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Provenance of metasedimentary rocks in the northern Gawler Craton, Australia: Implications for Palaeoproterozoic reconstructions

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Abstract

Isotopic, geochemical and U–Pb zircon geochronological characteristics of the Nawa Domain in the South Australian Craton, Australia, have been determined to place constraints upon Palaeoproterozoic reconstruction models. U–Pb detrital zircon analysis of the Nawa Domain metasedimentary rocks indicates deposition between ca. 1740 and 1720 Ma. Sedimentary rocks are shown to be enriched in REE and sourced from evolved crust ($\varepsilon_{\mathrm{Nd}}(1.6\,\mathrm{Ga}) = -7.0$ to -4.3). The combination of geochemical, Nd-isotope and U–Pb detrital zircon age data indicate the dominant source for the studied metasedimentary rocks is likely to be the Arunta region of the North Australian Craton. This indicates the Nawa Domain crustal segment was proximal to the North Australian Craton during the period ca. 1740–1720 Ma. Provenance correlations drawn between the Nawa Domain metasedimentary rocks, lower part of the Willyama Supergroup in the Curnamona (Broken Hill) region and Maronan Supergroup in the Mount Isa region suggest contiguity of these crustal terranes during the late Palaeoproterozoic. These spatial and temporal constraints negate some reconstructions of Palaeoproterozoic Australia suggested for this period, and indicate further refinement of other models is needed. Further, the intra-continental nature and Australian sourced detritus of the lower sections of these basins limits their use as piercing points between eastern Australia and possible neighbouring continents in the Palaeo- and Mesoproterozoic.

Keywords: Gawler Craton; Nawa; Arunta; Metasedimentary rocks; Detrital zircon; Provenance

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1. Introduction

Fine-grained sedimentary lithologies have been demonstrated to represent a geochemical average of the exposed continental crust from which they were sourced (Taylor and McLennan, 1985). This principle of averaging is the basis of many studies over the past two decades into the provenance of sedimentary packages and subsequently tectonic and crustal growth processes (e.g. Taylor et al., 1983; McLennan and Taylor, 1988, 1991; McLennan et al., 1995; Patchett et al., 1999; Lahtinen, 2000; Goodge et al., 2002; Lahtinen et al., 2002; Black et al., 2004; Li et al., 2005a). These studies operate on the assumption that particular elements, (REE, Cr, Th, Zr, Hf and Sc) are transported from source to sediment with insignificant modification due to sorting, fractionation, diagenesis or post-depositional tectonothermal effects. Studies have demonstrated REE mobility during diagenesis can occur (i.e. McDaniel et al., 1994; Lev et al.,

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1999) but consideration of these effects in data interpretation allows for the use of geochemical indicators in provenance studies.

Detrital zircon U–Pb geochronological studies provide age constraints on the maximum depositional age of sediments and the timing of significant magmatic and metamorphic events in the source region. This geochronological information is limited to predominantly felsic crustal processes, and those dominated by mafic rock systems may go unrecorded (e.g. Yamashita et al., 2000). Sm–Nd isotope and whole-rock geochemistry provide information on the crustal residence time of the sediment precursor rocks and compositional characteristics of the terrain type, such as Archaean granite-greenstone or magmatic arc terrains (e.g. Taylor et al., 1983; Taylor and McLennan, 1985; Patchett et al., 1999; Fralick, 2003). Hence, through combining these techniques, a relatively accurate picture of the crustal segment from which a sedimentary package was sourced can be created.

The importance of sedimentary provenance in constraining palaeogeographic reconstructions has been recognised by numerous authors (e.g. Ross et al., 1992; Stewart et al., 2001; Dawson et al., 2002). Sedimentary provenance may provide information as to which sources were proximal during the development of basin systems. Provenance may also provide limited information on tectonic processes that have shaped sediment source regions (e.g. detrital mica geochronology, Grimmer et al., 2003; Gutierrez-Alonso et al., 2005; Li et al., 2005b).

Assembly and dispersal of Proterozoic 'supercontinents' is the continuing focus of numerous studies (e.g. Borg and DePaolo, 1994; Idnurm and Giddings, 1995; Eriksson et al., 1999; Burrett and Berry, 2000, 2002; Karlstrom et al., 2001; Zhao et al., 2002a,b, 2004; Pesonen et al., 2003). Significant research has focused on determining the crustal blocks that were adjacent to the western margin of Laurentia in the Palaeo-Mesoproterozoic Columbia and Mesoproterozoic Rodinia supercontinents (Burrett and Berry, 2000; Sears and Price, 2000; Karlstrom et al., 2001; Li et al., 2002; Wingate et al., 2002). The proposed fits of Australia and Laurentia in the Palaeo-Mesoproterozoic are based upon: (1) inferred presence of Archaean crust to the west of the Wyoming Province (Bennett and DePaolo, 1987; Borg and DePaolo, 1994), (2) extension of 1.8–1.6 Ga orogens from Laurentia into central Australia (Karlstrom et al., 2001), (3) presence of ca. 1.6 Ga zircon grains in the Belt Supergoup (Ross et al., 1992; Ross and Villeneuve, 2003).

There have been relatively few studies on the provenance of Proterozoic sedimentary rocks along the eastern margin of Proterozoic Australia. Such data are required to constrain current conflicting models for assembly of Proterozoic Australia (Betts et al., 2002; Dawson et al., 2002; Giles et al., 2004; Wade et al., 2006). Additionally, little geological evidence has been presented from eastern Proterozoic Australian crustal terrains to assess the validity of Australia-Laurentia connections during the Proterozoic. Such evidence may be preserved in the sedimentary record of Proterozoic basins of central and eastern Proterozoic Australia.

This study utilises geochemical and Sm–Nd isotopic analysis and detrital zircon U–Pb dating to characterise the provenance of metasedimentary rocks in the northern region of the South Australian Craton (SAC) (Fig. 1). This region is the interface between the Archaean nucleus of the South Australian Craton (Swain et al., 2005b), the central Australian Mesoproterozoic Musgrave Block and the North and West Australian Cratons (NAC and WAC) (Fig. 1). The interface area is important in understanding the interaction of the NAC and SAC as it should record any interaction between the two cratons during the Palaeo- and Mesoproterozoic, such as suggested in various Proterozoic Australia reconstruction hypotheses (Dawson et al., 2002; Giles et al., 2004; Wade et al., 2006).

2. Geological background

The Gawler Craton (Fig. 1) of the SAC is composed of a central late Archaean-early Palaeoproterozoic nucleus surrounded, overlain and intruded by Palaeoproterozoic (1850–1610 Ma) and Mesoproterozoic (1590–1510 Ma) lithologies (Parker, 1993; Daly et al., 1998; Ferris et al., 2002; Swain et al., 2005b). Neoproterozoic and Phanerozoic sediments and sedimentary rocks overlie much of the craton. These cover sequences have greatly restricted the understanding of the crustal composition and tectonothermal evolution of the craton (Ferris et al., 2002). Historically, tectonic domains have been interpreted using a combination of Total Magnetic Intensity (TMI) and gravity modelling (Fig. 1, Fairclough et al., 2004). The most significant crustal scale feature on the TMI and gravity data is the Karari Fault Zone (Fig. 1). This structure splits the Nawa and Peake and Denison Domains from the bulk of the Gawler Craton.

The late Archaean nucleus of the Gawler Craton consists of the Christie, Wilgena, Harris Greenstone and Coulta Domains (Fig. 1). These domains are dominated by metasedimentary rocks, volcanic rocks and a granite-greenstone terrain (ca. 2560–2500 Ma, Swain et al., 2005b) which have been extensively deformed during the Sleafordian Orogeny (peak metamorphism ca.