Reconstructing the tectonic evolution of Proterozoic South Australia

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Introduction

Magmatic systems associated with plate tectonics provide the driving force for much of the world’s mineral systems.

Subduction can also re-fertilise the lithosphere, priming the region for subsequent events.

Mapping out subduction related magmatism and subduction modified lithosphere, particularly in areas under cover, can assist explorers in applying the correct exploration models and strategies.

Figure 2. Conceptual cross section of an arc system, depicting the setting for many types of gold deposits that occur due to subduction systems. From Groves et al., 2005.
Introduction

A number of attempts have been made to place the evolution of southern Australia into a plate-tectonic framework.

These have been hindered by the often cryptic evidence of subduction related magmatism.

Where are the volcanic arcs?

- There are some suites with known arc-like chemistry
  - 1620-1607 Ma St Peter Suite
  - 1590-1550 Ma Birksgate Complex
- But the relationships, spatial extents and geometries are poorly understood
Outline

In this presentation I will:

• Summarise existing data

• Present new data from the eastern Musgrave Province, St Peter Suite and the Coompana Province

• Show we can recognise a contiguous and migrating arc-system outboard of the Gawler Craton – North Australian Craton during the Mesoproterozoic

• Present some implications for mineral systems
Existing Musgrave Province

Predominantly granitic to tonalitic intrusives and volcanics

Wade et al. 2006 – Birksgate Complex
- Existing Geochronology* = 1590–1540 Ma

GSWA Data
- Warlawurru Supersuite = 1607–1583 Ma
- Unnamed unit = 1542 ± 6 Ma
- Papulankutja Supersuite = 1402 ± 4 Ma
- Wankanki Supersuite = 1351–1303 Ma

*Scrimgeour et al., 1999; Young et al., 2002; Camacho & Fanning, 1995
Existing Musgrave Province

Predominantly granitic to tonalitic intrusives and volcanics

- High K, calc-alkaline, magnesian
Existing Musgrave Province

- LILE and LREE enriched, HFSE depleted
- Chemistry typical of volcanic-arc setting
Eastern Musgrave Province

New GSSA data – Birksgate Complex

• Predominantly felsic but co-magmatic gabroic to granitic intrusives and volcanics

• 14 new SHRIMP ages = 1690, 1665–1592, 1564 Ma

• High K, calc-alkaline, magnesian
Eastern Musgrave Province

New GSSA data—Birksgate Complex

- Predominantly felsic but co-magmatic gabbroic to granitic intrusives and volcanics
- LILE and LREE enriched, HFSE depleted
- Chemistry typical of volcanic-arc setting
Musgrave Isotopic Evolution

- All three regions display a similar, juvenile isotopic evolution - limited or no evolved crust involved
- All sit on a crustal evolution curve tracking back to ~2000–1900 Ma suggesting reworking a common juvenile oceanic crust
- All have excursions to more radiogenic compositions indicating new mantle contributions
New St Peter Suite data

- Bi-modal co-magmatic intrusive suite
- Existing geochronology ~1620–1608 Ma*
- 6 new SHRIMP geochronology samples from across the outcrop extent
  - 1633–1608 Ma
- Within same age range as east Musgrave Birksgate Complex

*Flint et al., 1990; Knight, 1997; Ferris, 2001
New St Peter Suite data

- Swain et al. 2008 suggested a magmatic arc setting based on geochemistry
- New geochemical data supports this
- High K, calc-alkaline, magnesian
- LILE and LREE enriched, HFSE depleted
New St Peter Suite data

• Swain et al. 2008 suggested a magmatic arc setting based on geochemistry
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• High K, calc-alkaline, magnesian
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The link - New Coompana data

New data from the GSWA Eucla Drilling program (FOR004 and FOR008) and petroleum exploration well Kutjara 1*

- Ages for FOR holes = 1613–1604 Ma
- Age for Kutjara 1 = 1591 ± 11 Ma
- Within same age range as east Musgrave Birksgate and St Peter Suite
- Geochemically similar

*Neumann and Korsch, 2014. GA Record 2014/05
The link - New Coompana data

- High K, calc-alkaline, magnesian
- LILE and LREE enriched, HFSE depleted

Chemistry typical of volcanic-arc setting
St Peter Arc isotopic evolution

- All three regions display a similar, juvenile isotopic evolution - limited or no evolved crust involved
- All sit on a crustal evolution curve tracking back to ~2000–1900 Ma suggesting reworking a common juvenile oceanic crust
- All have excursions to more radiogenic compositions indicating new mantle contributions
An evolving magmatic arc system

St Peter arc complex - ~1650–1600 Ma
• Juvenile oceanic magmatic arc built on ~2000–1900 Ma oceanic crust outboard of the Mawson/North Australian Craton
  • Warumpi Province (part?)-east Musgrave Province-Coompana Province-St Peter Suite-west Terre Adelie Land

Birksgate arc complex - ~1590–1540 Ma
Loongana arc - ~1415–1389 Ma
Wankanki arc complex - ~1350–1300 Ma

Progressively younging sequence of magmatic-arc rocks as subduction retreats away from Gawler Craton margin
Implications for mineral systems

- Recognition of a contiguous magmatic arc system out-board of the North Australian/Gawler Craton at 1650–1600 Ma demonstrates a subduction driven Mesoproterozoic evolution of southern Australia.
- Links between Provinces now allows us to map out these systems beneath cover – potentially map where you are in the system in space and time
  - western Gawler/GRV – backarc setting?
  - Coompana
    - Porphyry/epithermal systems (crustal level?)
    - Backarc orogenic/intrusion related
    - Post-subduction magmatism - 1200 Ma
      - Shoshonites – re-melting of subduction modified crust
  - Implications for the development of a Gawler orocline

Figure 2. Conceptual cross section of an arc system, depicting the setting for many types of gold deposits that occur due to subduction systems. From Groves et al., 2005.
The next step - Coompana Drilling

- There are still gaps in our datasets
- The Coompana Drilling project aims to drill test different geophysical domains in the province
- $3M collaborative program between GSSA and GA
- Up to 18 drill targets
- Beginning in April 2017
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