July-September 2006

Y4 Project Quarterly Report

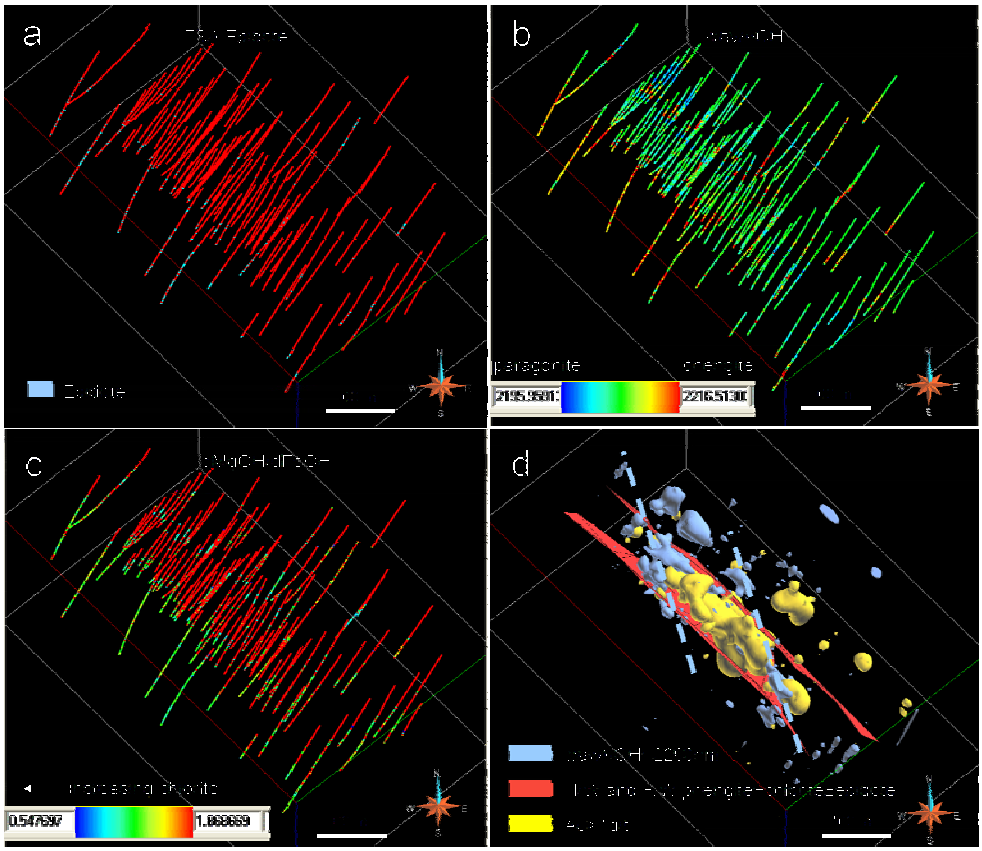
predictive mineral discovery CRC

Highlights:

- **St Ives alteration**
- **Sunrise shear zone stressed out**
- **Geochronology on many fronts**
- **Metamorphic Report number 2 delivered**
- **Penrose conference on 3D geological models**
- **The NNW contraction in the northern Yilgarn too!**
- **Embedded Researcher and Student News**

Structural controls of St Ives alteration gradients

Tony Roache the Embedded Researcher at St Ives has recently completed the Bellerophon Gocad model. Some of the results show sharp alteration gradients from phengite+chlorite±epidote to muscovite, which are parallel to the dominant foliation, S2 (Figure 1). The two most prominent gradients sit in the hanging wall and footwall position to gold mineralisation. The isosurface of white mica AlOH wavelength below 2203nm predominantly lies at the northern and southern termination of gold mineralisation. The alignment of the isosurface indicates a NNW-trending paragonite zone that corresponds to similarly-trending sub-audio magnetic gradients and the orientation of WSW-dipping crenulations (S3) measured in oriented core. These results will be of direct use in the interpretation of end of hole air-core spectra maps.



Oblique view down to north of Bellerophon. a) Epidote in light blue, concentrated along western and eastern margins. b) White mica composition (wavAlOH index). c) Relative chlorite and amphibole abundance. d) Isosurfaces and interpretation of point data. Light blue isosurface correlates with the WSW-dipping S3 crenulation zones (dashed lines), bounding the NW-SE strike-extent of mineralisation. Red surfaces represent sharp chlorite abundance/white mica composition gradients, and are parallel to the steeply NE-dipping metamorphic foliation (S_2). They lie in the immediate F/W and H/W to economic gold mineralisation.

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New Report from Sunrise Dam released

John Miller and Mike Nugus (AGA) have released a project report on the evolution of the Sunrise and related shear zones. The report:

- uses 3-D Mohr circles to assess if the structures would (or wouldn't) reactivate in each given stress
- argues for two major stress switches, other switches either relate to a decrease in far field major principal stress (i.e. the waning of an orogenic event) or a system with $\sigma 2$ and $\sigma 3$ close in magnitude.
- suggests that the stress shape ratio was low for either stress fields i.e. $\sigma 2$ close in magnitude to $\sigma 3$ and therefore favourable to stress switches (eg Wallaby)
- the stress switches occur around the same axes (i.e. not via progressive rotation).
- high shear stresses (τ) and low normal stresses (σn) due to fluid over pressure optimises reactivation. Some stress field switches were driven by a decrease in $\sigma 3$
- deformation occurred in an interval less than 10 million years at around 2650 Ma

Copies may be obtained from the Y4 Twiki website, or from the sponsors CD.

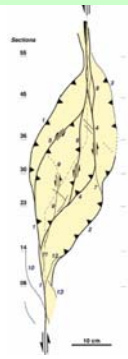
Y4 at the 3D Penrose meeting Durham UK

Y4 (Paul Henson and Richard Blewett) were invited the GSA Penrose meeting on 3D geological models held in Durham UK (17-21/9/06). The project made a presentation in gocad of some of the 3D maps we have constructed and a poster presentation in the novel Techno café. Both presentations were very well received by the participants. A total of 47 people were registered and it was a meeting in the Penrose style, with much time set aside for discussion and workshopping. It was pleasing to see that the Y4 project (and *pmd**CRC in general) stacks up well in world terms. See site http://www.geosociety.org/penrose/06-3Dsystems.htm for details.

Few other groups are dealing with the range in scale and range in disciplines (datasets) that we are routinely handling. Highlights were the talk by Alan Gibbs from Midland Valley on dealing with uncertainty and how they represent our deterministic models in terms of probability space (fuzzy boundaries rather than sharp surfaces). Similar remarks were made by others on preserving and illustrating the raw data (point clouds) rather than just presenting the neat final solution. Other themes dealt with complexity, dimensionality (1D to 4D), and complexity. All themes interlink. A more complete report is posted to Y4 Twiki.

Major deliverables next quarter

- New numerical simulation of sinistral slip kinematic system and regional Laverton architecture (*see picture to right*)
- PDT meeting delivery reports (21/11/06)
- Geodynamics workshop (22/11/06)
- Sunrise Dam workshop (22/11/06)
- Anthoney Morey PhD submission
- First views from the magneto-telluric survey across the EGF01 seismic line
- Completion of legacy data compilation for metamorphic study



Embedded Researcher (ER) News

Peter Frikken in Kalgoorlie:

- Peter left us to join RSG Global and we wish him well in his new venture

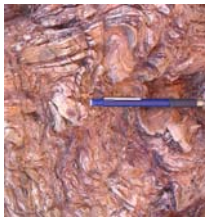
Tony Roache at St Ives:

- The Bellerophon Gocad model was completed in August, with results integrating mineral gradients with known structural trends (*see lead article*)
- The Greater Revenge Area Gocad model from Minotaur to Delta was presented for review in September. Results show that Mg-chlorite represents intermediate intrusive as a continuous planar body sub-parallel to the main Agamemnon Shear. The various chlorite end-members imaged the positions of many major structures.

- Further work to explore the intermediate intrusives and Fe-chlorite shear zones in the positioning of Au lodes. Supporting XRF, stable isotopes and paragenetic work to determine their relationship to alteration and gold-stage fluids.

Carl Young at KB:

- Collated a variety of datasets into Gocad models, for the purpose of formulating interpretative district scale models and sampling design
- Logged and sampled 3 drill holes as part of a larger campaign to characterise the paragenesis and geochemical characteristics of the different alteration domains in the district



- Designed a program of drill holes to analyse using the Hychipper. The objective of the programme is to assess the variation in the alteration types and intensity in the Kanowna Belle deposit.
- Coordinated the Hychipper data collection over 3 weeks.
- Processed the Hychipper results – currently ongoing.

Mark Pirlo at Granny Smith:

- Hychipper spectra from Lake Carey sediments were interpreted wrt hydrogeochemistry and multi-element data. Hypogene Au pathfinder enrichment zones were identified and related to definable regolith boundaries.
- Samples from 11 aircore holes from Lake Carey have been submitted for multi-element analysis, these are both proximal to known mineralization and more distal. The aim is to investigate links between hypogene enrichment and Au pathfinder elements in bottom of hole samples for exploration beneath Lake Carey.
- Investigating links between Au pathfinder elements and alteration minerals logged from PIMA spectra for predicting fluid provenance.
- Queried site database and GIS and examined drill core for developing a 3D model of Wallaby.
- 22 samples were submitted for polished thin section preparation for later stable isotopes (S, C & O).
- Continued examining previous research from Granny Smith/Wallaby and the Laverton district with a recent focus on soil gas geochemistry. This has included previous applications in the area and potential future uses.

Student News

Joanna Hodge:

- Paper completed for Economic Geology paper on New Celebration
- Thesis writing

Anthony Morey:

- Drafting thesis. Estimated completion date: 16th October.
- Final chapter completed, which assesses the boundary conditions of shear zones and resulting influences on fluid focussing and gold mineralisation.
- Paper presented at ASEC

Nick Williams:

- Careful multiple field measurements of whole drill core with a KT9 susceptibility meter give reliable estimates of magnetic susceptibility that correlate well with rigorous lab measurements
- Remanent magnetisation is common, especially in the ultramafic rocks and sulphidic rocks
- It appears that the directions of remanent magnetisation are almost entirely of normal polarity
- Only ultramafic rocks and massive sulphides have susceptibilities greater than 10 × 10-3 SI, Granite samples are the next most magnetic rocks. Samples of adcumulate ultramafic tend to have slightly lower susceptibilities than meso- and orthocumulate samples. This is consistent with the view that they resisted the influx of hydrating fluids and are less serpentinised, so underwent less magnetite creation. However, this may also be due to an increase in sulphides in the meso- and orthocumulate rocks.
- Paper presented at ASEC

Y4 Project Development Team (PDT) Meeting and workshop

The next pdt meeting is being held on the 21-22 November at the ARRC Building in Perth. The first day will be a delivery-focussed meeting with presentations from the Embedded Researchers and students, as well as updates on Northern Yilgarn structural correlations, metamorphism, time-space analysis, numerical simulations.

The 22nd will be a day focussed on Sunrise Dam and will involve delivery from the one-on-one project run out of the mine. This morning session will be augmented by contributions on regional structure, 3D Mohr circle analysis for predictive mineral discovery, regional architecture and painted faults, seismic mapping etc.

The afternoon session will be a workshop on Yilgarn geodynamics and the emphasis will be very much on discussion rather than delivery, with the hope that many (sponsors) will contribute. **Should be an action-packed and informative couple of days – hope to see you there.**

An agenda will be circulated shortly.

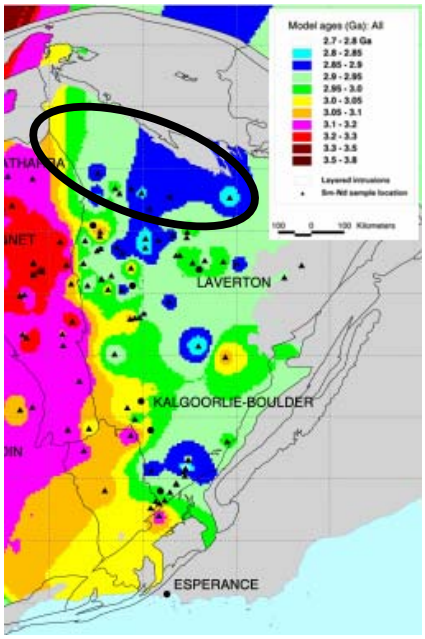
Rick Squire's re-evaluation of the 'Black Flags' @ St Ives

Rick's work on the structural and stratigraphic architecture at St Ives and Agnew is well under way, and looking like producing a wildly different stratigraphy at St Ives that may include some of the dolerites representing thick lavas with doleritic bases and pillowed tops. The sedimentary rocks either side of the thick basalts are completely different and (surprise, surprise) most of the Au deposits a located near the boundary of these different 'Black Flag' units. The sponsors at St Ives are pretty excited, but there's quite a bit of work to go to confirm all this. Rick is following this work up the following quarter.

Geochronology and other 'History' activities

Ben Goscombe has collected across the Eastern Yilgarn and has selected a number of samples for dating the metamorphism. These include the very high-grade metamorphic samples from Tropicana, tests on the age of the epidote-amphibolite vs garnet-amphibolite metamorphism, as well as the lower pressure high temperature assemblages (eg Mt Belches etc.). Samples will be processed for monazite (SHRIMP) and Lu-Hf and Sm-Nd for garnets.

The project is also infilling the Sm-Nd map from Dave Champion and Kevin Cassidy in key northern areas (*ringed area in picture to the right*). We are hoping to refine the boundary in the isotopes and test whether the undercover extension of Laverton-Duketon has a favourable mantle separation age of ~2.9 Ga or the less favourable younger age. The position of the Ida fault (as determined by the isotopes) is poorly constrained in the north near Wiluna, so more samples are being analysed there.



DID YOU KNOW?

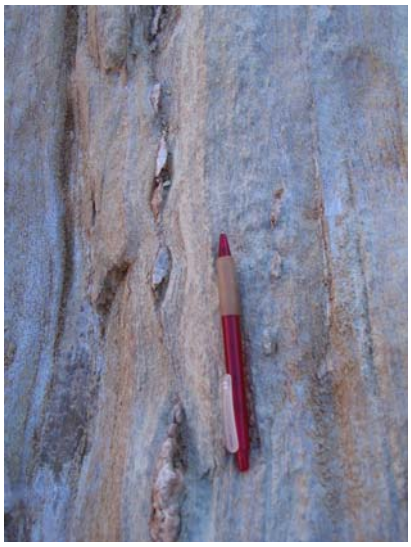
The High-Ca type porphyries at Sunrise Dam are geochemically identical to those exposed in the Mt Margaret Dome some 50 km to the north. This supports the inference from the Laverton 3D map that the Mt Margaret and Kirgella Domes are connected and that the SRD deposit taps into this architecture.

Northern Yilgarn structural correlations....

As a continuation of the AMIRA P763 structural synthesis of the central Eastern Yilgarn Karol Czarnota and Lloyd White conducted three weeks of field work documenting structural overprinting relationships in pits of the northern East Yilgarn. Areas visited included: Wiluna, Jundee, Gidgee and Plutonic.

Highlights:

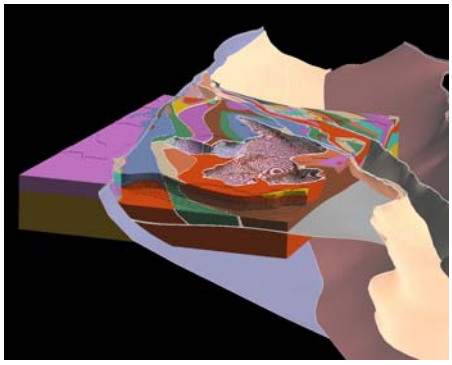
- Structural history of Wiluna region is very similar to Kalgoorlie with upright NNW trending upright folding followed by NNW trending ductile sinistral shearing which is cut by brittle dextral faults.
- The NW-SE to N-S compression associated with the main mineralisation event at Wallaby and Sunrise Dam is present in the North Yilgarn.
- Gold mineralisation related to normal faulting has been documented at Jundee.
- From first impressions there is a similar geological history in the Plutonic Greenstone belt as that deduced for the Eastern Yilgarn. This is despite a strong Capricorn Orogen overprint and mineralisation hosted by amphibolite-grade rocks.



Matilda mine Wiluna - View NNW

Apollo mine near Plutonic – contact of late basin conglomerate and porphyry intrusion with Au hosted in the porphyry View SW

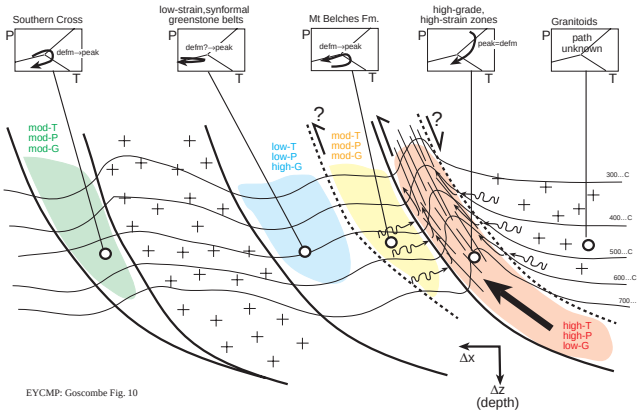
Kalgoorlie regional 3D map with 'solid' stratigraphy: released



Terry Brennan, the Y4 project's main 3D map builder, has completed the infill of the stratigraphy of the Kalgoorlie regional 3D map. The release of this revised map (*on the CD for this quarter*) marks a significant effort in R&D for the project, especially considering the 3D map's unprecedented size and complexity. The map goes well beyond the construction of surfaces and now allows the user to explore the map as a true 3D solid. The map is very complex with 52,000,000 cells and thus it is a computational challenge to manipulate. Terry has therefore segmented the map into four regions for ease of use.

Metamorphic Report number 2 delivered

Ben Goscombe has completed 3 weeks of metamorphic field work and sampling from the GSWA core library, as well as time on the CSIRO probe in Perth. He has compiled a comprehensive report which is posted to Twiki at the following link (it is also available on the ¼'s CD) https://pmd-twiki.arrc.csiro.au/twiki/pub/Pmdcrc/ProjectY4/Goscombe_Metamorphism_Report_#_2.zip.



Schematic generalized relationships between the domains of different metamorphic style (thermal regime) in the East Yilgarn Craton.

These concepts will be presented and discussed at the pdt and geodynamics workshop in late November

List of project events for the quarter

Project meetings and field activities

Name	*Date*	*Venue*	*Number of Researchers*	*Number of sponsors*
Fieldwork JW, PN, AR, PF, CY and hands-on sponsor presentation in core farm	19-21/7/06.	St. Ives	5	4
Presentation to Barrick and discussion of work program for Mark, JW, PN, MP	11/8/06.	Barrick, Perth	3	2
Visit to St Ives to log and sample core (RS)	7-18/8/06	St Ives	1	various
Visit to Agnew as above (RS)	18-25/8/06	Agnew	1	various
Fieldwork at Wallaby, JW, PN, MP, PF	21-25/8/06	Laverton	4	
Y4 talk at the Isa pdt meeting (RB)	27-28/7/06	Mt Isa	10	15
Field work (KC and LW) structural mapping in the northern Yilgarn and Plutonic Belt	12/8-2/9/06	field	2	Various at Plutonic
Fieldwork central Goldfields sampling metamorphic material and probing in Perth (BG)	18/8-10/9/06	Incl GSWA and St Ives	1	Various
Y4 talk at the Tasmanides pdt meeting (PH)	18/8/06	Melbourne	6	?
Fieldwork at St. Ives, JW, PN, AR, CY and hands on presentation in the core farm for sponsor	18-22/9/06	St. Ives	4	5

Workshops

Name	Date	Venue	Number of researchers	Number of sponsors

Conferences/Symposia

Name	Date	Venue	Number of researchers	Number of sponsors
Australian Earth Sciences Convention (RB, PH, YZ, KFC, JW, PN, JM, NW, AM, MB, JM, IR, RS)	2-6/7/06	Melbourne	13	various
16th Annual Goldschmidt Conference (PN, JW, KP, DC, KFC, JC, FE)	27/8-1/9/06	Melbourne	7	various
Penrose Conference on 3D mapping (PH, RB)	17-21/9/06	Durham UK	2	0

Shortcourses

Name	Date	Venue	Number of researchers	Number of sponsors
Peter Neumayr, Klaus Petersen and John Walshe continue to provide on-site training and development for sponsors	various	On site: St Ives, Wallaby	variable	variable