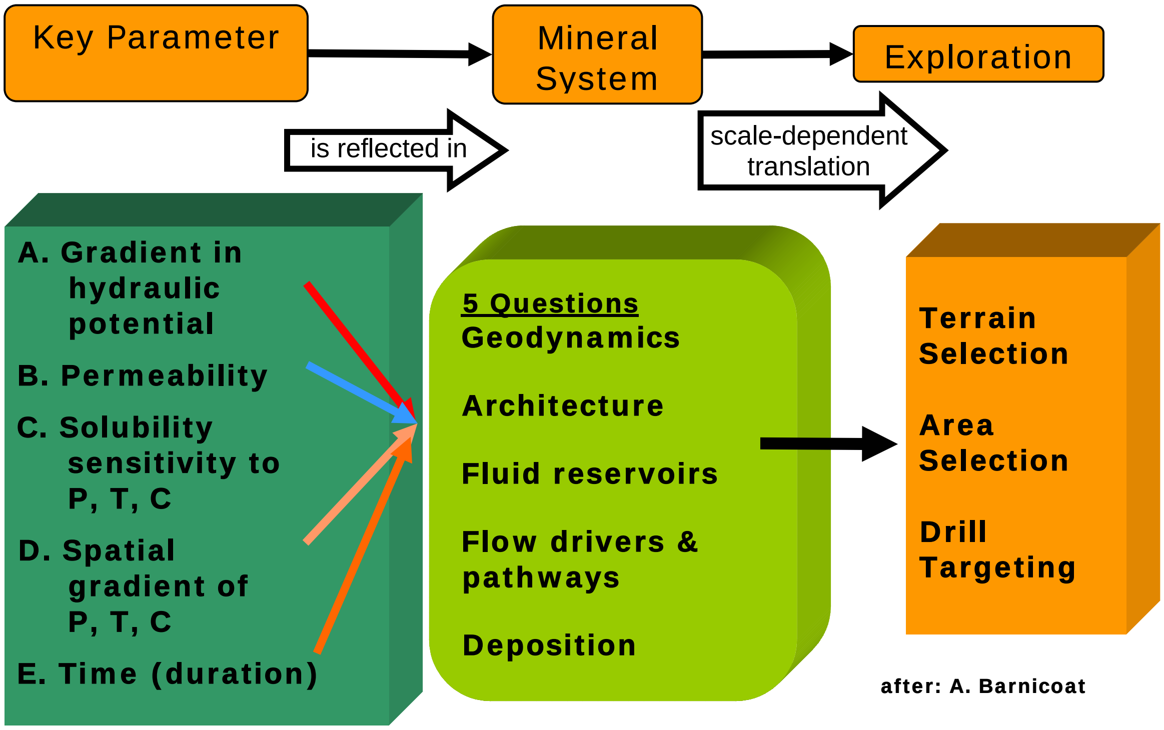
Lecture MS_2

Architecture



after: A. Barnicoat

Large scale structures are high-permeability domains in the crust and sites of elevated permeability (Barnicoat 2008) and therefore are potential pathways for fluids and magmas, from deep to shallow, but also as regions that draw down fluids from shallow to deeper levels. They also link the mantle with domes in the upper crust. Importantly, they offer potential fluid mixing environments, especially when long-lived and repeatedly reactivated. Fault architecture also controls the distribution of Superbasins, their contained Supersequences and related units. There is a strong correlation between large deposits and large cracks, across many commodity groups and in different terranes (e.g. Gold in the Yilgarn, Pb-Zn-Ag/ IOCGs in the Mt. Isa Inlier). Such crustal discontinuities are often long lived, exert a strong influence on geological evolution, and reactivation of these features is often associated with hydrothermal mineralisation. The large-scale conduits, which originally may have been terrane sutures, are characterised by high degrees of non-linearity, with large ore systems preferentially developed in second- and third-order structures within damage zones (Bierlein et al 2006).

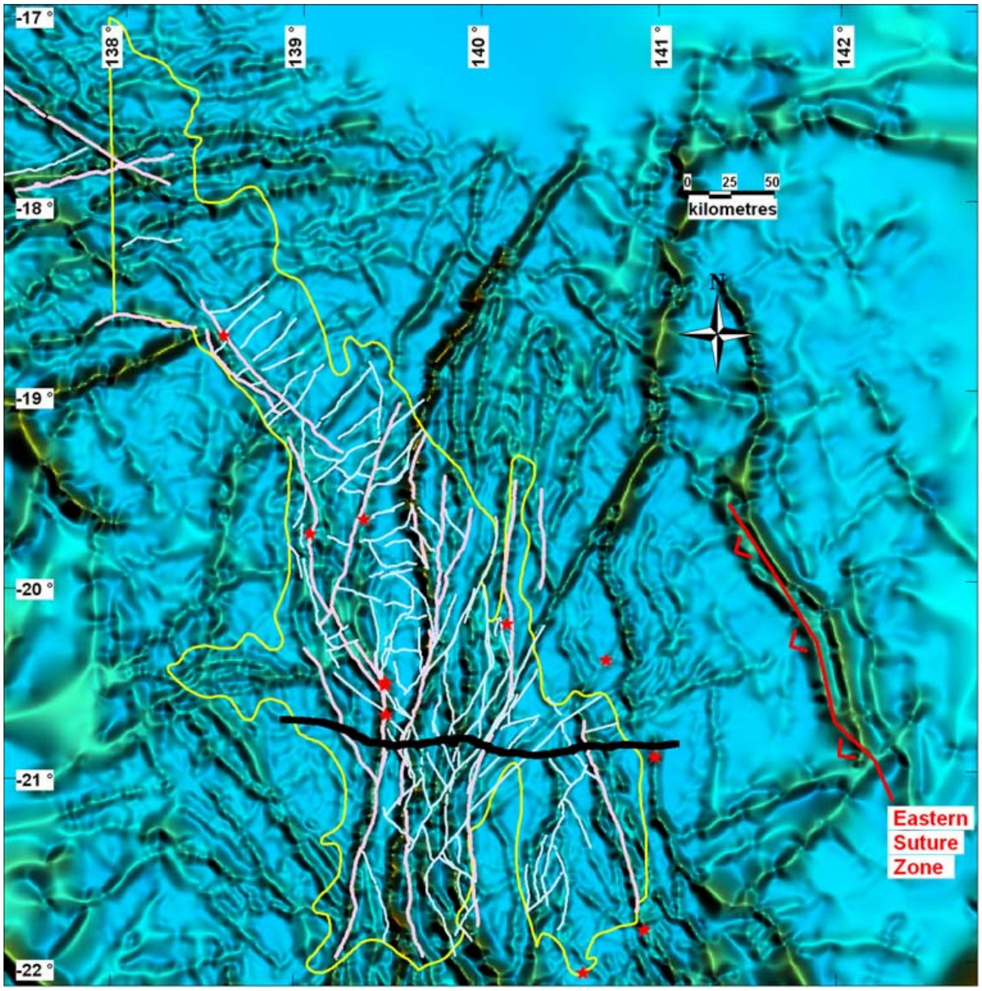


Figure 1: Edge length image from combined gravity and aeromagnetic interpretation. Major deposits (red dots) and outline of inlier (yellow line) and AGCRC Seismic Line 94_01 (black) and west dipping gravity gradient (Eastern Suture Zone) (Murphy and Hutton 2008).

Different tools are available for the analysis of the lithospheric/crustal architecture on the regional and district scale, including broadband seismographic studies (mantle tomography and crustal receiver functions), long-wavelength potential fields and their derivatives (Worms), deep-crustal and shallow high-resolution seismic reflection profiling, wide-angle reflection, magnetotelluric data (MT), and geochemistry and isotopic dating. The integration of these datasets can provide insights into the architecture of the lithosphere/crust and are helpful in predictive mineral discovery on the large scale (Blewett et al).

Structural architecture also controls the distribution of dilation sites that play an important role in developing steep hydraulic gradients and provide the space for mineral precipitation. It is therefore important to understand the stress regime and fault orientations. Detailed structural analysis and numerical models can help to determine sites of dilation, favourable orientation of faults and the preferred tectonic regime for fluid migration.

Because mineral deposits usually form during certain events, it is crucial to understand the deformation, magmatic and metamorphic history of the region. For example in the Yilgarn, ‘extensional’ gold deposits (Leonora, Lancefield, Kunannaling) which formed during the 3D extensional event are associated with metasomatised mantle melts, extensional shear zones and are always found adjacent to granite domes (Blewett 2008).

3D maps are a powerful tool. Regional 3D maps provide an improved understanding of the 3D architecture and alteration associated with mineralization. On the camp and mine scale the data density is higher and maps on these scales can provide insights that can not be gained from regional data alone (Henson et al 2008).

In the Laverton region in the EGST, a 3D scale integration was conducted by the pmd*CRC Y4 project. Based on mine scale structural analysis data from Sunrise Dam (Miller and Nugus 2006) and Wallaby (Miller 2006), Miller and Nugus (2006) determined that NE-SW striking fault segments that are dipping at ~30° towards 310° were preferred to reactivate during the NW-SE contractional gold event **(D4b)** at both Wallaby and Sunrise Dam. Figure 2 is a Gocad image of wireframes of major shear zones and the actual gold occurrence (both generated with Leapfrog), in the Sunrise Dam deposit, which were assigned orientation parameters according to the NW-SE gold event. Highlighted areas along the fault are suitable to reactivate during that event.

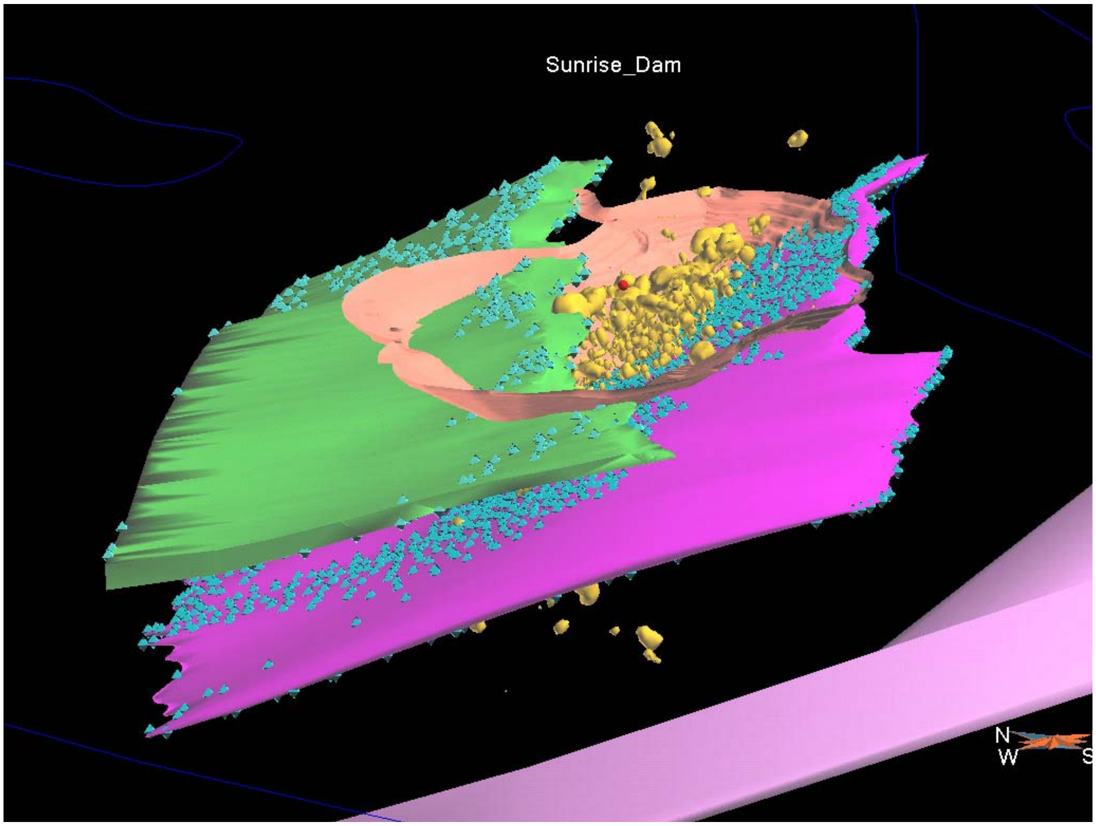


Figure 2: SRD painted faults. 3D image from Gocad looking to the NE of wireframes from Sunrise Dam mine. Blue diamonds show regions of suitably orientated fault segments to reactivate/ dilate during a NW-SE contractional event (D4b) (Henson et al 2008).

The same was done on the regional scale (Figure 3) and among the highlighted areas of suitably oriented fault segments (red regions) were Sunrise Dam, Wallaby and Lancefield, but also other potential regions (Henson et al 2008). These empirical relationships not only indicate that fault orientations were important in regards to gold mineralisation during the **D4b** event, but also that the dip of a fault is just as important to the reactivation process. Hence, a well constrained 3D map is necessary for the analysis of these orientation parameters, and scale integration proved to be a powerful approach (Henson et al 2008).

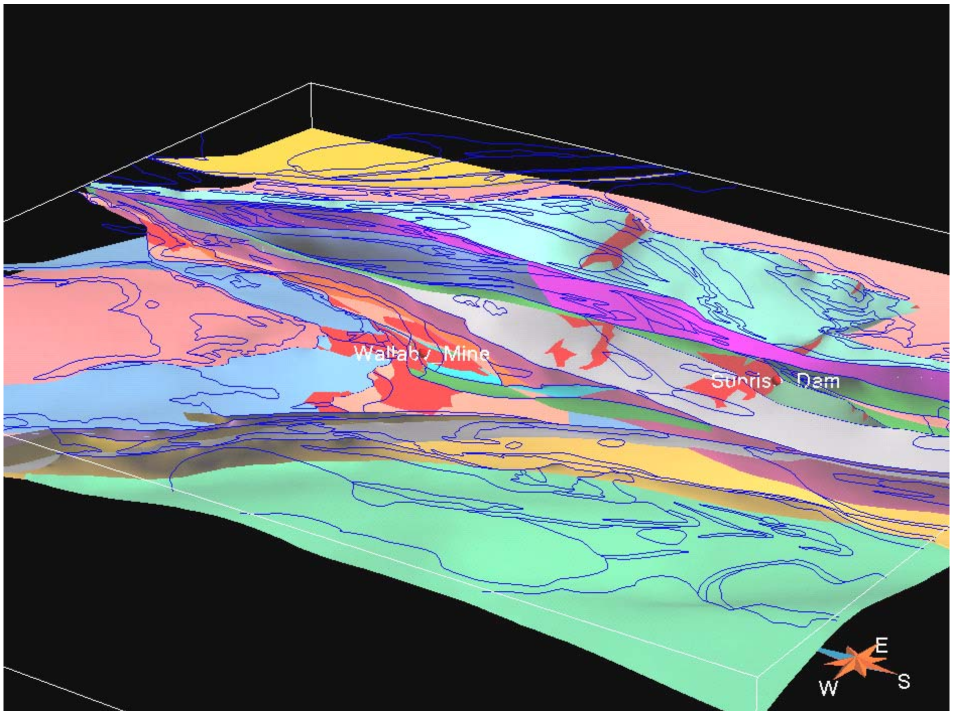


Figure 3: Laverton painted faults. 3D image from Gocad looking to the NE of the regional faults in the Laverton region. Red areas show regions of suitably orientated fault segments to reactivate/ dilate during a NW-SE contractional event (D4b) (Henson et al 2008).

To test geological processes, the constructed 3D architecture is exported into 3D meshing packages used for numerical modeling, where a variety of different parameters can be applied to simulate real geological processes and test hypotheses (Figure 4). This has been done for stress, strain and volumetric changes in the Laverton region under different stress regime. Figure 5 shows the results for the NW-SE contractional event, indicating the spatial distribution of regions displaying preferential dilation and, hence, regions of higher potential fluid flow and mineralization.

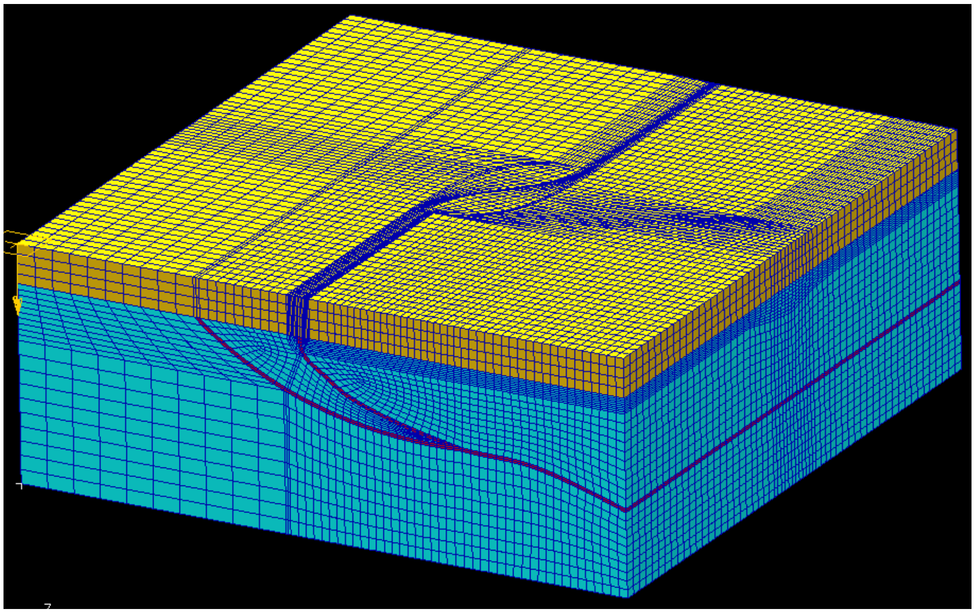


Figure 4: Image of the model displaying the fault locations and lithological distributions and the mesh used.

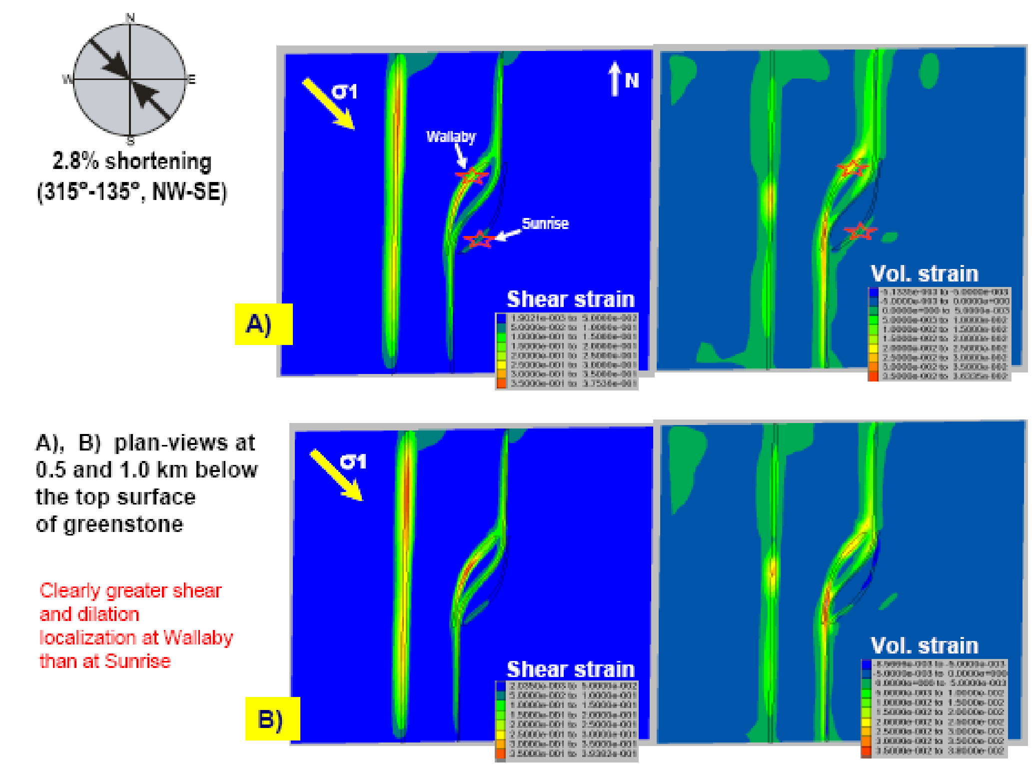


Figure 5: Image showing the Shear and Volumetric strain occurring during a NW-SE contraction event

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