Gondwana Research 56 (2018) 90–104

Contents lists available at ScienceDirect

Gondwana Research

journal homepage: www.elsevier.com/locate/gr

Thermal history of the northern Olympic Domain, Gawler Craton; correlations between thermochronometric data and mineralising systems

James W. Hall [a,*], Stijn Glorie [a], Anthony J. Reid [a,b], Alan S. Collins [a], Fred Jourdan [c], Martin Danišík [d], Noreen Evans [c,d]

[a] Tectonics, Resources and Exploration (TRaX), Department of Earth Sciences, University of Adelaide, SA 5005, Australia
[b] Geological Survey of South Australia, Department of State Development, GPO Box 1264, Adelaide, SA 5001, Australia
[c] Department of Applied Geology, Curtin University, GPO Box U1987, Perth, WA 6845, Australia
[d] John de Laeter Centre, TIGeR, Curtin University, GPO Box U1987, Perth, WA 6845, Australia

ARTICLE INFO

Article history:
Received 27 October 2017
Received in revised form 22 December 2017
Accepted 9 January 2018
Available online 10 January 2018

Handling Editor: M. Santosh

Keywords:
Olympic Domain
Apatite fission track
Gawler Craton
Apatite U/Pb
$^{40}Ar/^{39}Ar$

ABSTRACT

Multi-method thermochronology applied to the northern Olympic Domain of South Australia reveals a complex thermal evolution with multiple thermal events. Apatite U/Pb (closure temperature ~550–350 °C) and muscovite $^{40}Ar/^{39}Ar$ ages (~400–350 °C) record post magmatic cooling from 1850 to 750 Ma for the ~1850 Ma Donington Suite, and from ~1560–1500 Ma for the ~1590 Ma Hiltaba Suite and the Gawler Range Volcanics. Potassium feldspar $^{40}Ar/^{39}Ar$ ages (~350–150 °C) record disturbed spectra that are likely related to hydrothermal alteration at ~1000–650 Ma in the Neoproterozoic Adelaide Rift Complex. Apatite fission track (~60–120 °C), zircon (U-Th-Sm)/He (~180–200 °C), and apatite (U-Th-Sm)/He (~45–75 °C) ages reveal regional low temperature thermal events at ~1000 Ma, ~430–400 Ma, 350–330 Ma, and ~200 Ma, in addition to localised thermal events during the Cretaceous. The ~1000 Ma apatite fission track ages are amongst the oldest recorded for South Australia and are only preserved near the margins of the Olympic Domain. The ~430–400 Ma and ~350–330 Ma cooling events are interpreted to be driven by the Alice Springs Orogeny. The Mesozoic thermochronometric ages are interpreted to record localised thermal perturbations, possibly related with hydrothermal activity within the northern Olympic Domain. The presence of abundant IOCG deposits near these young thermal anomalies may indicate that these zones record more favourable thermal conditions and/or exposure levels for IOCG discoveries in the study area.

1. Introduction

The Olympic Domain is home to the world class Olympic Dam Iron Oxide Copper Gold (IOCG) mineral deposit, in addition to numerous other IOCG mineral deposits such as Prominent Hill, Carrapateena, Khamsin, and Emmie Bluff (Fig 1). The Olympic Domain is the most deposit-rich domain within the Gawler Craton of South Australia (in particular, the northern Olympic Domain; Fig. 1) and preserves a complex geological history that began in the Palaeoproterozoic (Hand et al., 2007). After initial formation of the Gawler Craton, the most notable thermo-tectonic event within the Olympic Domain was the ca. 1590 Ma Hiltaba Event (e.g. Daly et al., 1998; Budd et al., 2001; Skirrow et al., 2002; Fanning et al., 2007; Hand et al., 2007), which was associated with emplacement of the Hiltaba Suite granites and extensive IOCG mineralisation. Published work conducted on these IOCG deposits have inquired into various aspects of their formation (Belperio et al., 2007; Davidson et al., 2007; Direen and Lyons, 2007; Skirrow et al., 2007; McPhie et al., 2011; Ismail et al., 2014; Jagodzinski, 2014; Kamenetsky et al., 2016; Kirchenbaur et al., 2016; Macmillan et al., 2016). However, only few studies have ventured into investigating the post-Hiltaba thermal history of the Olympic Domain (Reid et al., 2017). Recent studies have highlighted that early Phanerozoic hydrothermal activity affected the Olympic Dam deposits (Maas et al., 2011; McPhie et al., 2011; Kamenetsky et al., 2016), and this activity appears to have remobilised and concentrated the uranium (Kamenetsky et al., 2016). Consequently, a better understanding of the thermal history of the Olympic Domain is becoming increasingly relevant to understand its regional complexity in relation to the occurrence of IOCG deposits, and, perhaps, inform future exploration.

This study applies multi-method thermochronology by combining apatite U/Pb, muscovite and potassium feldspar $^{40}Ar/^{39}Ar$, zircon and apatite (U-Th-Sm)/He, and apatite fission track (AFT) dating on selected drill cores from the top of Palaeoproterozoic basement to provide insights into the thermal history of the northern Olympic Domain between ~550 °C and surface temperatures (Wagner and van den Haute, 1992; McDougall and Harrison, 1999; Ehlers and Farley, 2003; Reiners et al., 2004; Schoene and Bowring, 2007). Where possible and relevant,

* Corresponding author.
E-mail address: james.hall@adelaide.edu.au (J.W. Hall).

https://doi.org/10.1016/j.gr.2018.01.001

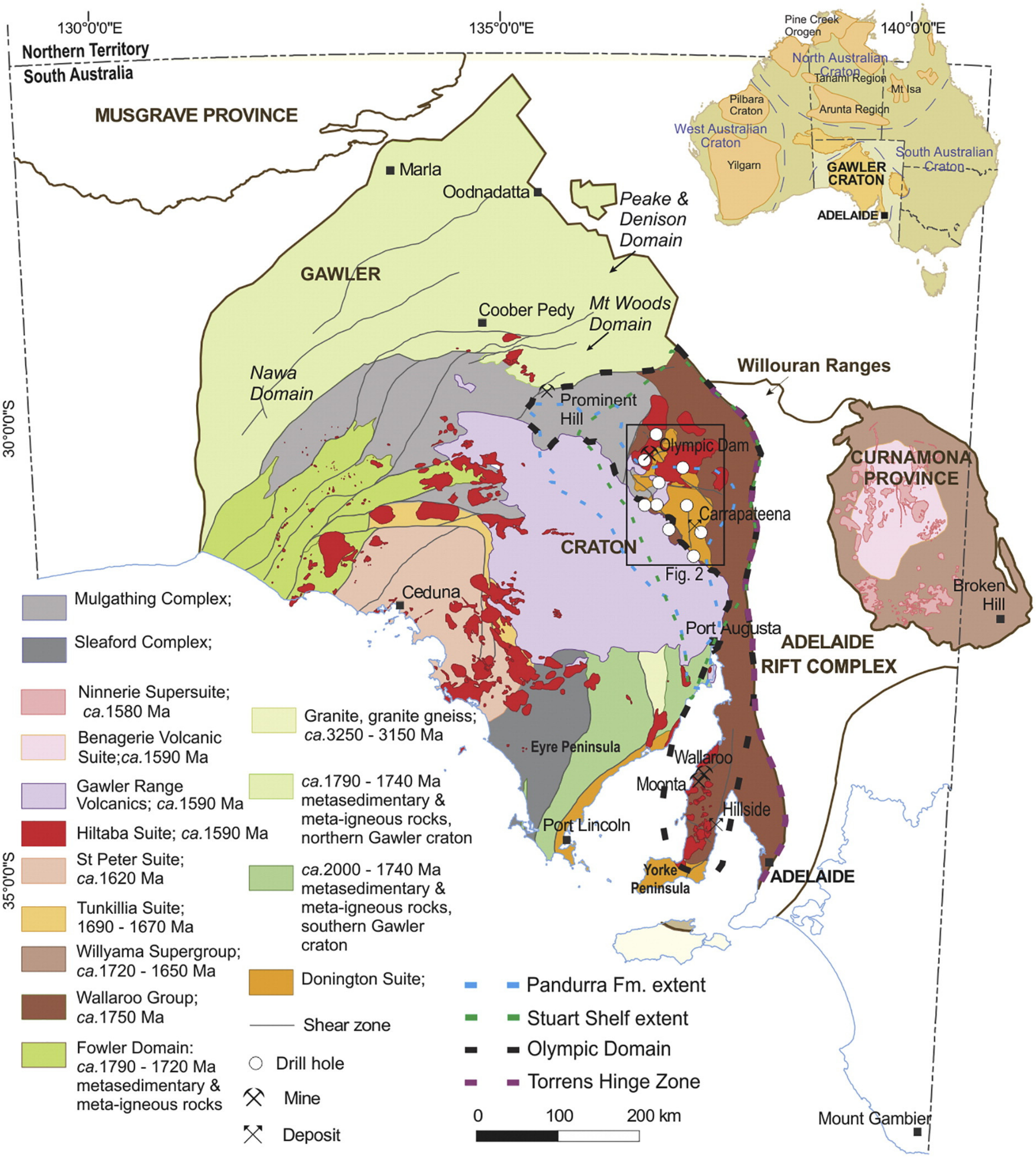

Fig. 1. Simplified geological map of the Gawler Craton and adjacent geological domains, showing the locations of sampled drill holes, major IOCG deposits, the Torrens Hinge Zone, and the extent of the Pandurra Formation and Stuart Shelf. Adapted from Reid and Fabris (2015).

thermal history models are presented. Associated thermal events that affected the northern Olympic Domain are linked to the tectonic events that affected the Gawler Craton and/or with thermal perturbations that are likely related with elevated geothermal gradients and hydrothermal activity.

2. Geological setting

2.1. Gawler Craton

The Gawler Craton is a Mesoarchaean–Mesoproterozoic craton that occupies most of South Australia (Daly et al., 1998; Fraser et al., 2010). The nucleus of the Gawler Craton is comprised of relatively small outcrops of Mesoarchaean rocks of the Cleve Domain that are surrounded by the ~2500–2400 Ma metasedimentary rocks of the Sleaford Complex in the southern Gawler Craton (Daly et al., 1998; Fanning et al., 2007; Hand et al., 2007) and the ~2500–2400 Ma metasedimentary rocks of the Mulgathing Complex in the western Gawler Craton (Fig. 1; Hand et al., 2007; Reid et al., 2014). Following tectonic quiescence from ~2400–2000 Ma, the remaining rocks of the Gawler Craton, including the units of the Olympic Domain, formed during the late Palaeoproterozoic–early Mesoproterozoic (Fig. 2; Hand et al., 2007). In the western and southern Gawler Craton, metasedimentary rocks of the Fowler, Nuyts, Coulta, and Cleve domains were deformed at about the same time as metasedimentary rocks of the Nawa Domain, at around 1730–1690 Ma in response to the Kimban Orogeny (Hand et al., 2007). The final stages of craton building were dominated by igneous activity, including the emplacement of the Tunkillia Suite within the