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Mineral systems as chemical reactors with no mathematics

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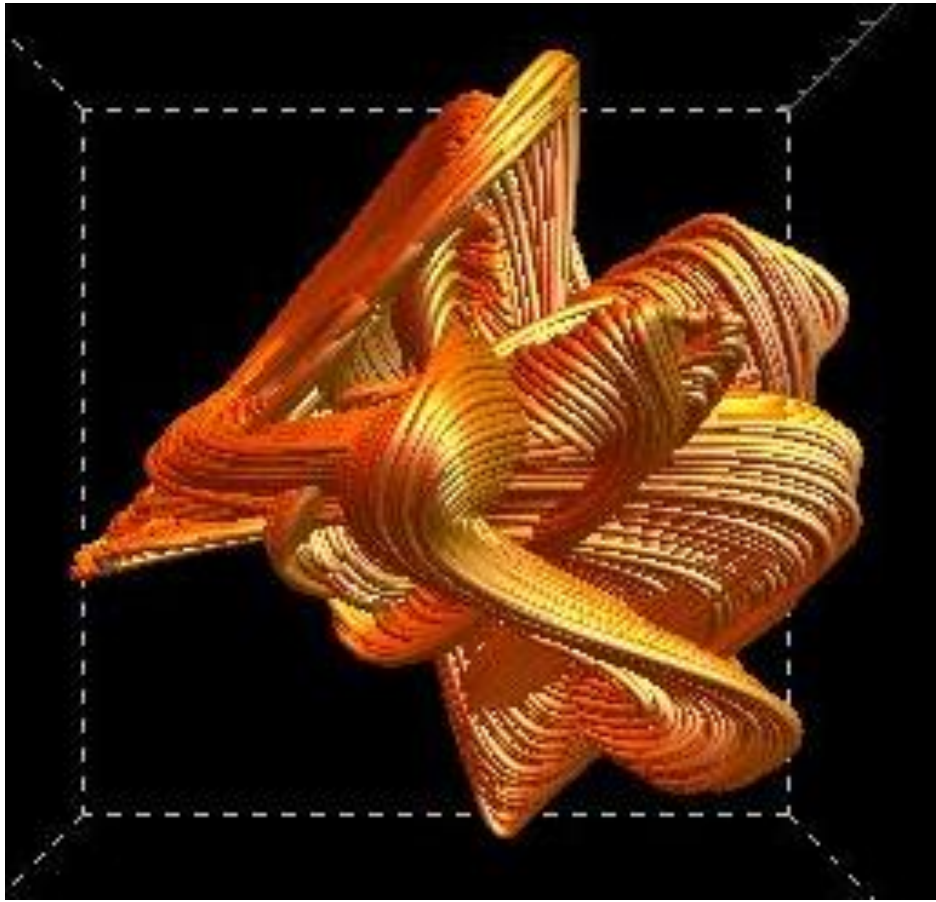
Welcome!

Fingerprint
for a mineralising system



Fundamental exploration questions:

1. How do I make a decision using limited data? Even if the data consists of alteration assemblages rather than mineralisation?

2. What is the most efficient data collection strategy? What is the minimum amount of data needed?

3. What is the most appropriate risk curve? When to quit?

4. How do I quantify uncertainty? Entropy analysis.

5. What is noise? What is an anomaly? What is and is not an outlier? What is a false positive?

6. How do I quantify the difference between mine site, brown fields and green fields exploration?

7. How do I quantify prediction? How do I quantify patterns?

8. What is the probability of discovering a world class ore body in this region?

The five fundamental exploration tenets:

1. **Mineralising systems should be viewed as living vibrant open entities far from equilibrium. They are not dead closed linear systems at equilibrium Hence we need *tools, languages and concepts* that take this into account.**

2. **Discovery is an extreme event. A discovery event is many standard deviations from the norm. Hence *extreme event statistics* are fundamental.**

3. **If you cannot measure it you cannot manage it or communicate it. Precise and rigorous science based language is fundamental. This also means that scientifically and information based *measurement standards* must be enforced.**

4. **New paradigms do not result from consensus. Hence leading edge companies must be prepared to be *scientific risk takers*.**

5. **Adoption of new paradigms does result from *consensus*.**

Takens' Theorem 1981:

In any coupled dynamical system the behaviour of one component (say arsenic) reflects the behaviour of all other coupled components.

This means that just one component can be used to predict the behaviour of all other coupled components.

This is because the behaviour of every single component depends on the behaviour of all others.

Takens' Theorem 1981: simple but profound.

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The behaviour of all components in a system is restricted to lie on an *attractor* for that system.

An attractor describes all the possible states that the system can evolve through.

An attractor exists in N-space where N is the number of independent processes operating.

An attractor can be drawn using any one component using a displacement process.

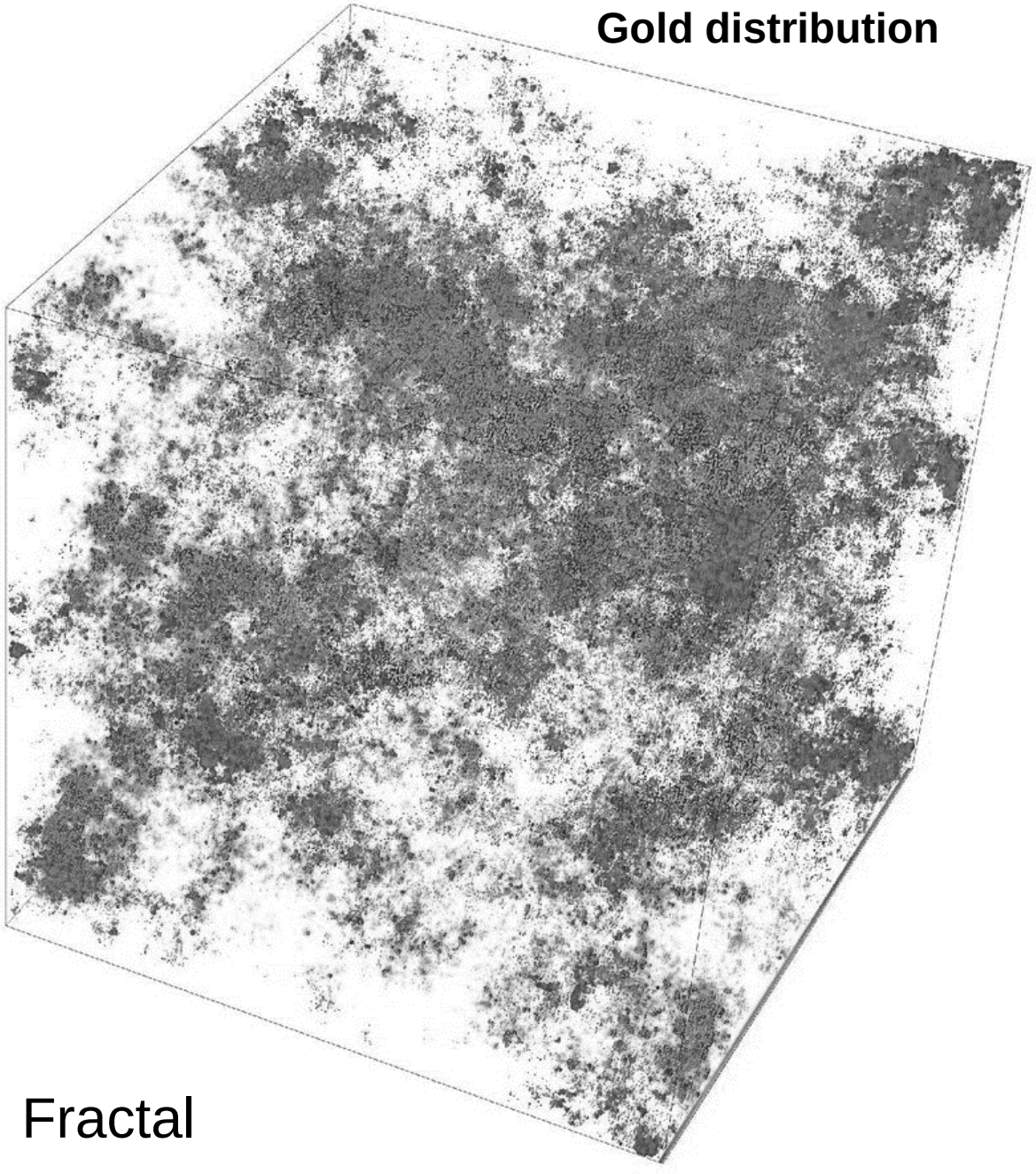
Takens' Theorem 1981: simple but profound.

Dynamical systems are characterised by three features:

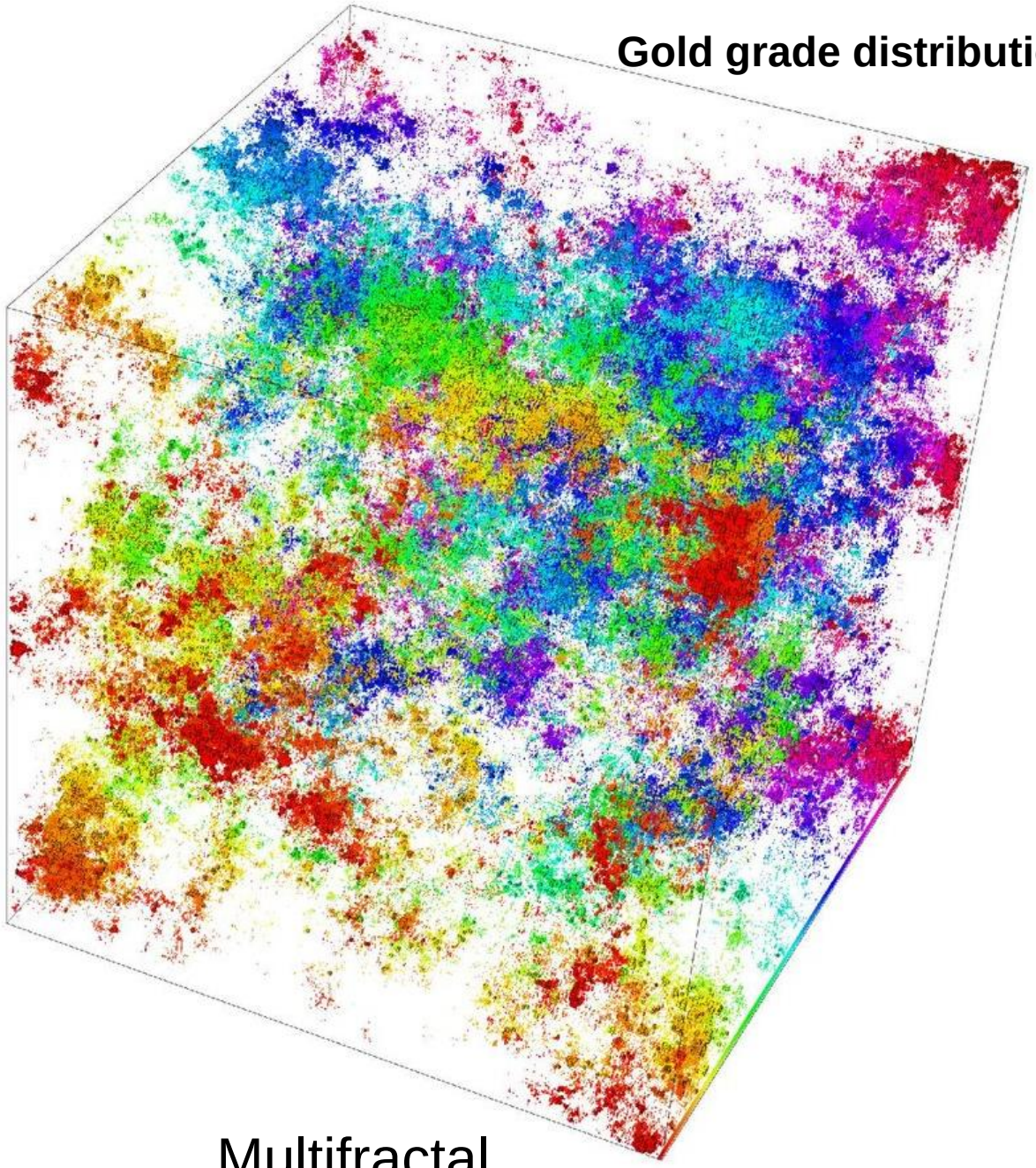
1. **Multifractal behaviour in space and time. A multifractal is a set of fractals embedded in each other.**

2. **Recurrence. The system repeats itself in a statistical sense in space and time.**

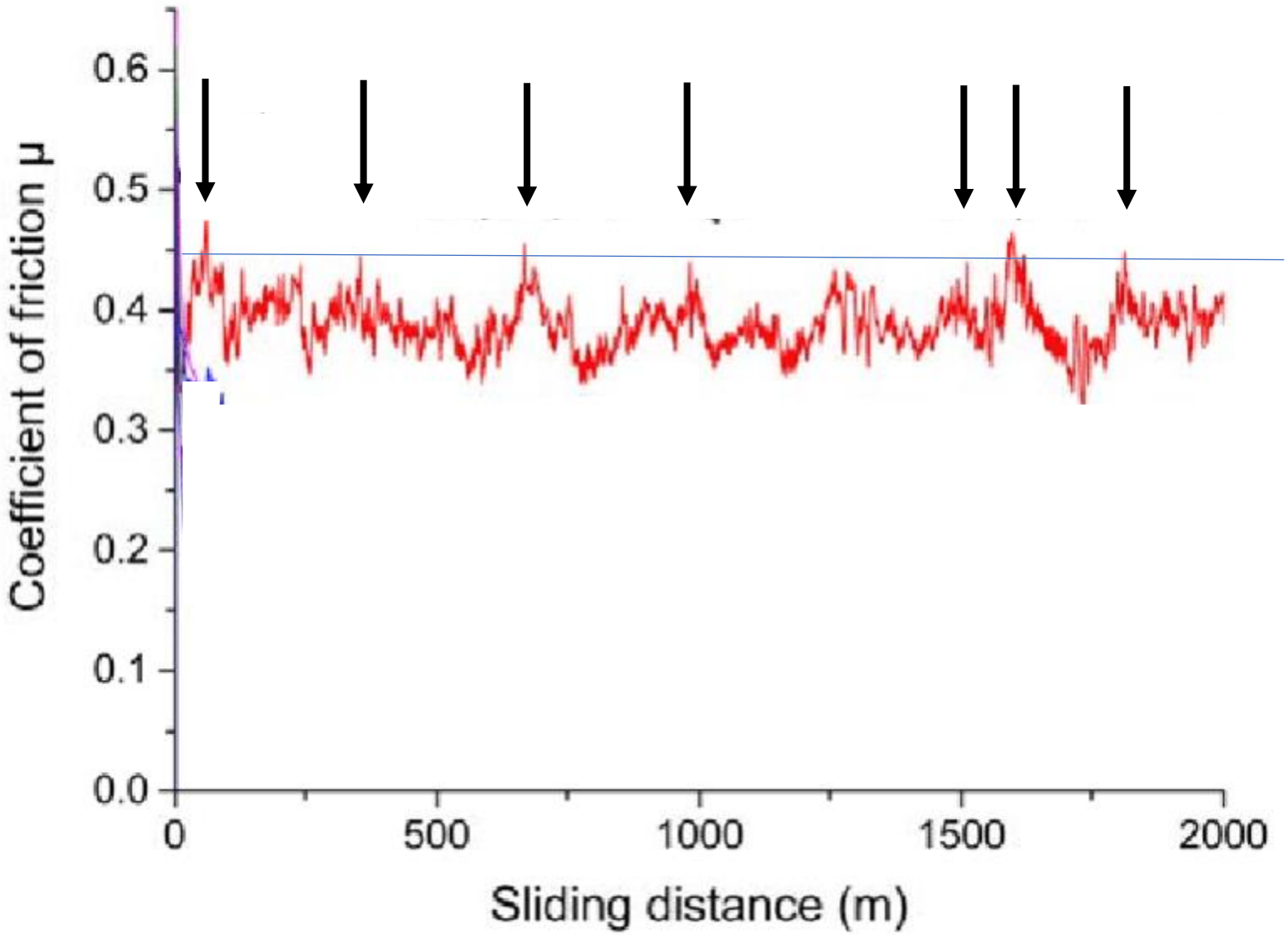
3. **The probability distribution of a component reflects the growth of the system.**

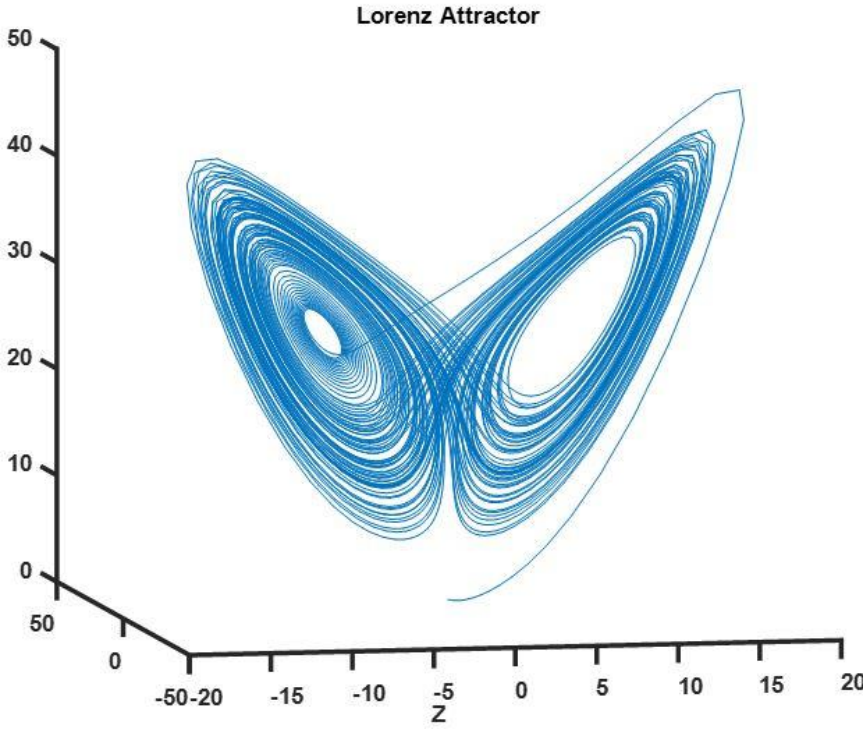


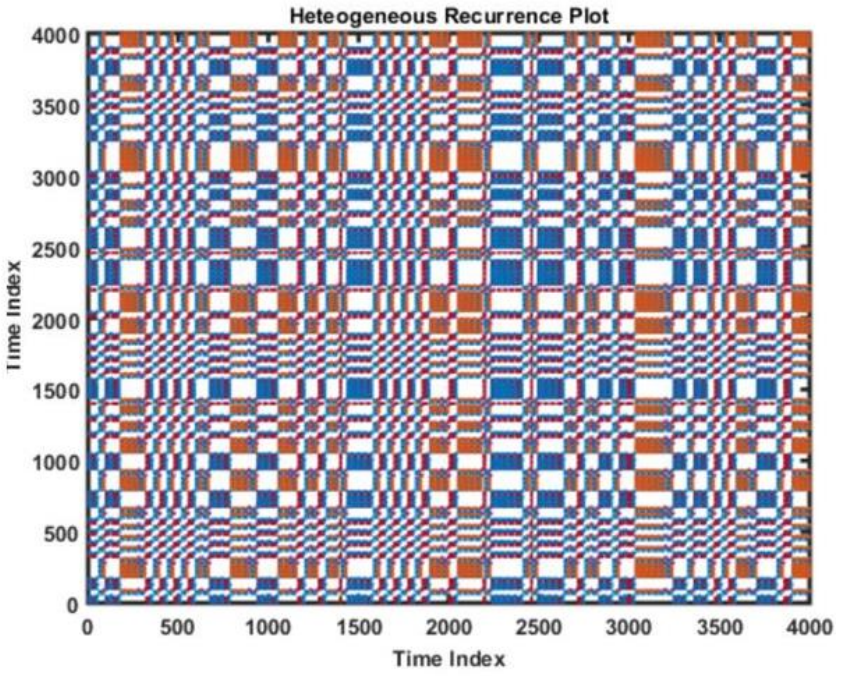
Fractal



Multifractal


Coefficient of friction μ
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
500
1000
1500
2000
Sliding distance (m)





The complete dynamical behaviour of a system lies in the recurrence plot.

Probability and growth

System starts slowly grows fast and stops early due to depletion of energy and mass

Weibull distribution

Low endowment.

Many mineralised sites

System starts quickly grows slowly and stops late due to continuous supply of energy and mass.

Fréchet distribution

High endowment.

Few mineralised sites

Timetable for Kalgoorlie worksop.

9:00 *Start up*: Summary and discussion of what people expect from this workshop?
9.15 – 9.45: Irregular data.
9.45 – 10.30: Mineral systems.
What is a mineral system?
Coupled nonlinear processes.
Takens' theorem. The concept that in a system all processes are interdependent and related. The information in one data set encodes all the data on the system.
Some examples using EXCEL. Periodic, quasiperiodic, chaotic signals and attractors.
10.30 – 10.45: Coffee.
10.45 – 12.30: The nonlinear toolbox.
Wavelets and multifractals. Long range correlations.
Recurrence
Probability distributions.
12:30 – 13:15: *Lunch.*
13.15 – 14.15: An example.
Sunrise Dam.
14.15 – 15.00: Other examples.
Pb Zn; Regional distributions.
15.00 – 15.30: *Coffee.*
15.30 - 17.00: Application to regional exploration.
17:00 - 17.30: Summary and wrap-up.