The mineral potential of major fault systems: a case study from NE QLD, Australia

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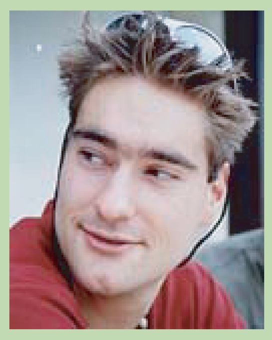


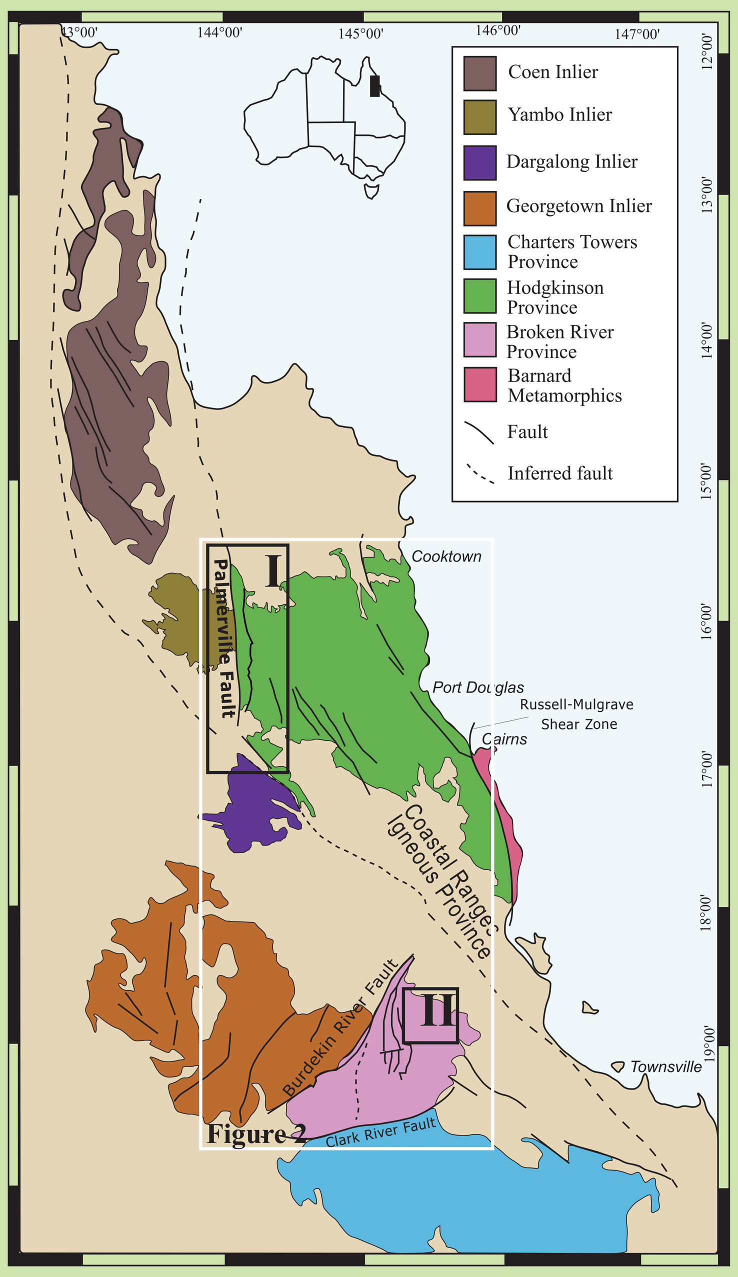


Figure 1: Outline of the geology of northeastern Queensland, Australia. White inset refers to Fig. 2. Black insets refer to locations of case studies I and II outlined in Figs. 3 and 8.

Introduction

Major fault systems that penetrate deep into the crust are poorly understood, but important architectural elements of the Earth. Conceptually, these structures can provide pathways and foci for mineralising fluids and magmatism into the upper crust. This study is an integral part of large-scale multi-disciplinary investigations that examine representative examples of well-endowed and poorly-endowed major fault systems in Archaean- to Phanerozoic-aged terranes (see Bierlein et al., this conference). Two case studies have been selected to explore the role that major fault systems play in the metallogeny of the low-data density Hodgkinson and Broken River provinces in northeastern Queensland, Australia (Fig. 1).
Both provinces are bounded and traversed by major fault systems and have recorded significant gold endowment (Fig. 2). To better understand the interplay between gold endowment and these fault systems, we have integrated spatial geological and geophysical datasets. Multi-scale edge analysis (worming) and forward modeling of magnetic and gravity data has been conducted to constrain the location, depth extent and length of structures. In addition, field studies have been carried out to test and constrain the geophysical modeling results. Our multi-disciplinary approach has enabled us to report on the nature of the major fault systems and their significance in the tectono-metallogenic evolution of both provinces.

The case studies:
Case study I focuses on the Palmerville Fault, which forms the boundary between the Palaeozoic Hodgkinson Province and Proterozoic rock assemblages to the west. Along the north-striking section of the fault no mineral occurrences have been identified. Where the strike of the fault changes to northwest, the fault system is stitched by granites that host several epithermal gold deposits.
Case study II focuses on the Amanda Bel Goldfield in the Broken River Province. The Amanda Bel Goldfield comprises a major orogenic gold-bearing region that occurs away from any recognized fault structures.

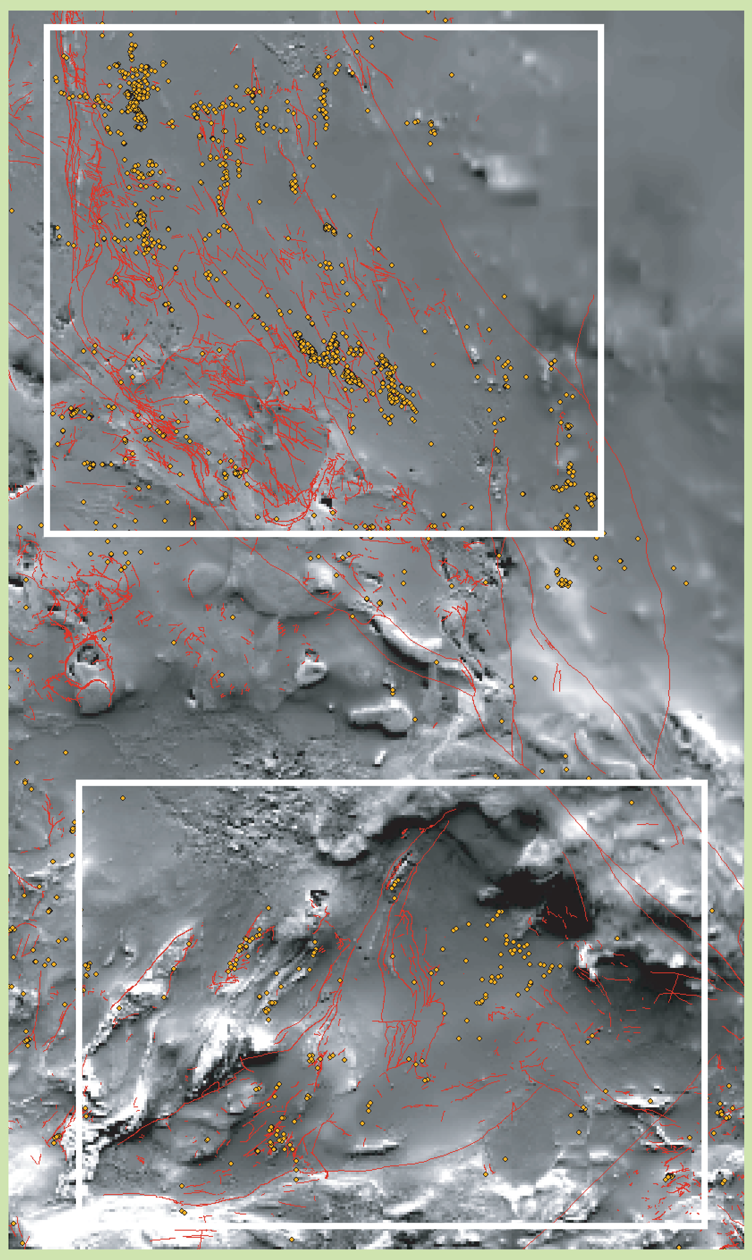


Figure 2: Total magnetic intensity image of northeast Queensland combined with fault and gold occurrences databases (Geoscience Australia) illustrating the strong relationship between gold occurrences and faults in the Hodgkinson (white inset - top) and Broken River (white inset - bottom) provinces.

Case Study I: The Palmerville Fault

Background:
* Terrane boundary between Proterozoic and Palaeozoic sequences (Fig. 3)
* No direct association with mineralisation along NS section
* Pathway for Permo-Carboniferous granites associated with porphyry skarn deposits (e.g. Red Dome) along NW-SE section
* Enigmatic structure in terms of kinematics and tectonic evolution of the province

Methods:
* Worming - validate the extent and subsurface expression of the fault (Fig. 4)
* Forward modeling - test the validity of eastward dipping fault model (Figs 5, 6 and 7)

Results:
* Worming indicates presence of near-vertical structure at the surface, becoming listric at deeper levels
* Gravity / magnetics expressions suggest presence of continental basement underneath the Hodgkinson Province which was also suggested by previous studies on granite geochemistry

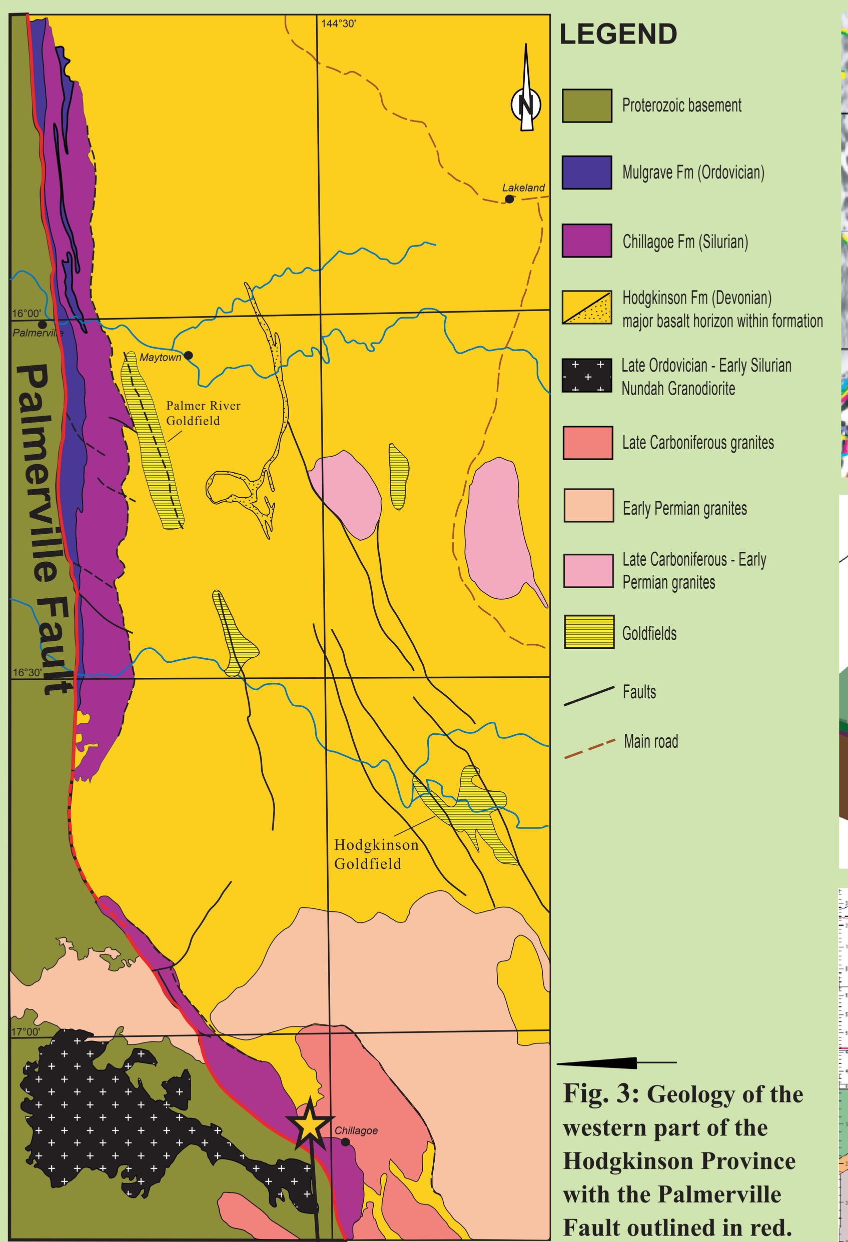


Fig. 3: Geology of the western part of the Hodgkinson Province with the Palmerville Fault outlined in red.

Red Dome Au-Ag-Cu-Pb-Zn
12.8 Mt @ 2g/t Au and 0.5% Cu

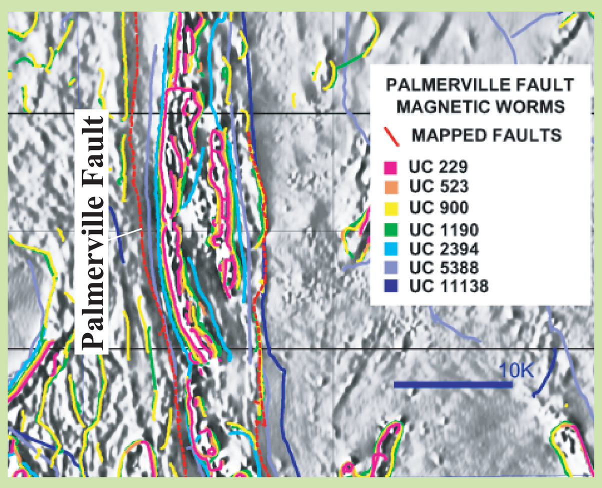


Fig. 4: Magnetic worms over part of the western section of the Hodgkinson Province comfirming the long strike length of the Palmerville Fault. Gravity worming, however, indicates that the structure may be subordinate to the adjacent Mitchell Fault Zone.
The worms indicate that the fault is near vertical at the surface, but dipping eastward and becoming more listric at depth. (UC = upper continuation)

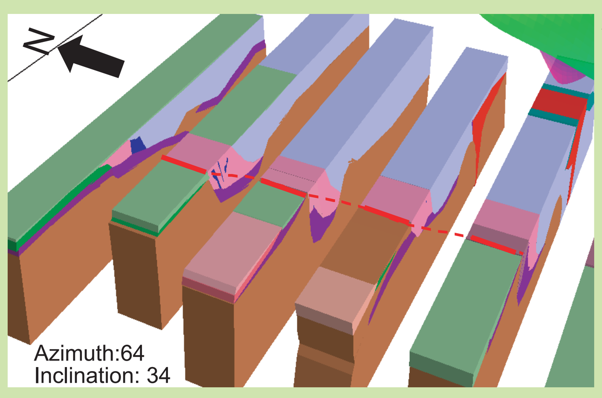


Fig. 5: Modeled cross-sections across the Palmerville Fault (in red) and part of the Hodgkinson Province resulting from forward modeling (ModelVision).
The sections indicate the presence of basement (in brown) underneath the Hodgkinson Basin.

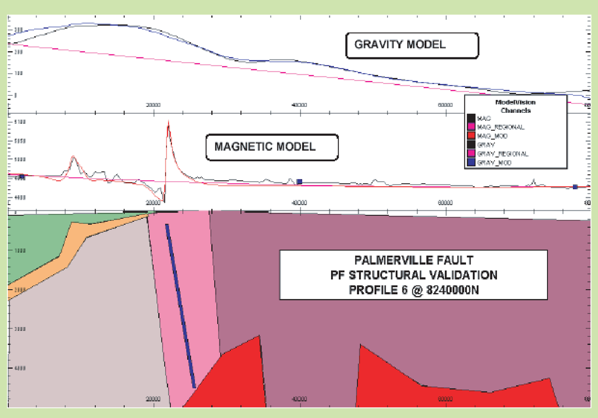


Fig. 6: Modeled cross-section across the Palmerville Fault. The magnetic peak to the east of the Palmerville Fault has been correlated to magnetic intrusives within the Silurian-Devonian sequences (known from outcrop). Modeled as conformable, they confirm a dip of the sequences to the east. Note the observed magnetic peak where the fault is, probably as a result of incorporation of magnetic packages along the dip of the fault.

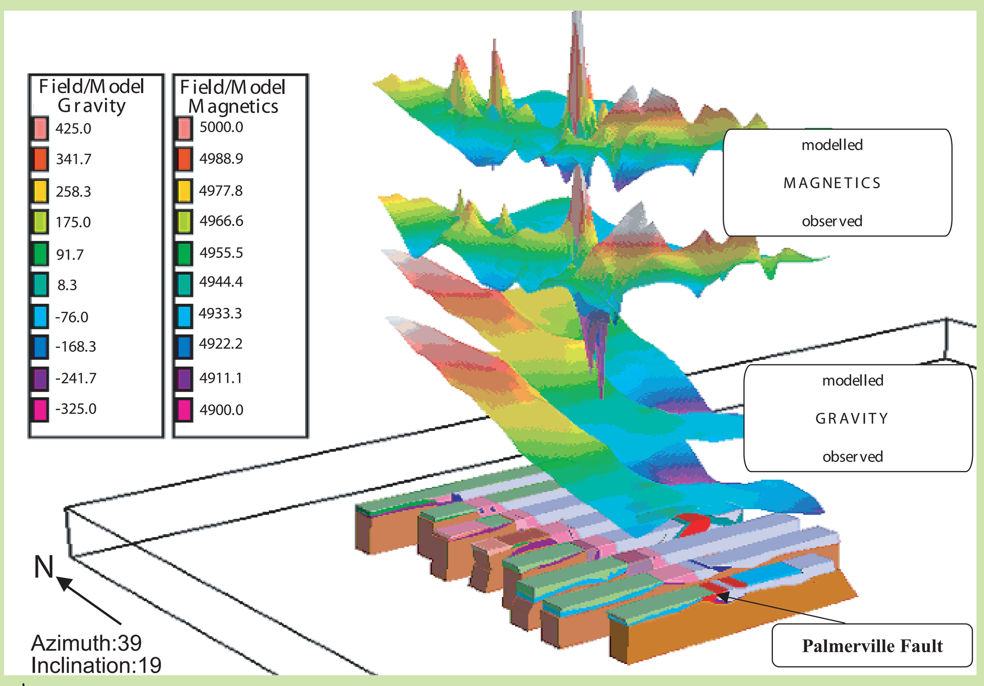


Fig. 7: Forward model for Palmerville Fault from cross-sections. Observed and modeled fields shown for both gravity and magnetic data. Each set uses the same scale shown on the left for gravity and magnetics.

Why is the Palmerville Fault poorly endowed?
* The Palmerville Fault most probably functioned as a backbone structure from which fluids were drained by subsidiary structures.
* Absence of structural complexity as compared to the adjacent Mitchell Fault Zone, most probably tapping into the Palmerville Fault.
* Structuring of the fault itself is considered too simple; no significant cross-cutting features are present to provide dilational zones.

Case Study II: The Amanda Bel Goldfield (ABG)

Background:
* 'orogenic' Au-Sb deposits along distinct NE-SW trend (Figs. 8 and 9)
* Deposits hosted by Silurian to Devonian meta-sedimentary rocks in eastward younging fold/thrust belt
* No recognized major fault zones (Fig. 10)
* Presence of Permo-Carboniferous granitoids and felsic to mafic dykes
* Total production '89-'94: >80,000 oz of gold (oxide zone only)

Methods:
* Field investigations - structural relationships to metallogenesis
* Worming and dataset integration - determine controls on mineralisation (Fig. 10 and 11)

Results:
* Strong structural control invoking presence of previously unrecognized fault systems
* Kinematics and orientation of the fault systems suggest an association with the 1st-order Burdekin River Fault (Fig. 10)

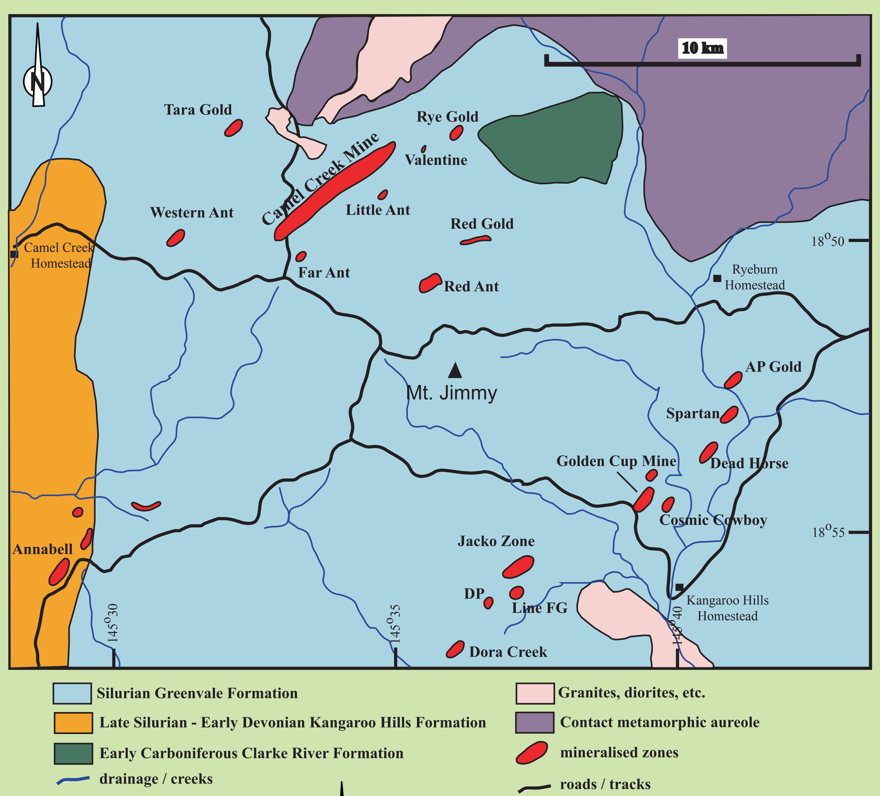


Fig. 8: Geology of the western part of the Amanda Bel Goldfield, mineralised zones outlined in red.

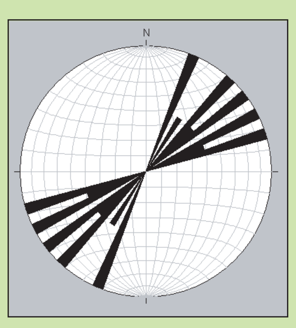


Fig. 9: Rose diagram of measured strike directions of a number (n=9) of orogenic gold lodes indicating a predominance of NE-SW strike suggested to be controlled by underlying fault systems.

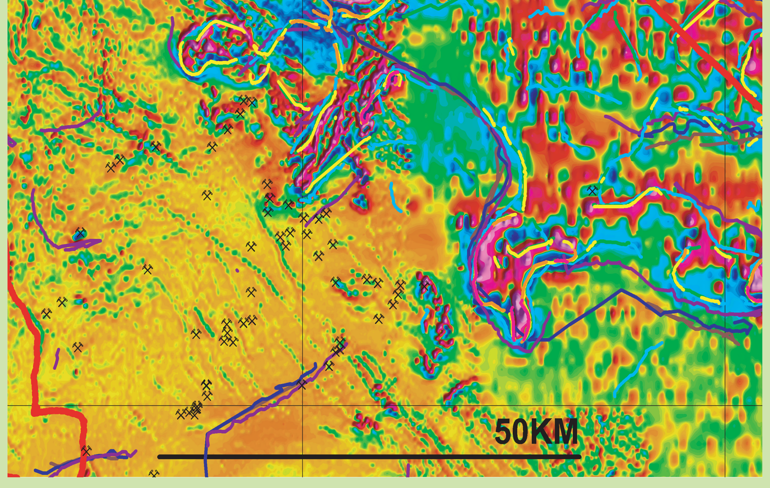


Fig. 10: Magnetic image over Amanda Bel Goldfield (roughly similar to Fig. 8) draped with gold deposits and magnetic worms. Note that there is an absence of worms tracing the dominant NE-SW direction along which the gold deposits are situated. This is considered a result of the absence of gravity contrasts in the lithologies.

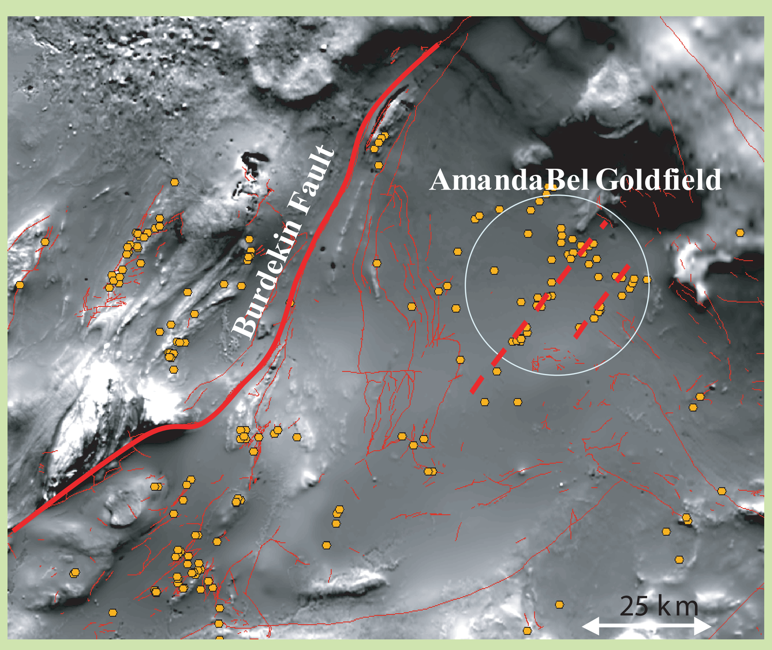
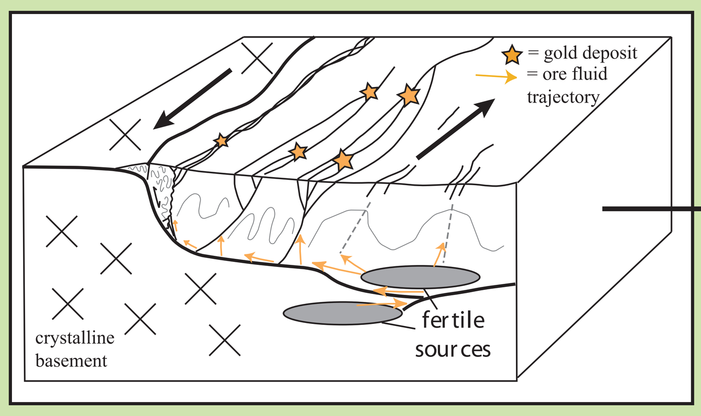


Fig. 11: Total magnetic intensity of the Broken River Province with known faults and gold deposits. Note parallellism between Burdekin Fault and controlling fault structures (dashed red lines) in the ABG.

Controls on orogenic gold mineralisation in the Amanda Bel Goldfield?
* The presence of previously unrecognized fault systems controlling gold mineralisation on a local scale has been demonstrated.
* Most probably these local faults tap into the first-order Burdekin Fault, which functioned as a backbone structure (Fig. 12).
* The relatively minor mineralisation is considered a result of the nature of the basement. More mineralisation may be present at depth providing 'fertile sources' are present.

Fig. 12: Hypothetic block model indicating the mineralisation of subsidiary fault structures tapping into a backbone structure that provides the main ore fluid conduit but itself remains barren. Such a model could be applicable to northeastern Queensland, where the Palmerville Fault would form the backbone structure.



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