New data, new information and new knowledge for new discoveries in new frontiers:

new precompetitive geoscience for mineral exploration in South Australia

Steve Hill
Director
Geological Survey of South Australia

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New!

I hope he tells us something NEW!

NU THINGS PLS! UR M8 KW
This presentation...

1. If only exploration was easy....
   High expense, variable return, high risk, technological limits, challenging land access ... and then ITS COVERED!

2. Making it easier in South Australia...
   Innovative & effective pre-competitive geoscience for greater exploration quality and quantity leading to discovery

3. Sustained support into the future for South Australia...
   The job is not done and there is a long way to go!
   But where are we going?
1. If only exploration was easy...
October 2014 JUMEX Survey

Australian junior mineral explorers
Top ten issues – Exploration industry performance

- Funding constraints at crisis point for some
- Very strong competition for capital
- Commodity price volatility is a major constraint
- Regulatory challenges persist
- Ongoing constraints will limit operational activities
- Future discovery pipeline weak
- Employment conditions remain depressed
- Mergers and acquisitions outlook is up
- Early signs of hope that investor interest may be starting to improve
- Improvements will not be dramatic

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SA Exploration Expenditure

Minerals and Petroleum exploration expenditure 1998-99 to 2013-14
For 2013-14 $647.6 million ($531.3m – Petroleum and $116.3m – Minerals)

Source: ABS data cat. 8412.0 June 2014
BUT!
(from Minister Koutsantonis this morning):

“Although the mineral exploration expenditure and the number of drilling approvals has dropped significantly, I am advised that the number of individual companies holding Exploration Licences in SA has stayed at a pretty constant level of around 200 since our last mineral expenditure peak in 2011-12.....

Clearly you believe in the prospectivity of South Australia and the way we do things here and are keen to stick around!”

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Copper Exploration
Primary copper deposits >0.3Mt found in western world: 1950-2009

[Image of a bar graph showing exploration expenditures and metal discovered over the years from 1950 to 2010.]
Mines in Exposed or Shallow Basement

- Outcrop Shallow basement
- Basement depth <500m
- Basement depth 500m to 1000m
- Basement depth > 1000m
South Australia – the state is covered .... the “sediment impediment”
Gawler Craton DTB

Regular updates available via SARIG

Or speak to Laz Katona and George Gouthas (GSSA)
Gawler Craton DTB

Regular updates available via SARIG

Or speak to Laz Katona and George Gouthas (GSSA)
Impediment becomes Opportunity!

- If conservatively 75-80% of State is covered and exploration has been most focused/effective on the 20% with outcrop.... Think of your opportunities in buried (not necessarily incredibly deeply buried) regions....
Copper deposits in South Australia

**Total Remaining Cu**

Statistical under-representation of large 1-3 Mt Cu occurrences and no giant 3-80 Mt Cu... so far
Impediment becomes Opportunity!

• If conservatively 75-80% of State is covered and exploration has been most focused / effective on the 20% with outcrop .... Think of your opportunities in buried (not necessarily incredibly deeply buried) regions ....

• If only we have the framework and the approach best suited to these settings ....
‘READING’ the geology of the cover (e.g. Hillside)

- Gossans
- Ferricrete
- Fe-alteration
- Kaolinised Granite
- Basal Gravels
- Regolith Carbonates
- Reduced/Oxidised clays & sands
- Barren aeolian sands
- Joints / Faults
- Supergene Cu zone
- Fe-alteration
- Gossans
- Ferricrete
How does cover geology work? (e.g. Tunkillia)
NATIONAL MINERAL EXPLORATION STRATEGY & UNCOVER

VISION:
Unlocking Australia’s hidden mineral potential.

MISSION:
To address greenerfield exploration challenges, stimulate new discoveries, ensure continuity of the pipeline of mineral resource investments, and the longevity of Australia’s mineral resources industry.

SCOPE OF THE STRATEGY
This National Mineral Exploration Strategy focuses on the acquisition and delivery of pre-competitive geoscience, applied geoscience research initiatives to aid exploration underneath and a mineral exploration investment allocation plan. Supporting activities associated with the strategy aimed at cross-jurisdictional collaboration on regulatory issues are also underway. The strategy will not address the financial challenges facing the minerals sector.

THE THREE ELEMENTS OF THE NATIONAL MINERAL EXPLORATION STRATEGY ARE:

- Pre-Competitive Geoscience Information
- Mineral Exploration Investment Attraction Plan
- National Geoscience Research Initiative

SEARCHING THE DEEP EARTH
A vision for exploration geoscience in Australia
South Australia Economic Priorities...

1. Unlocking the full potential of South Australia’s resources, energy and renewable assets
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   But where are we going?

[官方网站](statedevelopment.sa.gov.au)  [Twitter](@StateDevSA)
Government / Private Drivers of Discovery

**Government**
- Land Access
- Human & Intellectual Capital
  - Education and training
  - R&D - new exploration and processing technologies
- Precompetitive Geoscientific Data and Information
  - Capture and Delivery
  - Value-add Research
  - Underexplored / Covered Regions
  - Targeted Programs

**Private**
- Availability of Finance

**GREENFIELDS**
- Quality of Exploration
- Quantity of Exploration
- Discovery

Adapted from Derek Carter
PACE – 10 years of economic impact

Fifteen significant exploration successes from collaborative drilling

Extra $700 million in private mineral exploration expenditure

Extra state mineral production value of $2.4 billion

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## PACE Funding

### Financial Year Funding Allocation ($ million)

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<th>Initiative</th>
<th>Duration</th>
<th>12/13</th>
<th>13/14</th>
<th>14/15</th>
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<td>PACE Frontiers (Extension)</td>
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<td><strong>Current PACE Total</strong></td>
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<td>3.8</td>
<td>4.8</td>
<td>2.8</td>
<td>2.8</td>
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Previous Collaborative Drilling

- 8.8M Government spend leveraged over $24M from industry
  - New assay results; down-hole logs; petrophysics; geophysics;
- Doesn’t take into account follow-up programs and further investment

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<td>3616</td>
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<td>56.6km</td>
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plus

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PACE Discovery Drilling 2015

Call for proposals **NOW OPEN**

- 50% grant for direct drilling costs (capped at $100,000 ex GST)
  - *New guidelines and application process*
  - *Streamline contract generation*
  - *Drilling Round April 2015 – April 2016*

**Proposals DUE – 30 January 2015**

- Project Proposal Form and Guidelines downloadable from the Minerals website
- For more information please contact

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Miles.Davies@sa.gov.au

**Chris Wilcox**
Phone: +61 (8) 8463 3673
Christopher.Wilcox@sa.gov.au

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GAP 2015
New Geoscientist Assistance Program
- Linking industry with graduates and under employed geoscientists
- Opportunities include:
  - Field and Drilling programs
  - Geophysical
- 3 and 6 month work programs
  - 50% GAP / 50% Company funded contracts

Strategic Partnership between SACOME and DSD (through PACE Frontiers)
- Maintain, develop and diversify the States geoscientist skill base
- Minimise the loss of graduates and skilled professionals to other States and Sectors

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Collaborations

• International
  – China GS, China National Nuclear Corp, Chile (Sernageomin), Saskatchewan Geological Survey, University of Iowa,

• National
  – Australia Minerals, Geoscience Australia, CSIRO, DET CRC, NSW, NT, UTAS, UWA, HiSeis, NICTA, AMIRA,

• State
  – SACOME, UoA, DEWNR, Industry partners...
Industry workshops

- Pre-competitive Geoscience – Industry Workshop (March 28, 2014)
- Regional Drilling Workshop (Friday 9 May, 2014)

- Land Access!
- Ongoing PACE support
- GSSA regional mapping & geology
- Collaborative Drilling
- Drill core library
- Geochronology
- Regional Geophysics
- Open file digital capture of industry data sets
- Regolith Mapping
- Regional Geochemistry!
- Regional Drilling?
Pre-competitive Geoscience workflow

Greater Geological certainty

Tenement Exploration

Mineral Occurrence Studies
Collaborative / Targeted drilling

Regional Mineral System Drilling
Geophysical & Geochemical Case studies
‘Distal Footprint’ Characterisation

Stratigraphic Drilling
250k Geological Mapping
Targeted Geophysics and Geochemistry
4D Geodynamic & Metallogenic evolution

Regional Geophysics
Regional Geochemistry
Regional Geological Mapping
Lithospheric Architecture

Greater Geological Uncertainty

COMPETITIVE GEOSCIENCE (INDUSTRY)

PRE-COMPETITIVE GEOSCIENCE (GOVERNMENT)

@StateDevSA
2014-15 GSSA Projects

**Eastern Gawler Craton (Olympic Domian)**

**S Gawler Ranges / N Eyre Peninsula**

**TIER 1 PROJECTS**

- W Gawler Craton / Eucla Basin
- Musgrave Province
- Curnamona Province
- Basins

**TIER 2 PROJECTS**

- Geophysics and GIS
- Regional and Statewide Geology, Geophysics & Geochemistry
- HyLogger
- Geochronology
- Resource Assessment
- Tenement assessment & advice
- Mineral Potential mapping
- SA Geodata
- Core Library
- Geohazards
- Field logistics
- Software

**TIER 3 PROJECTS**

-Twitter handle: @StateDevSA
2014-15 GSSA Project Portfolio

1. - Eastern Gawler Craton
   - S Gawler Ranges / N Eyre Peninsula

2. - W Gawler Craton / Eucla Basin
   - Musgrave Province
   - Curnamona Province
   - Basins
e.g. Eastern Gawler Craton
WPA Gravity (Dec 2013 release)

~$2M PACE funded

34,541 new gravity stations at 1x1 km and 2x2 km spacings

Subsequent industry infill surveys
~5000 stations
South Australia Atlas of Geoscience and Mineral Exploration Data – Woomera Prohibited Area within the Gawler Craton

- 63 key maps and images!
- Land Access & Administration
- Geology
- Geophysics
- Drillholes & Rock Samples
- Remote Sensing

Available on SARIG!!!
Prospectivity modelling by Tom Wise

New Woomera Prohibited Area Gravity data
Eastern Gawler Craton (GSSA / DET CRC)

- Re-assayed 95 DHs
- Scanned 100s of DHs
- Collected 1000s petrophysical measurements
- Data integrated

- Workflow for characterising alteration (van der Wielen et al 2013; Fabris et al 2013).
Unconformity sampling

- Unconformity sample – above, below and gravel intervals within overlying units. This sampling media has been shown to work (Tonkin, 2009).

Hematite cementation of Pandurra Fm just above major basement unconformity

Hematite-rich clasts within Pandurra Fm
Samples from the central eastern Gawler
• Some elements can be used to define broad geochemical anomalies (areas of interest)
Hylogger™ data

Olympic Dam - RU 39 5371

White mica: dominance of muscovite in ore zone and phengite in alteration zone

Chlorite: dominance of Fe-end member in proximal alteration zone

Hematite breccia
Hematite and granite breccia
Altered granite (Roxby Downs Granite)

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Why Map Alteration?

- Increase the size of the target
- Predict where you are within the mineral system
- IOCG deposits - large alteration systems
Olympic Dam: New Data Available

• Data from 30 Diamond Drill holes
• 19,737m of core
• Section through the OD Deposit
• Visible-Shortwave IR to Thermal IR at 1cm res.
• Mineralogy, Geochemistry, Mag Susc, Density
• Tray images 0.1mm resolution
• March 2014 – September 2014
• Deepest hole 2084m to a depth of 2328.9m
• Available for download via SARIG and Auscope Portal

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RD 2773
524 trays
2084 m

Deepest near vertical hole at OD

2329 m
Olympic Dam Hylogger™
Olympic Dam HyLogger™
Olympic Dam HyLogger™

Fe-Oxides
• GSSA / DET CRC IOCG index
  (commercialisation with Reflex for ioGAS 5.2 release)
Gravity Inversions

From Simon van der Wielen
GSSA

Density Contrast (g/cm$^3$)

No Data
IOCG-WPA 3D Model

Available via SARIG
(Simon van der Wielen, GSSA, 2014)
The 2015 Regional Mineral System Drilling Program

• **PACE Frontiers...**
  
  $2M / year for 2013/14 and 2014/15

  2013/14: budget for regional pre-competitive surveys
  2014/15: $2M budget entirely to regional mineral systems drilling with DET CRC
2015 Mineral Systems Drilling

- This is something new! – Drill program offers opportunity to understand a region and facilitate discovery. THEY RECOVER A SAMPLE OF THE GEOLOGY!
- Joint project with exploration Industry and DET CRC.
- Moves away from single, “wildcat” drill holes (“geo-confetti”)
- Helps industry argue the case beyond one-hole test
- Provides coherent uncover of geological samples towards mapping capabilities
SA Mineral Systems Drill Program

- Funding ~$2M (PACE Frontiers)
- Collaborative project involving DET CRC
- Q1/Q2 2015 calendar year

Aim

- Trial a new style of industry collaboration
- Test geological questions + economic focus.
- Field test DET CRC technology within real life scenario.
- Mineral systems mapping
- Test prospectivity indices
- Develop land access and data delivery protocols

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Drilling Specifications

- Regional drilling – 5-10 km spacing.
- Holes will be cored from surface where practical
- Diameter of drillholes will be large enough to fit DET CRC probes (HQ and NQ)
- Preference for areas less than 500 metres of cover (Maximum depth 1,200 m)
- Areas with more than 1,000 m of cover will be excluded
- Minimum of 50 m drilled into basement
- Where possible holes will be cased and remain open for future research/re-entry
- Access to Sample Recovery Unit – environmentally friendly drilling
Drilling Specifications

- Core will be stored at the Department of State Development Core Library

- Core will be sampled and analysed using low detection limit multi-element geochemistry (1m every 10m)

- Petrophysical measurements (density and magnetic susceptibility) will be acquired on the core

- Core will be scanned with the HyLogger™
Lab-at-Rig® Prototype deployed during the Victorian regional drilling program in mid-2014
Brukunga Drilling
Where?

- GSSA – Key areas of interest highlighted although all proposed locations will be considered
Industry Collaboration EOIs

• 2 external workshops
• 1 internal (DSD staff) workshop
• SAREIC presentations
• SAEMC 2013

• Industry EOIs closed in September 2014

• 6 EOIs received
Mineral Systems Drill Program – Target Region
IOCG – Porphyry – Epithermal Continuum
(Claire Wade, GSSA)
Southern GRV Regional Mineral System Drilling

- **Key focus on 1590 Ma palaeosurface along southern margin of GRV**
  - Geological and mineralisation mapping and understanding
  - Link known occurrences to mineral system model (inc. links between IOCG, epithermal, porphyry)
  - Key ingredients for mineralisation
  - Alteration and geochemical footprints (equiv to Emmie Bluff IOCG model)
  - Stratigraphy of lower GRV
  - Test and develop DET CRC technologies inc. ‘real time’ data delivery
  - Collect further samples for Hylogger, lithogeochemistry, geochronology, metamorphic grade ....
  - Add to GSSA field mapping program in region
  - Bring forward development of mineral province with large ‘junior explorer’ holdings
2015 Regional Mineral System Drilling Program

- Integrated approach in government...
Integrated Approach

- **GSSA Geologists**
  - GSSA regional mapping, mineral systems, geophysics, GIS, drill core library....

- **Collaborative industry staff**
  - Minotaur Exploration / Kingston Resources and other participants

- **DET CRC** (participant companies and HO)

- **GSSA Database and Geoserver staff** (SAGEODATA / SARIG)

- **DSD Minerals Resources Division**
  - PACE, Mineral Tenements & Exploration, Resource Land Access Strategy, Resource Information...

- **MIPO Real Drill Time Project**
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[@StateDevSA](https://twitter.com/StateDevSA)
Western Gawler Craton / Eucla Basin Targeted Geoscience

Photo: Steve Hill
- Significantly thickened crust beneath Fowler/Christie Domain with large Moho offsets
- Highly reflective lower crust beneath the whole section showing duplexing
- Low reflectivity bland zone in mid crust
- Moderately reflective zone in mid to upper crust – Sleaford Complex and pre-Kimban basins?
- Juvenile and younger Coompana Domain overthrust on Gawler Basement
- No fold in the Karari SZ
- Uneven moho and thickend crust of Coompana Domain suggestive of compressional tectonics – known geochronology suggests this must be post 1500 Ma, possibly Musgravian?
‘Coompana’ Airborne Survey

Magnetic and Radiometric Survey

- ~250,000 line km of new data
- ~85,000 km²
- 400m lines spacing with detailed infill of 200m over the ‘Coompana Anomaly’

Major GSSA and GA Partnership

Status:

- Tender process complete
- Final contract negotiations underway
- Proposed late January start
- Notifications underway
Coompana Survey
Eucla Basin – Gawler Craton
AusLAMP Magnetotellurics

50 km station grid (plus 5km stations along railway line)
Western Gawler / Eucla Basin
Geochemistry / Biogeochemistry

~450 plant samples
~170 sample sites
Sneak Peak – Eucla biogeochemistry
RB and MESA J article coming soon!
State Drill Core Library - Tonsley
Open Space Concept Design with Workshop, 3D Imaging Lab, Education/Conference Facilities
Upcoming Conferences

– Broken Hill 24-27 May 2015
– AESC 2016
BROKEN HILL 2015
POSITIVELY DIFFERENT
24-27 MAY 2015 BROKEN HILL

Broken Hill was the birthplace of Australia’s largest and most iconic international resource company BHP, it provided the wealth to build Rio, was the centre of bitter industrial disputes that led to occupational health and safety, collective bargaining and a minimum wage and provided the wealth that initiated the industrialisation of Australia. It is fitting that the Resources Investment Symposium is held in the unique outback city of Broken Hill.

- Sunday 24th May
  Outback Gold Challenge & Icebreaker BBQ/drinks
- Monday 25th May
  Day One of Symposium & Networking Drinks
- Tuesday 26th May
  Day Two of Symposium & Rock n Roll Dinner
- Wednesday 27th May
  Technical Day by Geological Surveys of NSW & SA

This event is an outstanding gathering of key minds and players in the resources industry in a place where mining began. Broken Hill is where real business is done either at the symposium, on the golf course, or in one of the many watering holes around town.

Prof. Ian Plimer,
Patron of the Resources Investment Symposium

Register Now. Visit our website symposium.net.au/brokenhill

BROKEN HILL 2015
UNCOVER CURNAMONA
WEDNESDAY 27TH MAY 2015 BROKEN HILL

A one-day technical conference highlighting the latest data and research from the Geological Surveys of New South Wales and South Australia.

- Release of new Broken Hill metallocenic map
- New mineral system studies
- Uranium exploration opportunities
- SARIG updates
- Exploration highlights
- New geological maps
- Fieldtrip Thursday 28th May (details coming soon)

This event is an outstanding gathering of key minds and players in the resources industry in a place where mining began. Broken Hill is where real business is done either at the symposium, on the golf course, or in one of the many watering holes around town.

Register Now. Visit symposium.net.au/brokenhill

www.symposium.net.au
Conferences

– Broken Hill 2015
– AESC 26-30 June 2016
- Technical Presentations
- Fieldtrips & Workshops
- Exhibition booths
- Sponsorship opportunities
- Symposia
  - Uncover 2016
  - 40 year anniversary of OD discovery

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