic image interpretation indicate that the Mount Ragged Formation was deformed by a northwest-vergent fold and thrust system. A minimum age for deposition, and structural emplacement, is provided by a crystallisation age of 1175 ± 12 Ma for a cross-cutting monzogranite exposed at Scott Rock, part of the Esperance Supersuite. Upper-crustal thrusting in the Mount Ragged Formation can be linked to deeper, large-scale regional structures such as the Tagon and Rodona Shear Zones, the latter of which represents the eastern edge of the Albany–Fraser Orogen.

1. Introduction

The formation, fill, burial, deformation and metamorphism of sedimentary basins are important processes along convergent margins. Sedimentary basins can track, through their provenance signature, facies architecture, and deformation history, the geodynamic evolution of craton margins through their extensional, passive and compressional phases. The Albany–Fraser Orogen in Western Australia is an arcuate, Archaean-Proterozoic orogenic belt located along the southern and southeastern margins of the Yilgarn Craton (Fig. 1), which preserves the remnants of three basin systems that chart the evolution of this margin. From oldest to youngest, these are the Barren, Arid, and Ragged Basins, respectively (Spaggiari et al., 2014a).

Many different styles of syn-orogenic sedimentary basins and depositional centres can be formed in different tectonic settings. In convergent settings, for example, these include trenches, trench-slope, forearc, intra-arc, backarc, retro-arc foreland, remnant ocean, peripheral foreland, thrust-top 'piggyback' and foreland intermontane basins (Dickinson, 1974; Ingersoll, 1988; Ingersoll and Busby, 1995). Syn-orogenic terrestrial rift basins can also form during extensional phases or locally at releasing bends in predominantly strike slip settings. Nevertheless, each basin style is associated with a characteristic geodynamic setting, subsidence and uplift

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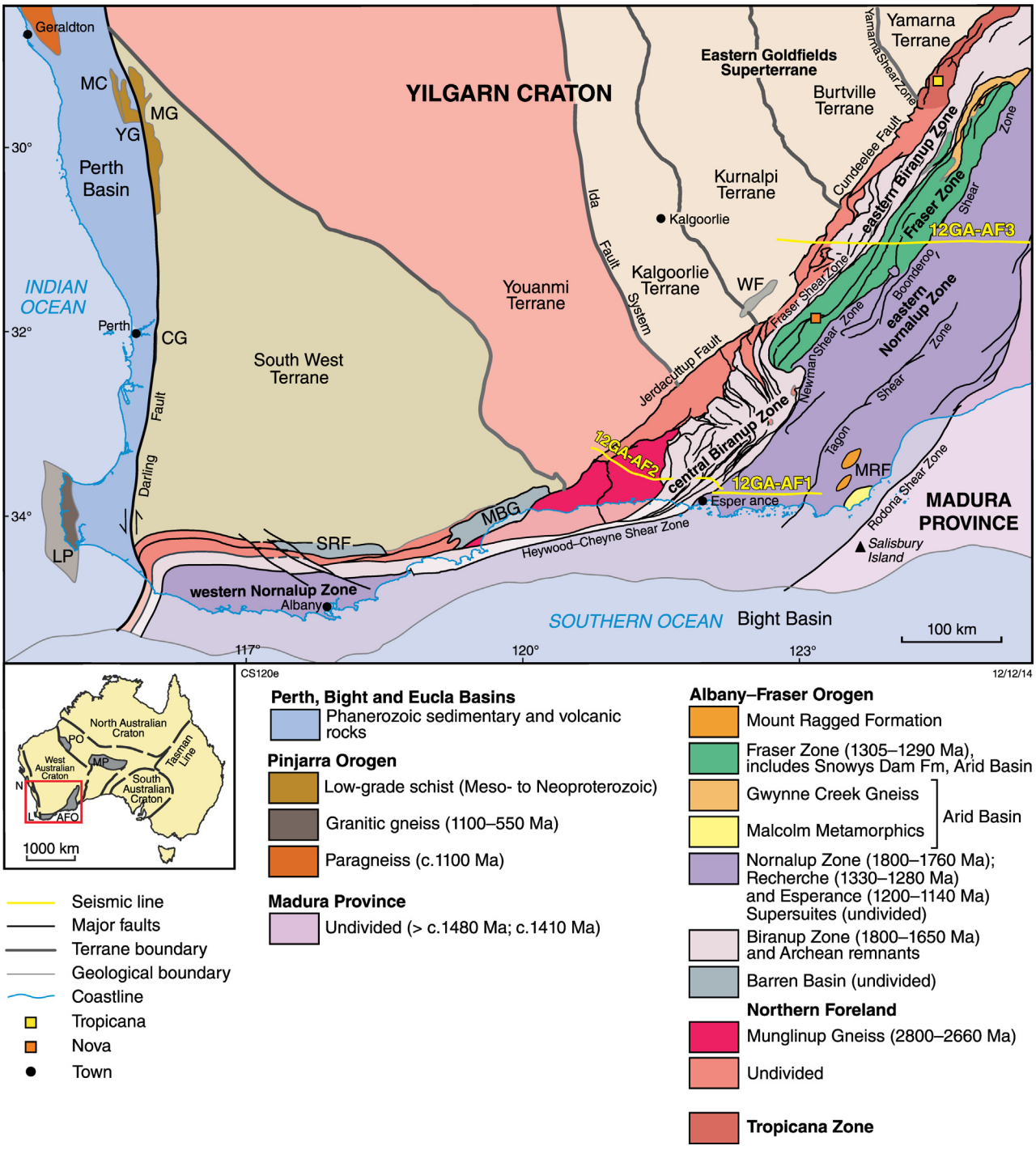

Fig. 1. Simplified geological map of the Albany–Fraser Orogen showing the main lithotectonic units (after Spaggiari et al., 2014c). The Kepa Kurl Booya Province comprises the Tropicana, Biranup, Fraser and Nornalup Zones. The study area is located between 5225000 mE and 570000 mE and 6276000 mN and 6325300 mN (MGA Zone 51), in the Cape Arid National Park. The position of deep crustal seismic reflection lines discussed in the text are shown in yellow. MC, Mullingarra Complex; LP, Leeuwin Province; MBG, Mount Barren Group; MRF, Mount Ragged Formation; SRF, Stirling Range Formation; WF, Woodline Formation. (For interpretation of the references to color in this figure caption, the reader is referred to the web version of this article.)

evolution and, consequently, basin architecture and sedimentary fill pattern (Wilson, 1966; Dickinson, 1974; Bally and Snelson, 1980; Ingersoll, 1988; Ingersoll and Busby, 1995; Miall, 1996, 1999; Allen and Allen, 2005). Examination of detrital material from syn-orogenic basins not only provides a glimpse of the provenance from exhumed crust at the time of basin fill, but also provides critical timing constraints on basin formation (Gehrels et al., 2000).

In the Albany–Fraser Orogen, both the c. 1815–1600 Ma Barren Basin and the c. 1600–1305 Ma Arid Basin are regionally extensive (Spaggiari et al., 2014a). The third basin, the Ragged Basin, is smaller and has been interpreted to have formed in an intracratonic setting between c. 1280 and 1215 Ma (Clark et al., 2000; Bodorkos and Clark, 2004b; Spaggiari et al., 2014b). The development of these basins on the Yilgarn Craton margin charts the importance of changing processes that provide the accommodation space for clastic sediments to accumulate. An extensive U–Pb zircon geochronology dataset has been used to demonstrate that the regionally extensive Barren and Arid Basins record the first