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"What are the fundamental characteristics of mineralised (trans-lithospheric) fault systems?"

Project Leader: Frank Bierlein, Monash University

Key Researchers: Peter Betts, Ivo Vos (Monash University)
Bruce Goleby, Barry Drummond (Geoscience Australia)

Program: A1 (Architecture)
Linkages: H1, H4, I4, T1, Y2, Y3
Commencement Date: May 2002
Project Duration: 3 years

predictive Mineral discovery

MONASH UNIVERSITY

GEOSCIENCE AUSTRALIA

Project Aims

- To understand why some fault systems are mineralised, and why others are barren
- Determine set of critical parameters that can be applied to identify favourable conduits and faults that are well-endowed
- Predictive mineral discovery at significantly reduced risk

Progress against Plan

Deliverables	Progress
Data base (*initial design*)	Completed (to 1 Dec 02)
Data base (*population*)	Ongoing (52 entries by Nov 02)
Data base (*web-enabled*)	Resource-dependent
Data base interrogation	Commenced Nov 02
Detailed analysis of key faults	Commenced Aug 02 (Mt Isa)
Critical parameters	In progress (anticipated Dec 04)
PhD study (Ivo Vos)	Completion Apr 05

Major Highlights and Implications

(by 30 June 2003)

1. **Data base design & structure**
2. **Key area studies**
3. **Fractal dimensions of fault traces**
4. **Geophysical indicators of fluid systems in faults**

Fault ID

- **Dimensions**
  - range of strike length
  - width of fault zone/corridor
  - dip geometry
- **Dynamics**
  - tectonic setting
  - kinematic evolution
  - duration of fault movement
- **Lithology and metamorphism**
  - dominant lithology hosting fault
  - nature of basement
  - metamorphic grade
- **Magmatism**
  - nature of dominant magmatism
  - timing of magmatism
  - method used to determine age
- **Mineralising events**
  - MIME?
  - age of mineralising event
- **Mineralisation and alteration**
  - endowment
  - alteration
  - fluid source
- **Most important deposit**
  - name of deposit
  - fault kinematics during ore stage
  - source of ore-stage fluid
- **Geophysical data**
  - depth of Moho & LAB
  - interpreted strike length
  - Magnetics
- **Additional Information**
  - key reference number
  - reliability rating
  - Comments (key words)
- **References**

Fault ID	Fault or Segment of Fault being documented	Fault segment - single structure or structural corridor	Single fault segments distinguished by	Linkage of single fault segments/relationship between structural elements within corridor	Range of strike length (minimum - km)	Range of strike length (maximum - km)	Width of corridor/ fault zone (minimum - km)	Width of corridor/ fault zone (maximum - km)	Dip geometry of fault
1	Turkestan Suture	single	offset by fault	discontinuous	1000		2	6	listric
2	Atbashi-Inylchek Suture	single	offset by fault	discontinuous	1000				
3	Talas-Ferghana Fault	single	not applicable	continuous	800	900			
4	Atacama Fault Zone	corridor	change in strike	continuous	200	500			
5	Sumatra Fault	corridor	jog separation	discontinuous	50	200	1	20	planar
6	New Guinea Suture	corridor	not applicable	continuous	1000				
7	Gowk Fault	single	not applicable	continuous	100	200	2	4	planar
8	Carlin Trend	corridor	not applicable	discontinuous	50	100	8	10	planar

Occurrence of magmatism along fault	Nature of dominant magmatism along fault	Timing of dominant magmatism along fault relative to fault zone formation	Absolute age of dominant magmatism along fault (minimum - my)	Absolute age of dominant magmatism along fault (maximum - my)	Error associated with age (+/- my)	Method used to determine absolute age of magmatism	Mineral used to determine absolute age of magmatism	Subordinate magmatism
felsic-intermediate dykes	both S- and I-type	syn-tectonic and post-tectonic	90	100	5	Ar/Ar	biotite	
major felsic-intermediate intrusives	I-type granite	post-tectonic	390	400	2	SHRIMP U-Pb	zircon	
major felsic-intermediate intrusives	I-type granite	post-tectonic	400	400	4	SHRIMP U-Pb	zircon	andesitic-tholeiitic
major felsic-intermediate intrusives	S-type granite	syn-tectonic and post-tectonic	370	400	4	Ar/Ar	muscovite	andesitic-tholeiitic
major felsic-intermediate intrusives	I-type granite	post-tectonic	360	370	4	Ar/Ar	amphibole	
major felsic-intermediate intrusives	S-type granite	post-tectonic	360	400		other		andesitic-tholeiitic
major felsic-intermediate intrusives	I-type granite	post-tectonic	380	390	10	K/Ar	amphibole	
major felsic-intermediate intrusives	S-type granite	syn-tectonic and post-tectonic	380	390	2	Ar/Ar	biotite	
major felsic-intermediate intrusives	S-type granite	syn-tectonic	420	430		other		
major felsic-intermediate intrusives	S-type granite	syn-tectonic	390	430	20	K/Ar	biotite	
major felsic-intermediate intrusives	both S- and I-type	syn-tectonic	400	420	4	Ar/Ar	biotite	
major felsic-intermediate intrusives	both S- and I-type	syn-tectonic and post-tectonic	240	300	4	SHRIMP U-Pb	zircon	

Fault ID	Mineralising event	Endowment	Mineralisation interval along fault	Mineralisation styles
1	1	world-class (several major deposits; > 10t Au > 1mt Cu etc)	irregular with discrete deposits	orogenic gold
2	1	significant (at least one major depost historically/currently mined)	irregular mineralisation - some good deposits	orogenic gold
3	1	poor (no known deposits historically/currently mined)	none	
4		world-class (several major deposits; > 10t Au > 1mt Cu etc)	regular	porphyry Cu-W-Sn-Mo (associated greissen and skarn)
7	1	poor (no known deposits historically/currently mined)	none	
8	1	world-class (several major deposits; > 10t Au > 1mt Cu etc)	irregular with discrete deposits	sediment-hosted disseminated Au
9	1	world-class (several major deposits; > 10t Au > 1mt Cu etc)	irregular with discrete deposits	sediment-hosted disseminated Au
10	1	significant (at least one major depost historically/currently mined)	irregular with discrete deposits	sediment-hosted disseminated Au
11	1	world-class (several major deposits; > 10t Au > 1mt Cu etc)	irregular with discrete deposits	sediment-hosted disseminated Au
12	1	significant (at least one major depost historically/currently mined)	irregular with discrete deposits	orogenic gold
13	1	world-class (several major deposits; > 10t Au > 1mt Cu etc)	irregular mineralisation - some good deposits	orogenic gold
13	2	significant (at least one major depost historically/currently mined)	irregular mineralisation - some good deposits	orogenic gold
14	1	world-class (several major deposits; > 10t Au > 1mt Cu etc)	irregular mineralisation - some good deposits	orogenic gold
15	1	anomalous (several known deposits historically/currently mined)	irregular with discrete deposits	volcanogenic-hosted massive sulphides

Key Reference Number	Reliability rating
1, 2, 3	good (1 - 5 published references)
4, 5, 6	good (1 - 5 published references)
7, 8, 68	good (1 - 5 published references)
4	poor (1 published reference)
10, 11, 12, 13, 14, 39	excellent (> 5 published references)
11, 13, 14, 39	good (1 - 5 published references)

Fault ID: The Moyston Fault (#13)

Geographic information:

Australia; western Lachlan Orogen; Palaeozoic

Dimensions:

single fault structure; not applicable; continuous; 50 - 100km

Dynamics:

active; reverse top-west; 140-160°; 60-90°; compressional; brittle-dominated; complex; terrane; accretionary prism; 440 - 90 Ma; Ar/Ar, fission-track

Lithology and metamorphism:

continental; 500 Ma; basement exposed; oceanic;sub-greenschist; mid-amphibole

Magmatism:

major felsic-intermediate; I-type; post-tectonic; 390-400 Ma; SHRIMP U-Pb; zircon, none

Mineralisation and alteration:

significant; irregular; orogenic gold; silicification; no data

Most important deposit:

Moyston goldfield; 440 -390 Ma

Geophysical:

251-500km; discrete structure; 31-60 km; 151-200 km

Additional information:

15, 16, 17, 18, 28, 46, 90; excellent

***References*:**

(15) Gray, D.R., Foster, D.A. 1998: Journal of Structural Geology

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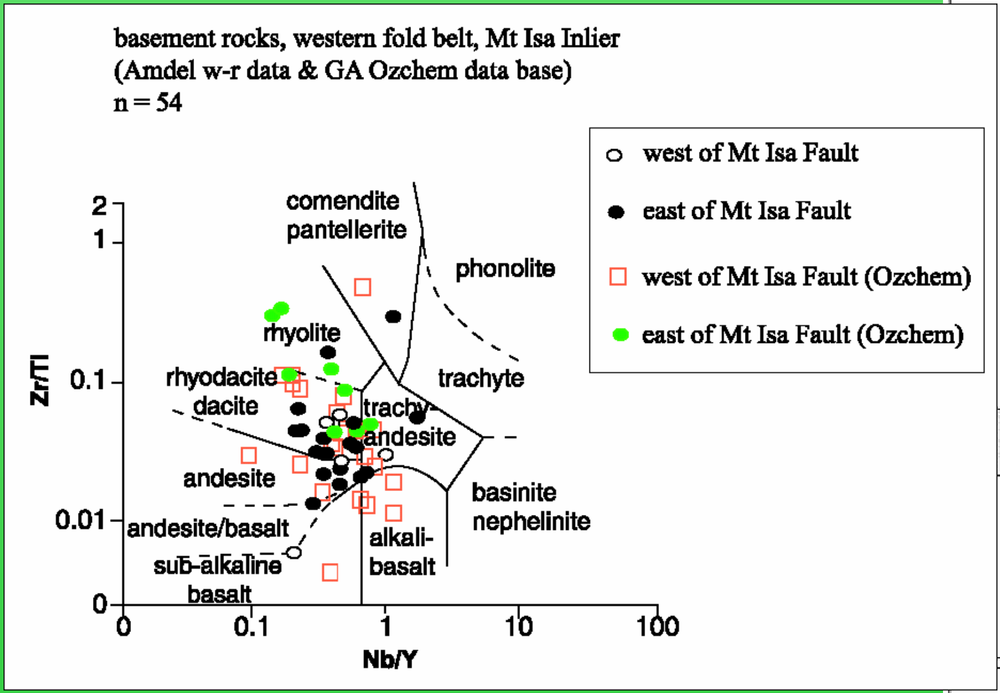
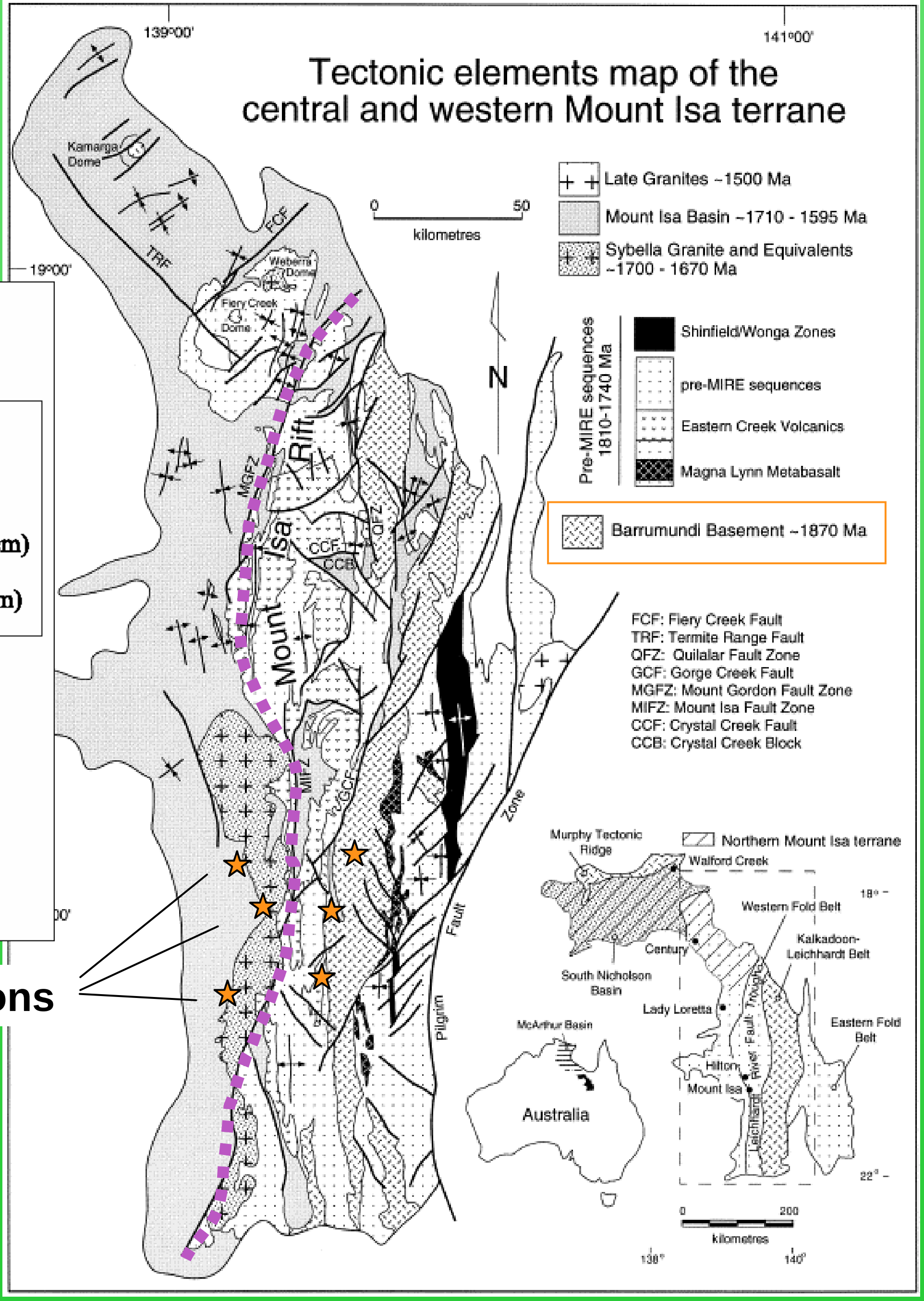
Data base interrogation (example)

	mineralised faults	unmineralised faults
Fault dimensions:		
linear fault	6/34	5/17
Fault dynamics:		
brittle-dominated	9/34	6/17
intra-plate	7/34	8/17
evidence for inverted extension	?	?
Lithology:		
presence of ophiolites	9/34	1/17
Magmatism:		
no magmatism along fault	4/34	10/17

Key area studies (I)

(Frank Bierlein & Peter Betts)





sample locations

also: Yilgarn Craton (Y2, Y3)

Lachlan Orogen (H1, H4, T5)

Colorado Mineral Belt (USGS)

from Betts et al. (1998)

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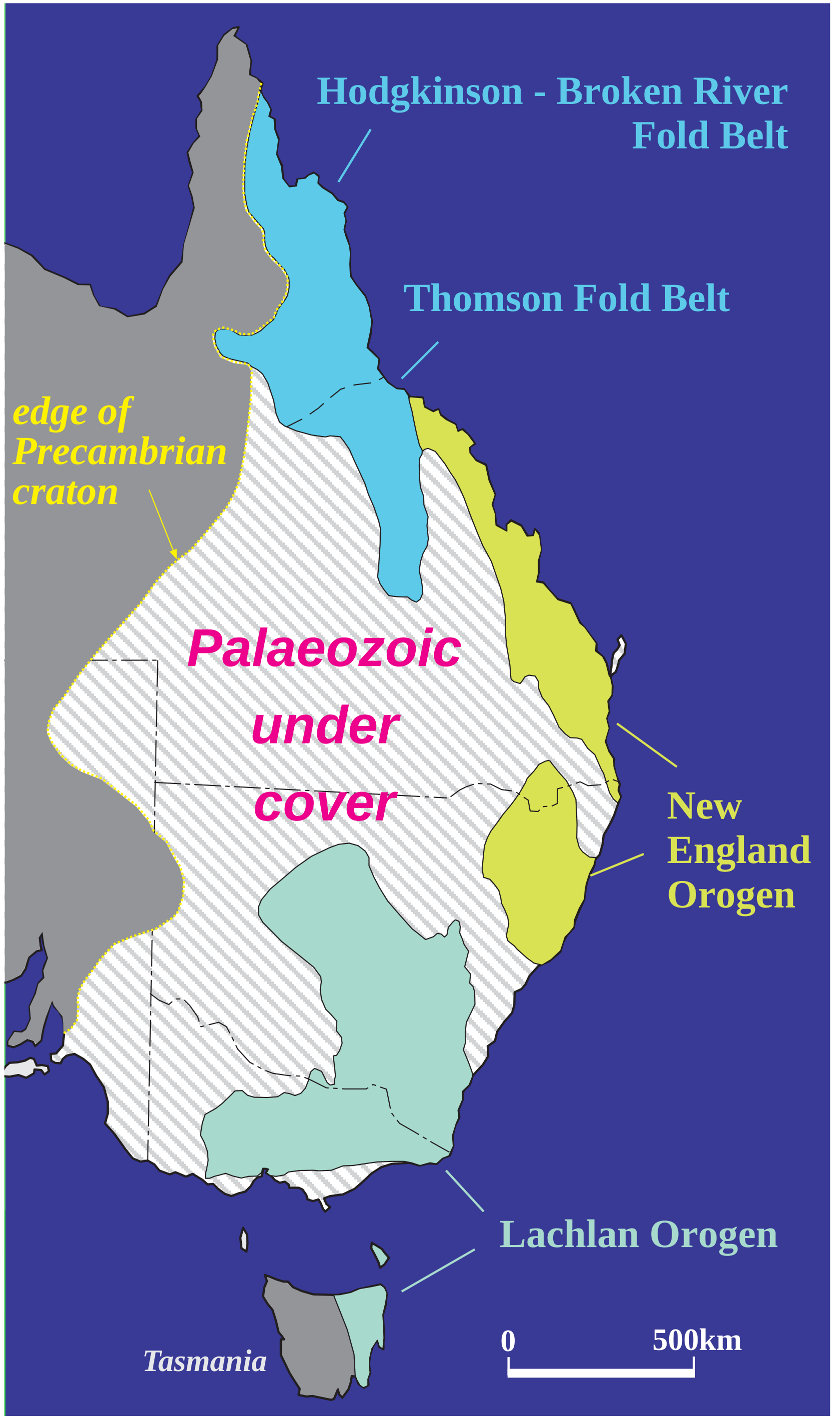
Key area studies (II)

Ivo Vos' PhD project at Monash University

(see poster display)



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Fractal dimensions of fault traces: Quantifying fault irregularity

(Thomas Blenkinsop & Frank Bierlein)

***Rationale*:**

- **bends and jogs on faults are well-known to control syn-tectonic hydrothermal mineralisation**
- **a method of quantifying fault irregularity may reveal significant aspects of fault-related mineralisation**

$$L \sim e^{1-D}$$

L - length of fault; e - ruler dimension;

D - Fractal Dimension (D increases with fault irregularity)

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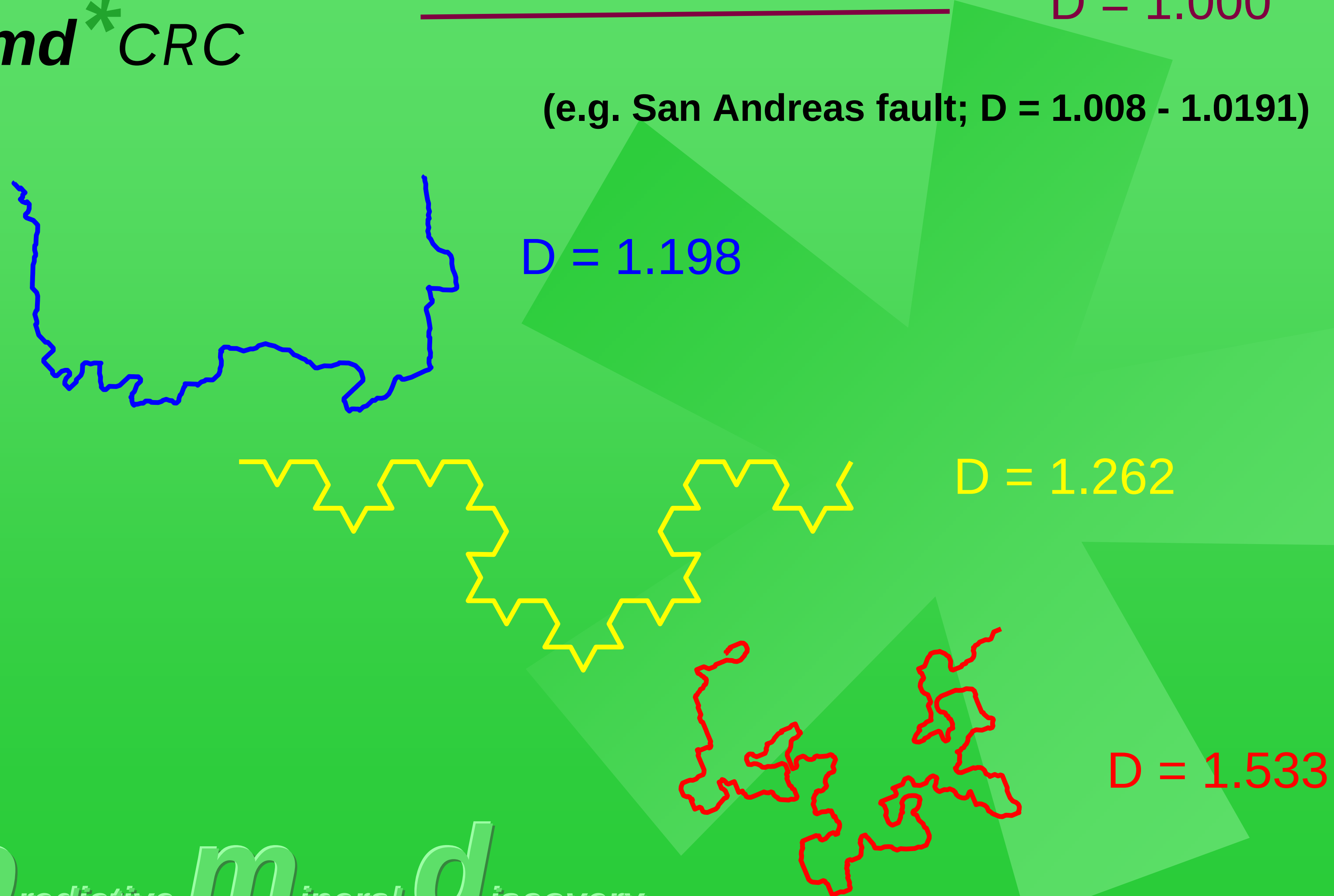
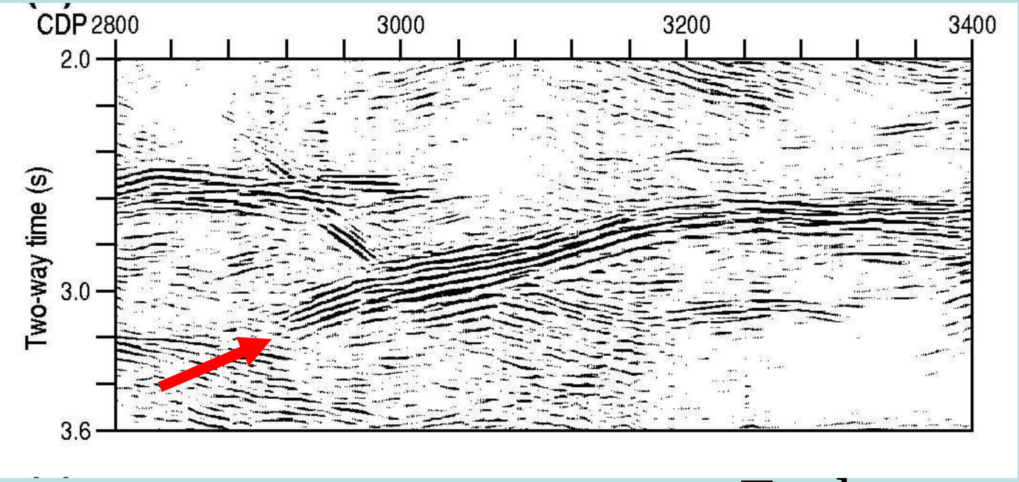
Some examples:

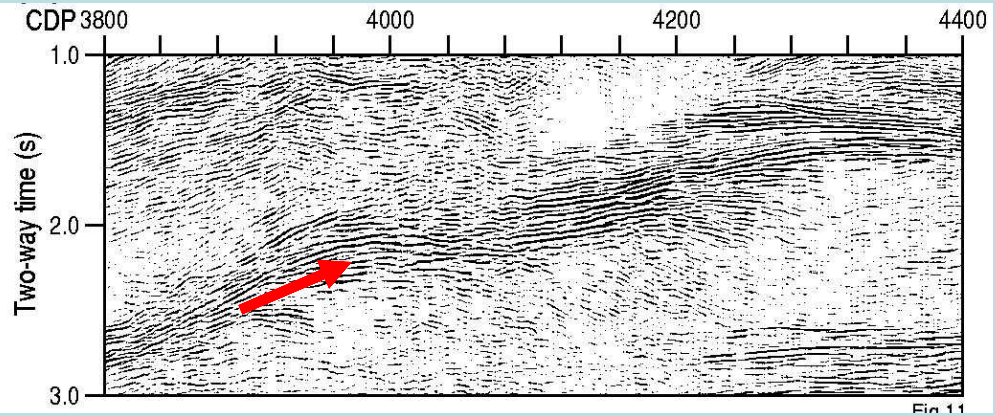


Investigating deep faults as fluid pathways using seismic data



Fault

develop geophysical tool for fluid pathways within fault zones



Shear Zone

Key Project Issues

- **Currently on track (deliverables; db open-ended)**
- **Resources required for development of data base**
- **Empirical parameters from data base**
- **High-risk** (faults not cause, just provider; deposits away from faults; detection of obscure(d) faults; local processes; scale)
- **Needs improved collaboration and linkages with other projects !**

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Future Directions

(beyond 30 June 2003)

- **Web-enabled interactive data base**
- **Set of geological, geochemical and geophysical criteria for distinguishing mineralised from non-mineralised faults**
- **Improved understanding of role, significance of deep-seated structures in generating major ore deposits**
- **Provision of scenarios for numerical modelling**
- **Powerful predicitive tool in exploration for major mineral deposits**