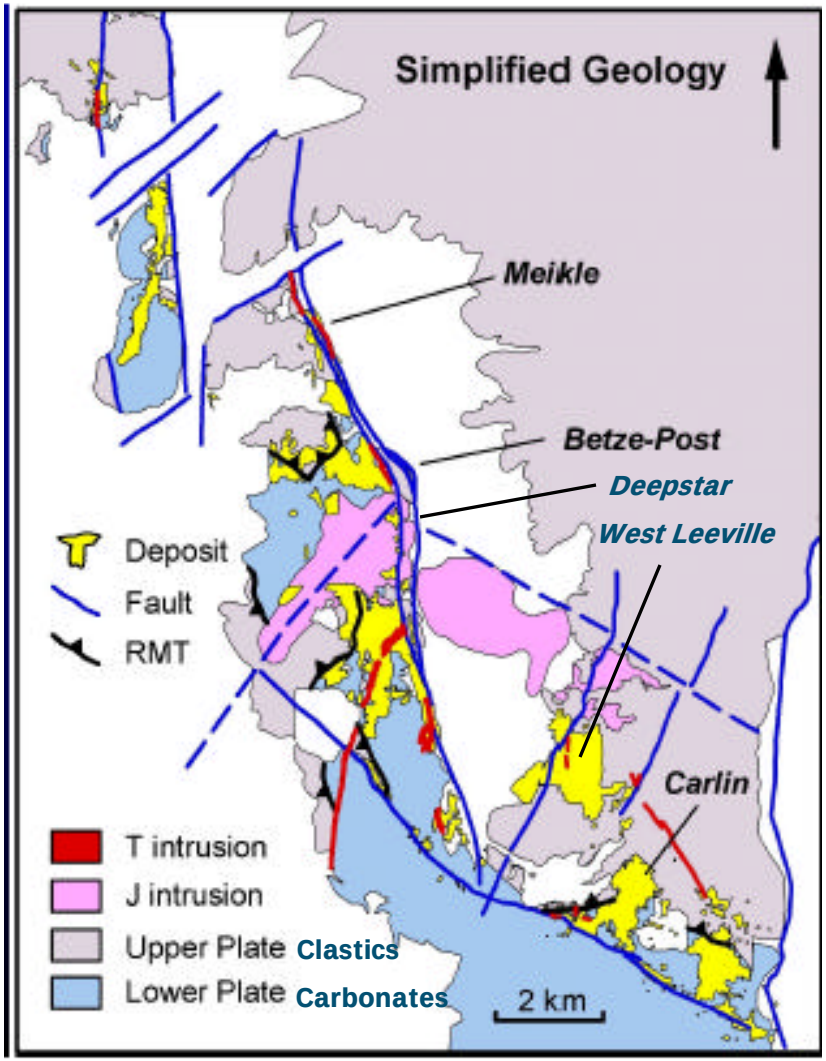
Petrological Studies by Terry Leach at the North Carlin Trend, Nevada

Keith Bettles

October 17, 2008

North Carlin Trend



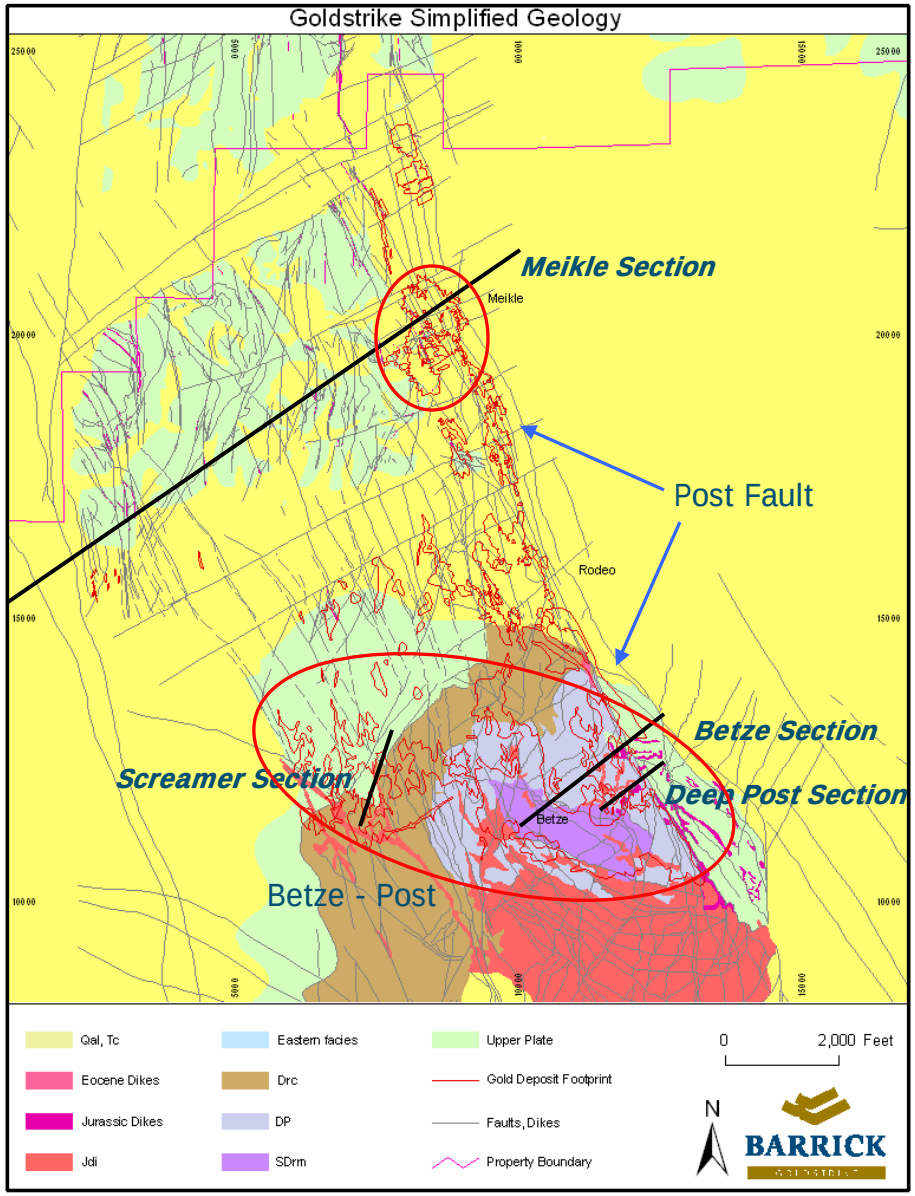
From 1999 to 2003 Terry Leach studied the Betze and Meikle ore bodies for Barrick plus Deepstar and West Leeville for Newmont.

Terry's work was the first to define the distribution of alteration in the Betze-Post area and develop a comprehensive model for North Carlin Trend deposits that linked alteration, mineralisation and the evolution of the mineralising fluid.

The gold deposits in the North Carlin Trend are:

- Mainly hosted in near shelf to slope calcareous clastic units. There is a very low metamorphic grade.
- Associated with complex faulting from multiple contractional and extensional events.
- Coeval with Eocene magmatism and are also located in the vicinity of an older Jurrassic intrusive center.
- A relatively shallow depth of formation.
- Total endowment of ~ 90 M oz.

Goldstrike



Betze - Post

Stratiform 45 M oz ore body located along the north margin of a Jurrassic diorite to granodiorite stock. Highest grades are found in the Deep Post area in the footwall of the Post fault (20 g/t) and lowest to the west in the Screamer area (5 g/t). Eocene dikes are associated with the Post fault.

Descriptions of 131 samples from fourteen drill holes from 3 cross sections were completed in 2002.

Meikle – Clydesdale

Descriptions of 187 samples from 15 drill holes at Meikle and along a cross section extending 4,000 m to the SW were completed in 2003.

Examples of alteration will be shown from the Betze, Screamer and Meikle sections

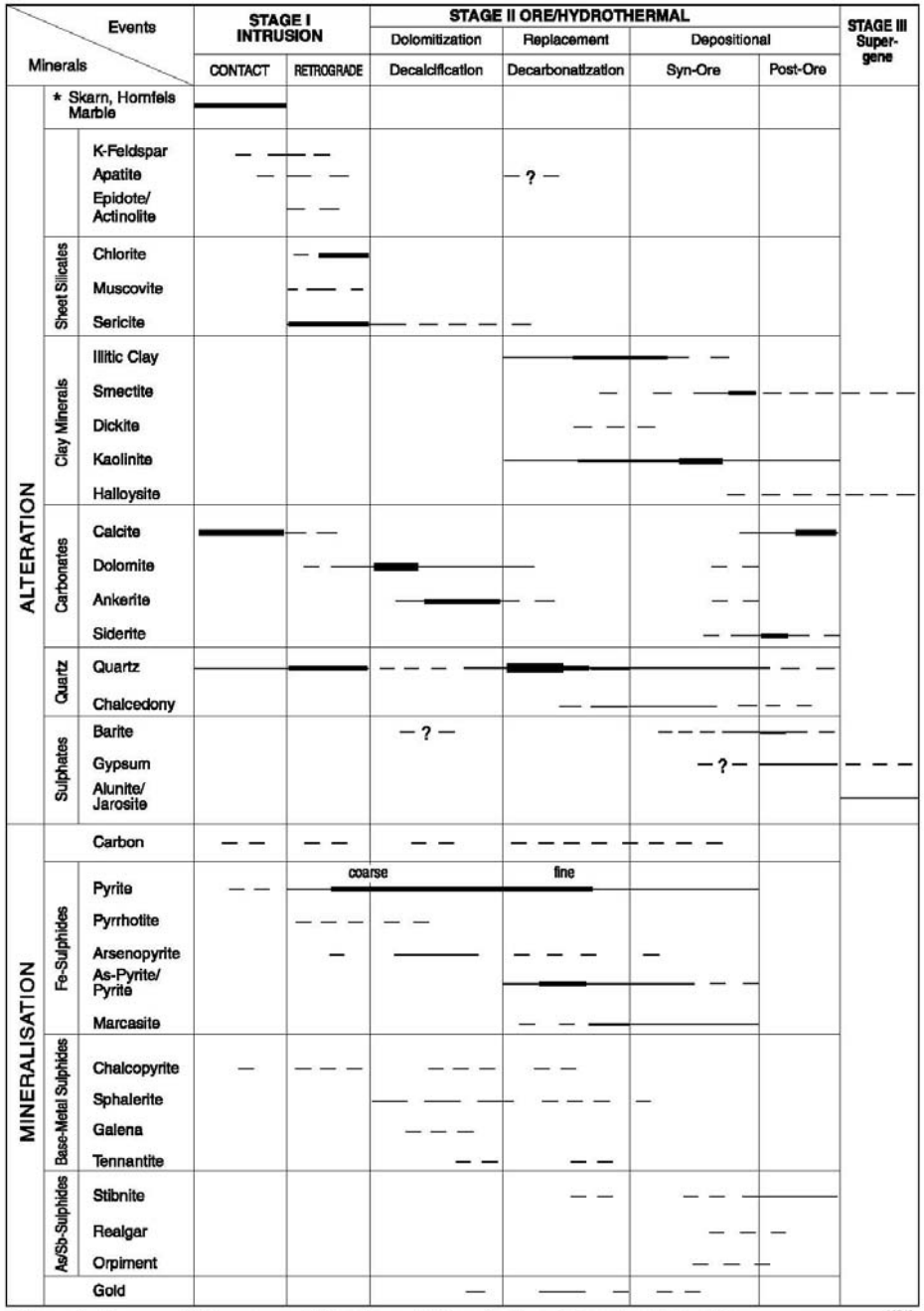


Figure 6: Paragenetic Sequence of Alteration and Mineralization at Deep Post-Betze-Screamer

* *(garnet, clinopyroxene, brittle mica, albite, biotite-phlogopite)*

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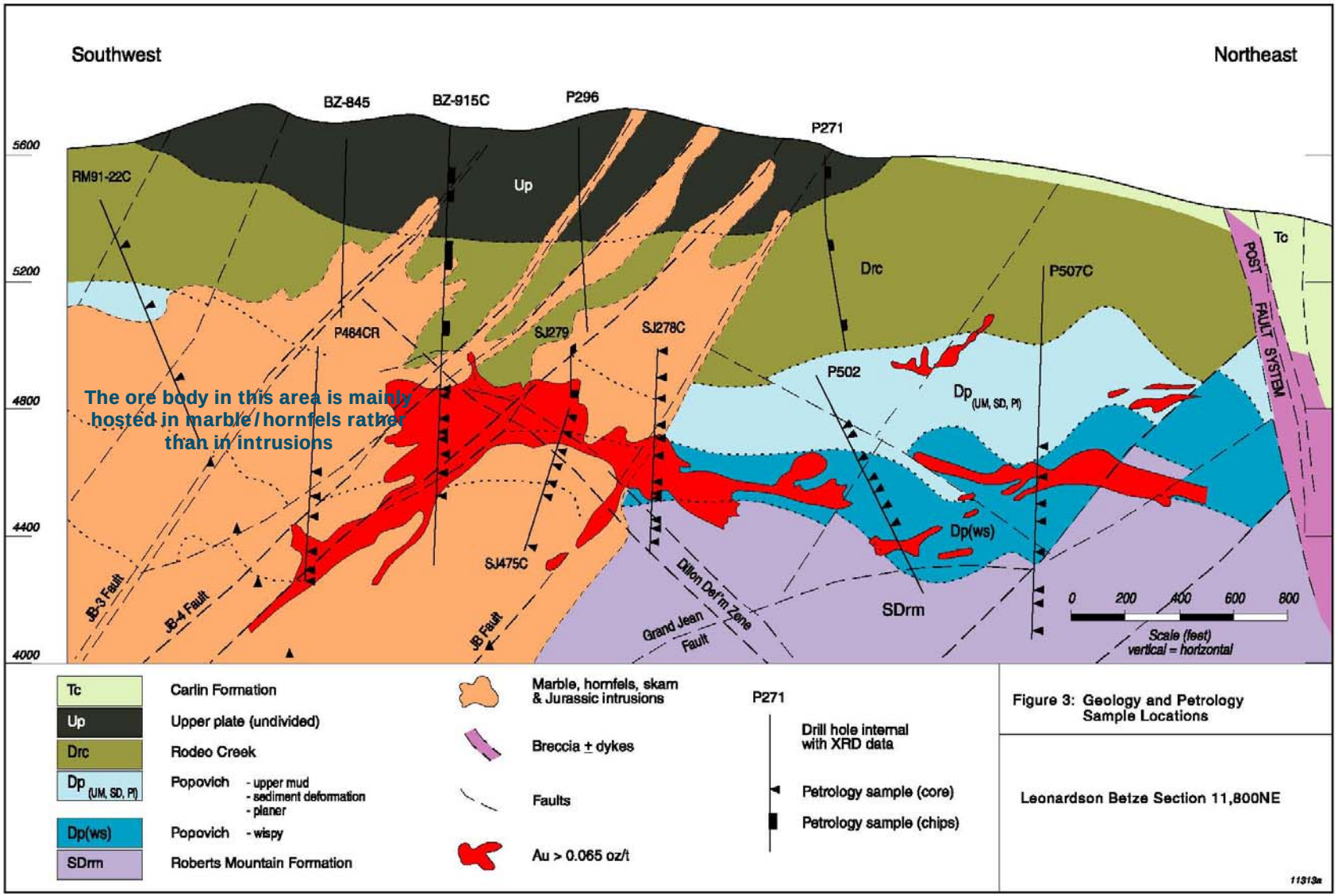
Betze - Post Paragenesis

Jurassic contact metamorphism and retrograde quartz-sericite-pyrite alteration.

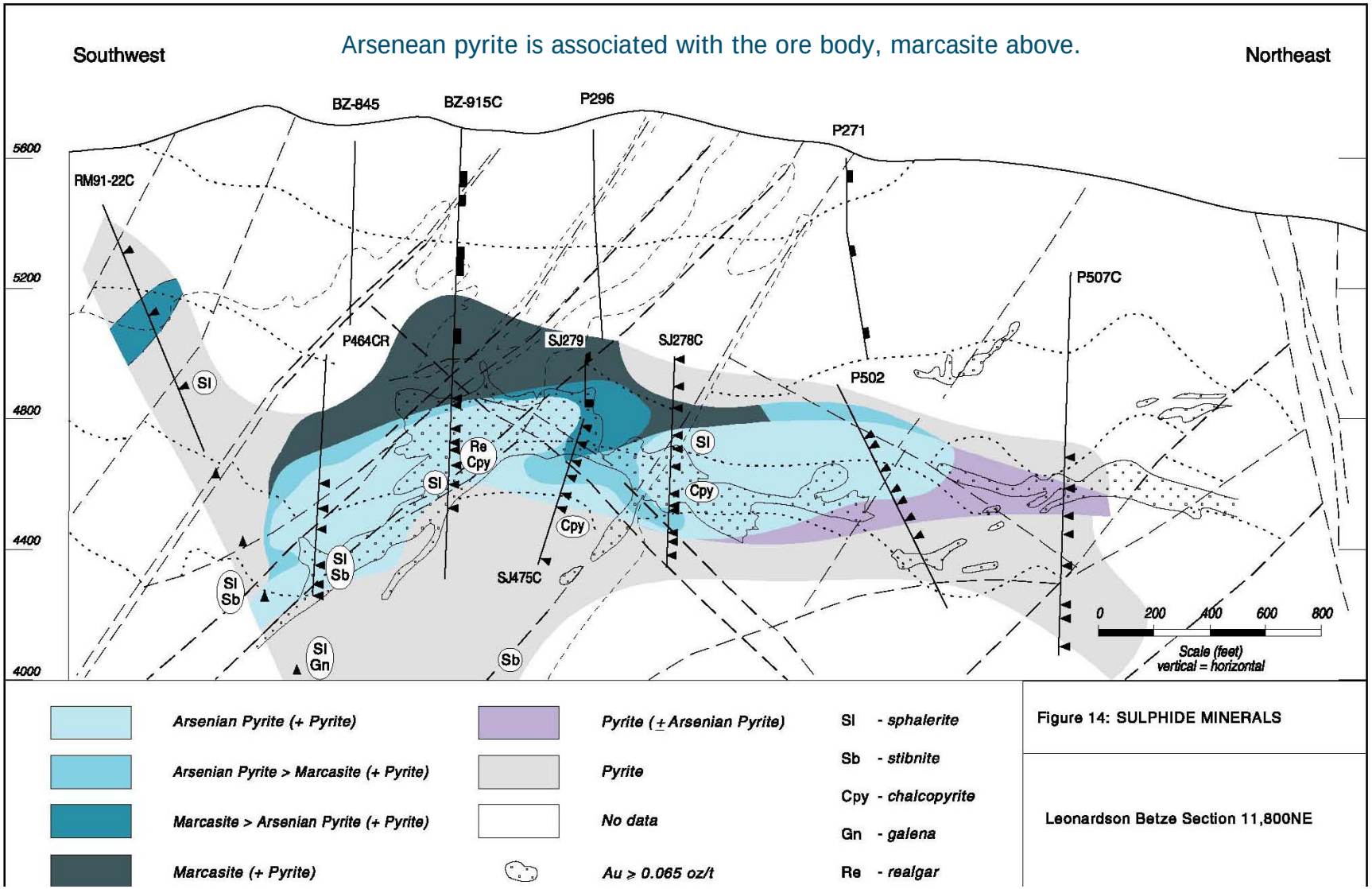
Three phases of Eocene alteration:

1. Decalcification and dolomitisation (including ferroan dolomite and ankerite)
2. Replacement by quartz and/or clays and iron sulphides. Au is deposited in arsenean pyrite by sulfidation of Fe.
3. The replacement phase is overprinted by open space deposition of quartz, clay, sulphates (barite), carbonates and sulphides (pyrite, realgar, stibnite) and some Au.

Betze Section 11,800 NE

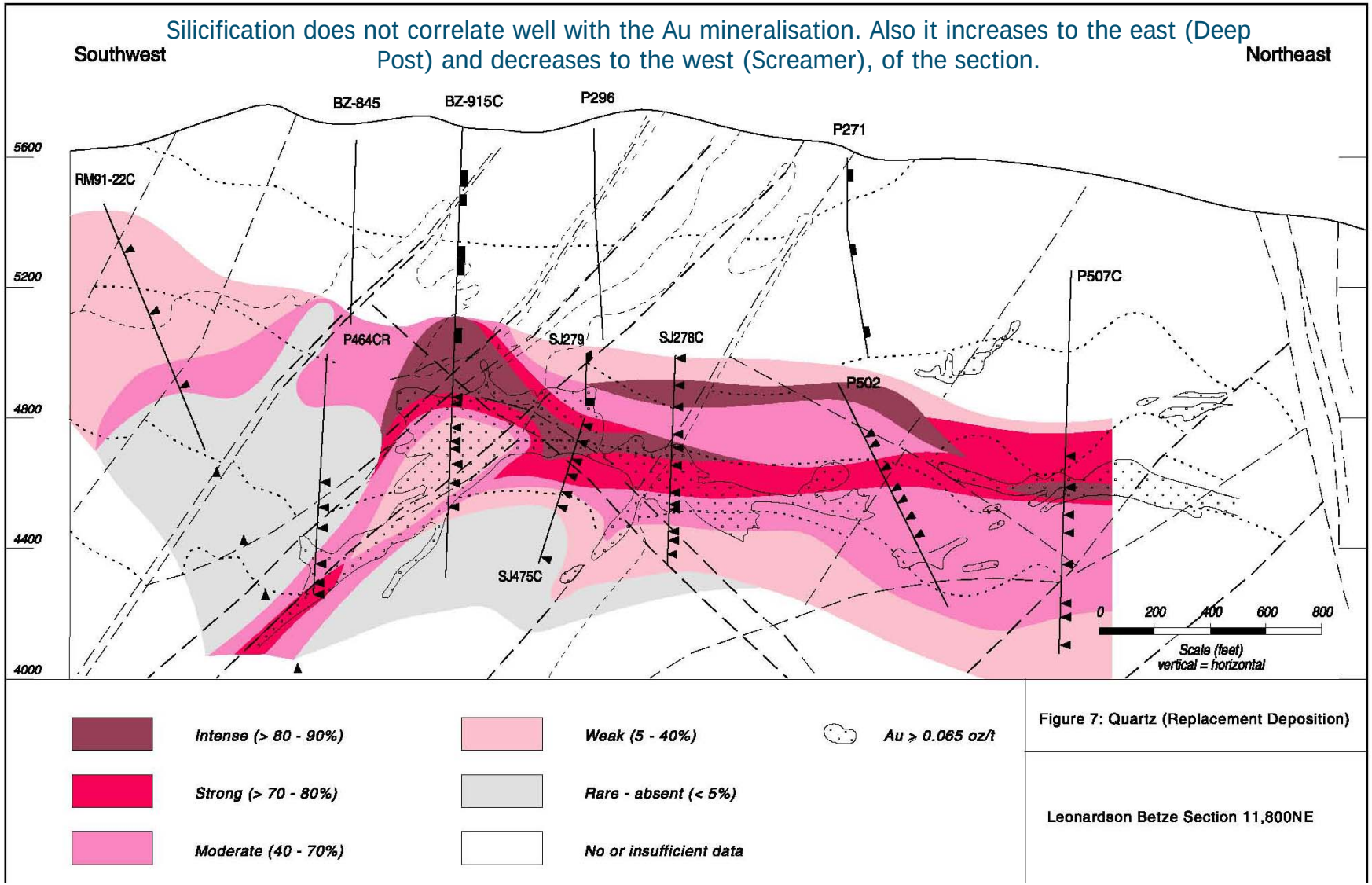


Betze Sulphides Section 11,800 NE

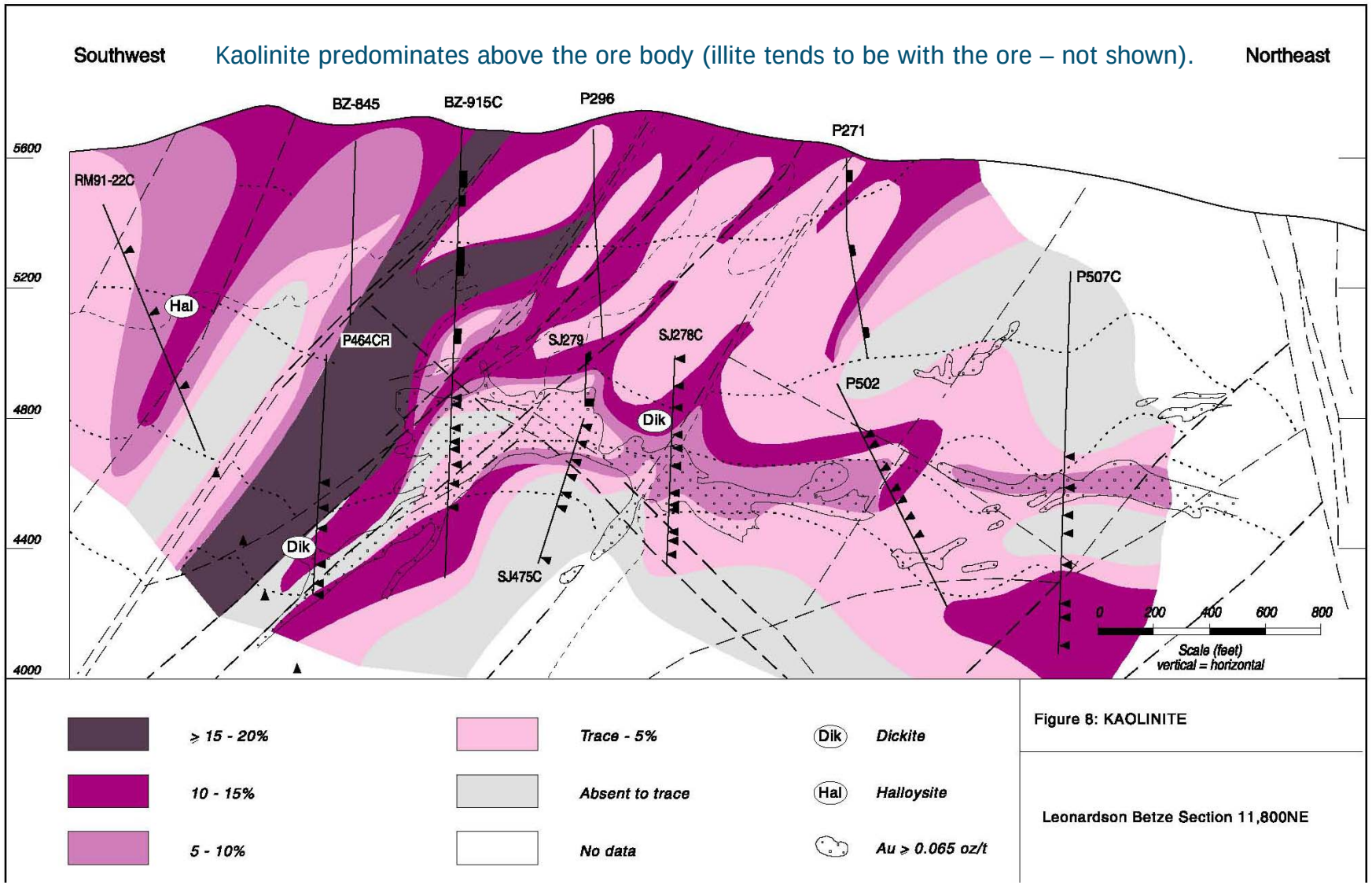


Betze Quartz Replacement Section 11,800 NE

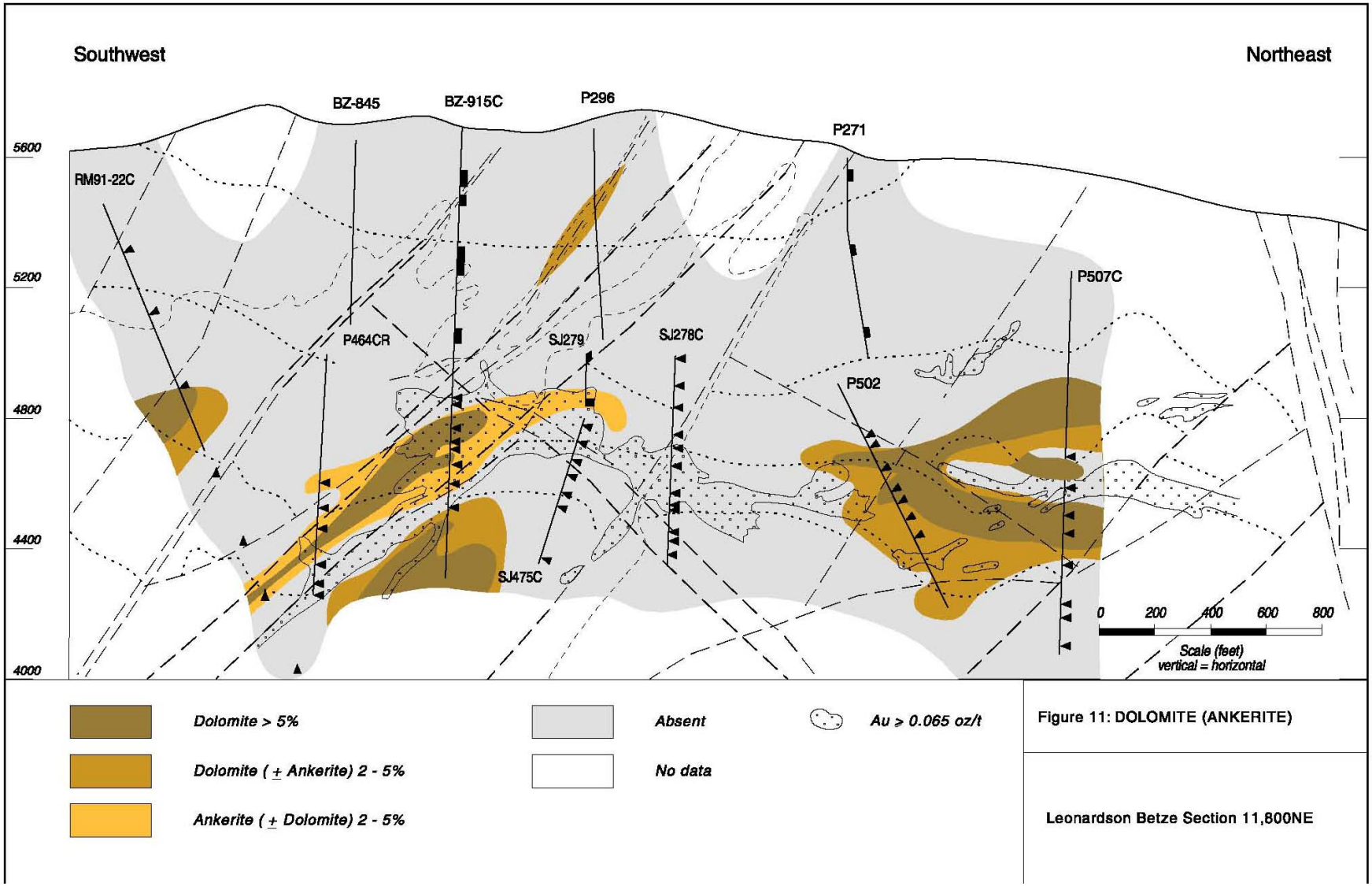
Silicification does not correlate well with the Au mineralisation. Also it increases to the east (Deep Post) and decreases to the west (Screamer), of the section.



Betze Kaolinite Section 11,800 NE

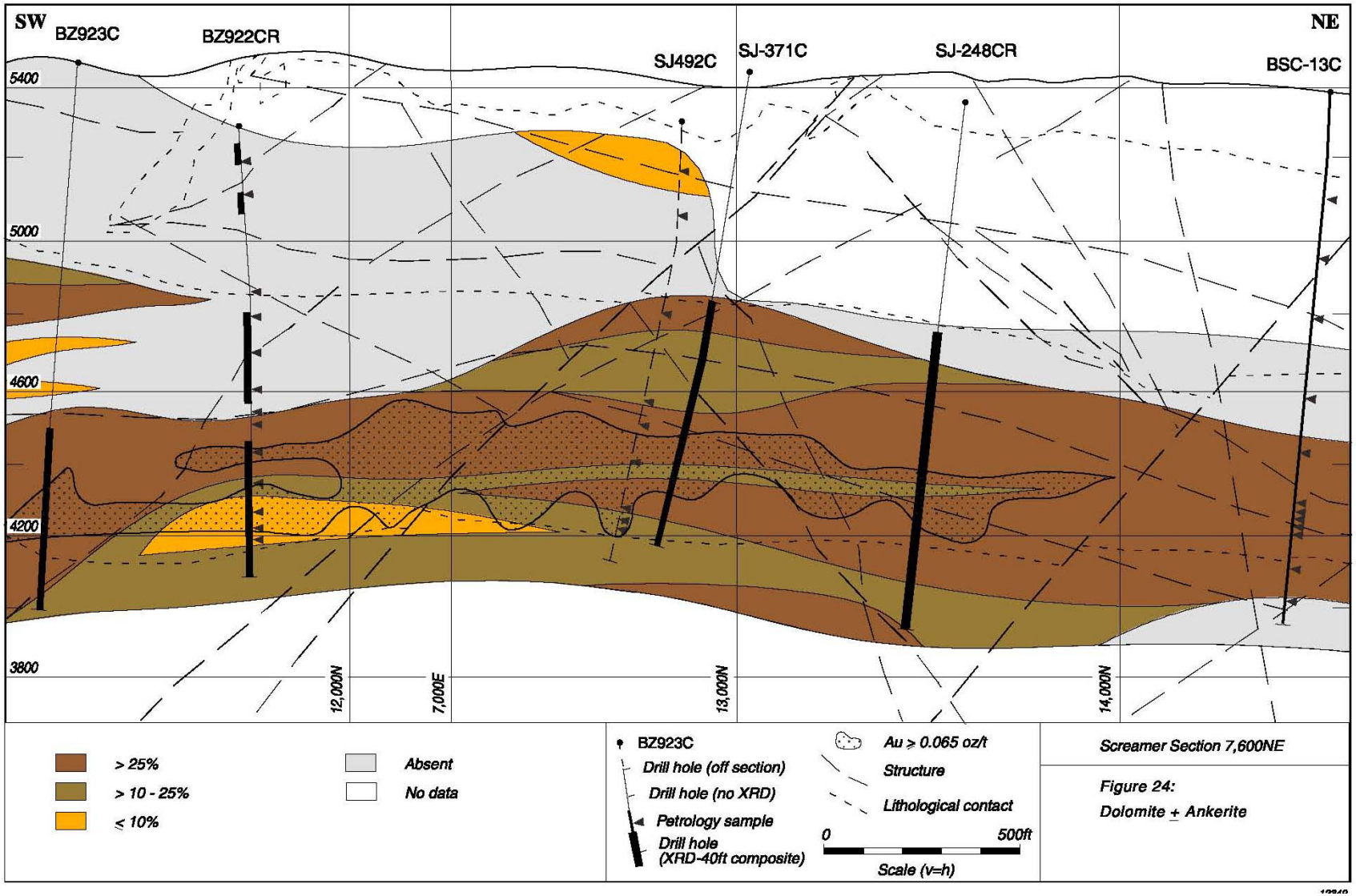


Betze Dolomite - Ankerite Section 11,800 NE

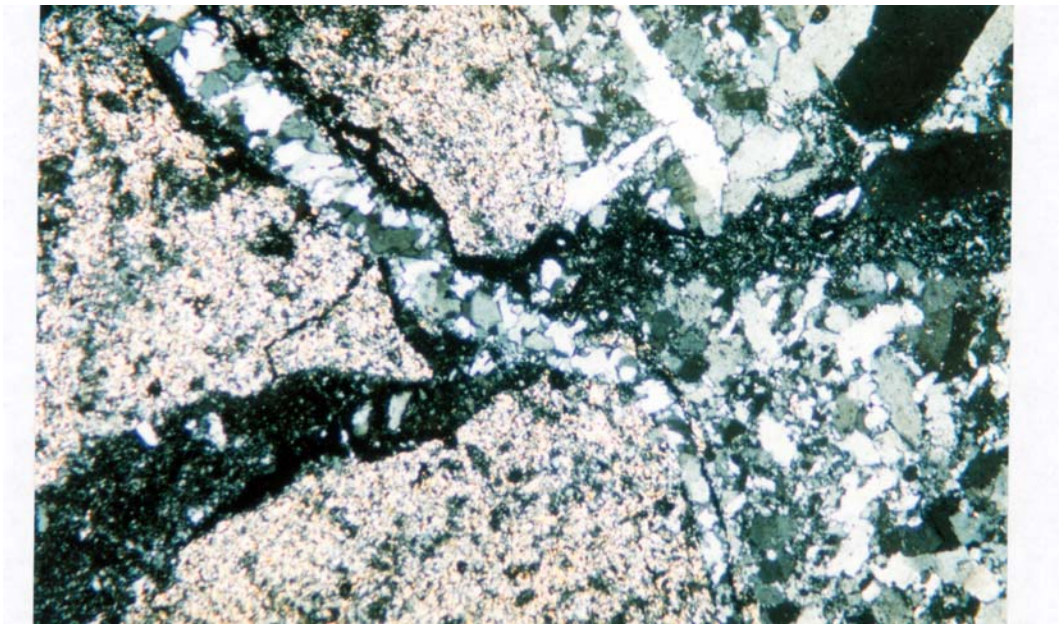


Betze (Screamer) Dolomite – Ankerite Section 7,600 NE

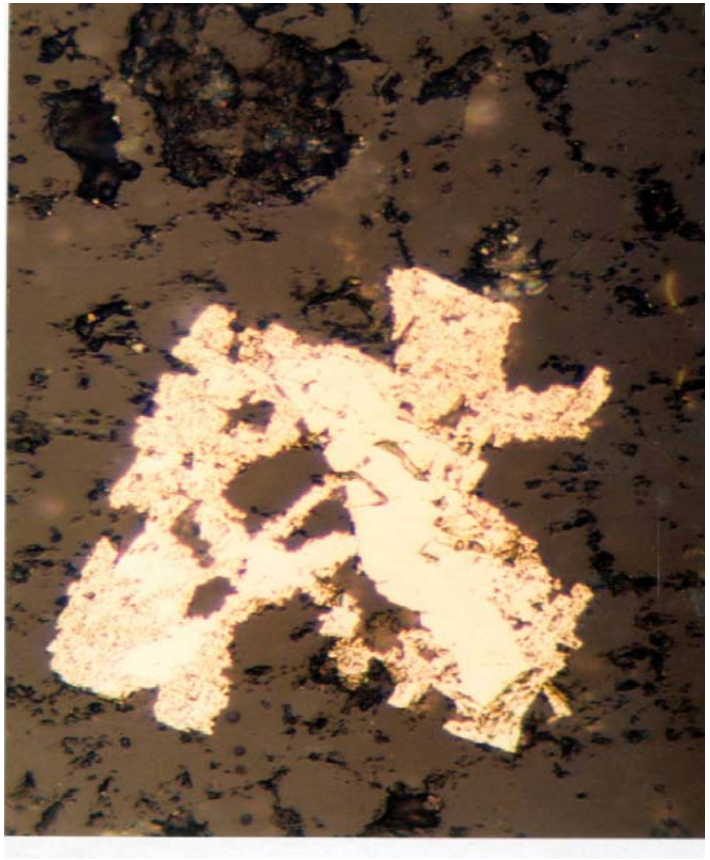
Extensive dolomitisation at Screamer, very weak silicification and clay alteration.



Betze Photomicrographs



Polyphasal Stage II veining of silty micrite altered to an early stage of quartz-sericite. Cut by a vein of clear quartz (right), then veinlets of fine sulphides + quartz + illitic clay, then by late stage quartz veinlet. Field of view 2.6 mm.



Coarse grained pyrite in silicified sediment with pitted, etched and partially dissolved rims, that are overgrown by very fine grained poorly crystalline arsenean pyrite. Field of view 0.3 mm

Betze – Post Conclusions

- Very poor correlation of gold and ore zones with alteration zones.
- Postulated controlling factor for gold mineralisation is sulfidation of iron that is released during dissolution of iron bearing carbonate and/or silicification.
- Alteration is consistent with an influx of a fluid at near neutral pH and a temperature > 250 C, that cooled as it moved to shallower, more distal or later stages.
- Cooling, quartz deposition and sulfidation during the replacement phase would decrease the pH to about 4, which would favour the formation of kaolinite over illite.
- In distal or late settings the deposition of smectite and siderite indicate that the fluid was neutralised by the host carbonates. Late calcite, barite, gypsum and stibnite were deposited under these cool, neutral conditions.
- Depositional assemblages indicate considerable telescoping and the mode of deposition indicates a progressive decrease in pressure (breccias to veins to fracture fill).

Meikle – Clydesdale NE-SW Section

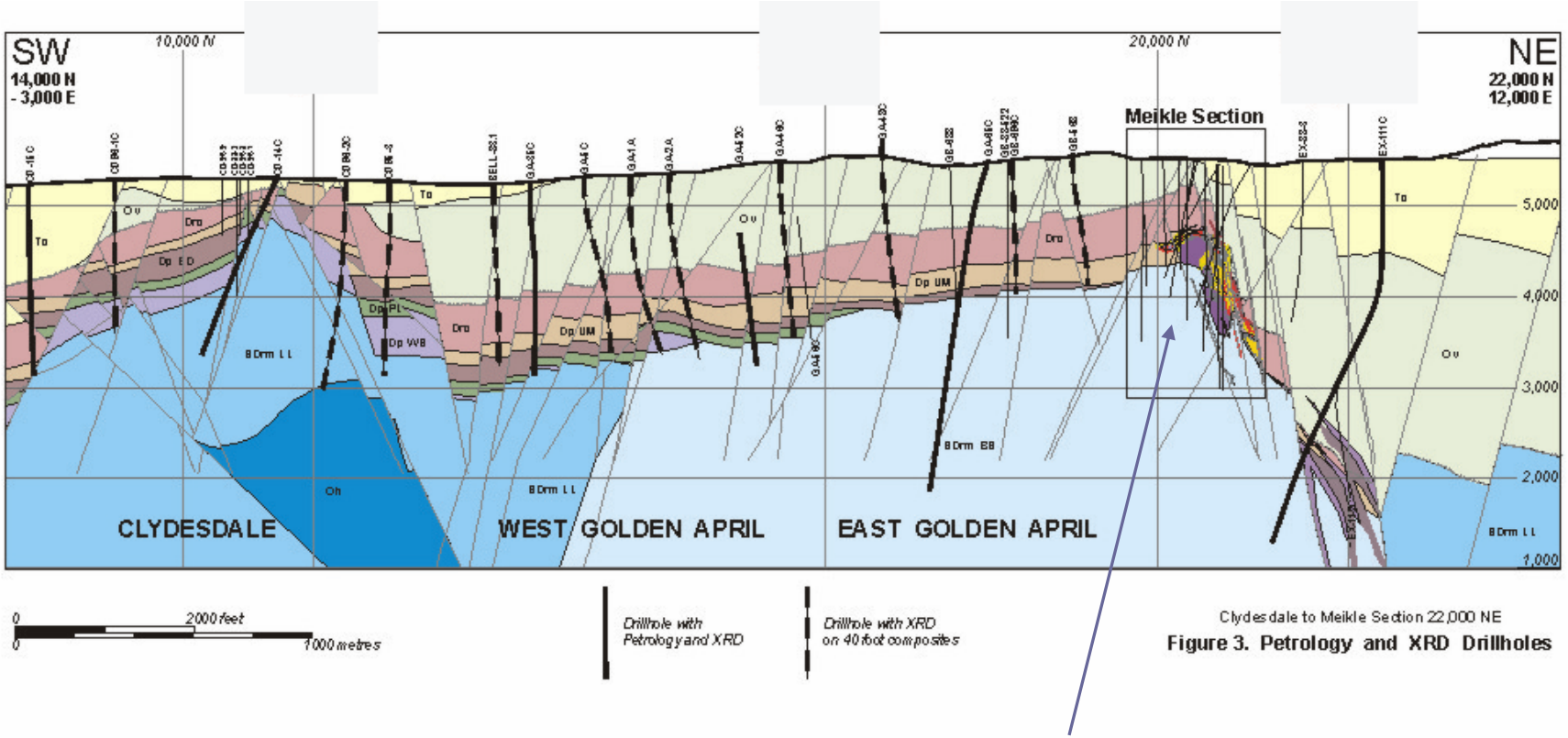


Figure 3. Petrology and XRD Drillholes

Ta Carlin Formation
Ov Vinini Formation
Dro Rodeo Creek Formation
Lamprophyre Dykes
Breccias

Popovich Formation
Dp UM Upper mud
Dp SD Soft sediment deformation
Dp PL Planar laminar
Dp WB Wispy

BDrm LL Roberts Mountain
BDrm BB Roberts Mountain Bootstrap
Oh Hanson Creek Formation

Samples at Meikle and from unmineralized areas up to 4,000 m to the west were studied. Carlin type alteration was seen in these distal samples.

Meikle is a 7 M oz ore body at a grade of 24.7 g/t hosted in dissolution/collapse breccias footwall to the Post fault.

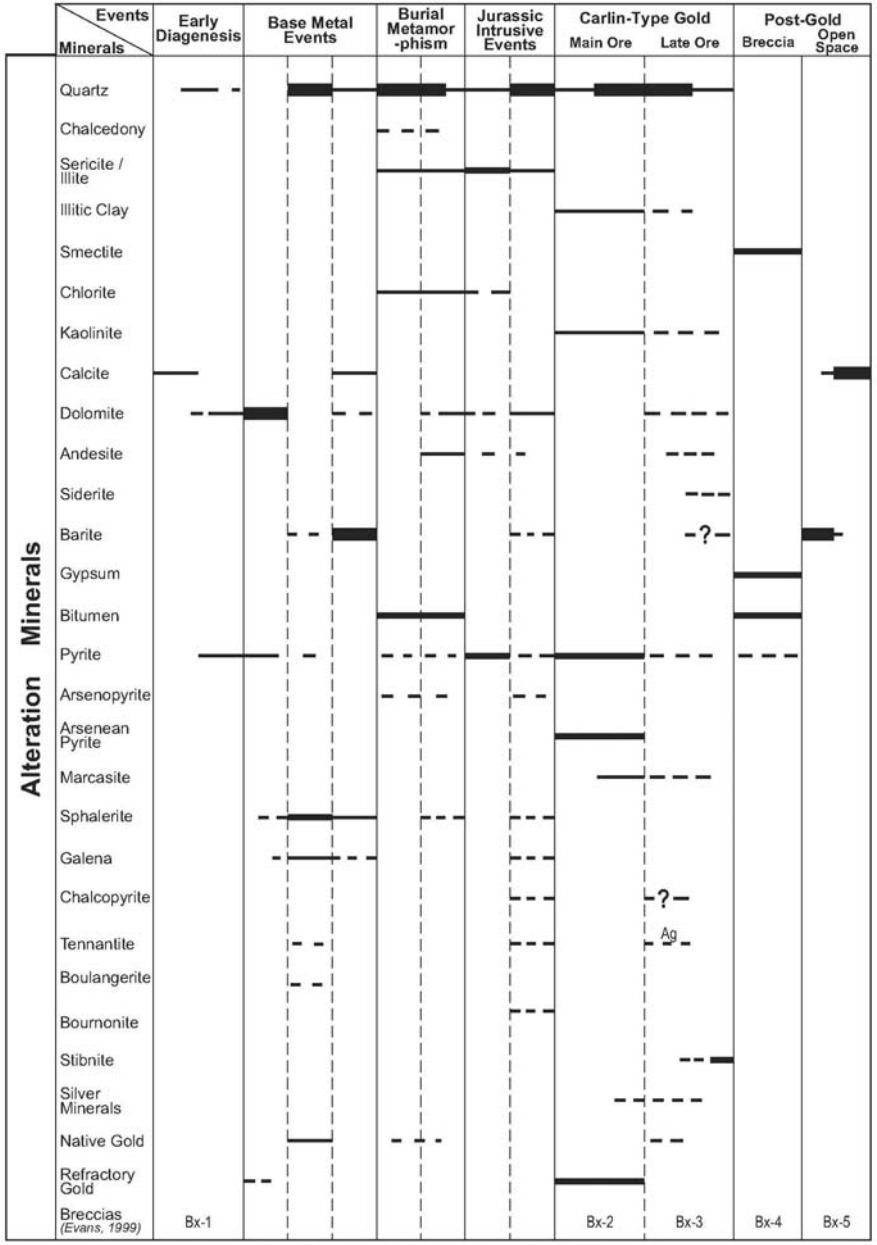


Figure 6 : Paragenetic Sequence of Events at Meikle.
(Evans, 1999; Emsbo, 2000, current work)

Meikle Paragenesis

At Meikle there is Devonian hydrothermal activity. Replacement of limestone by ferroan dolomite, quartz, barite, pyrite, sphalerite, galena, boulangeite and galena (local Au).

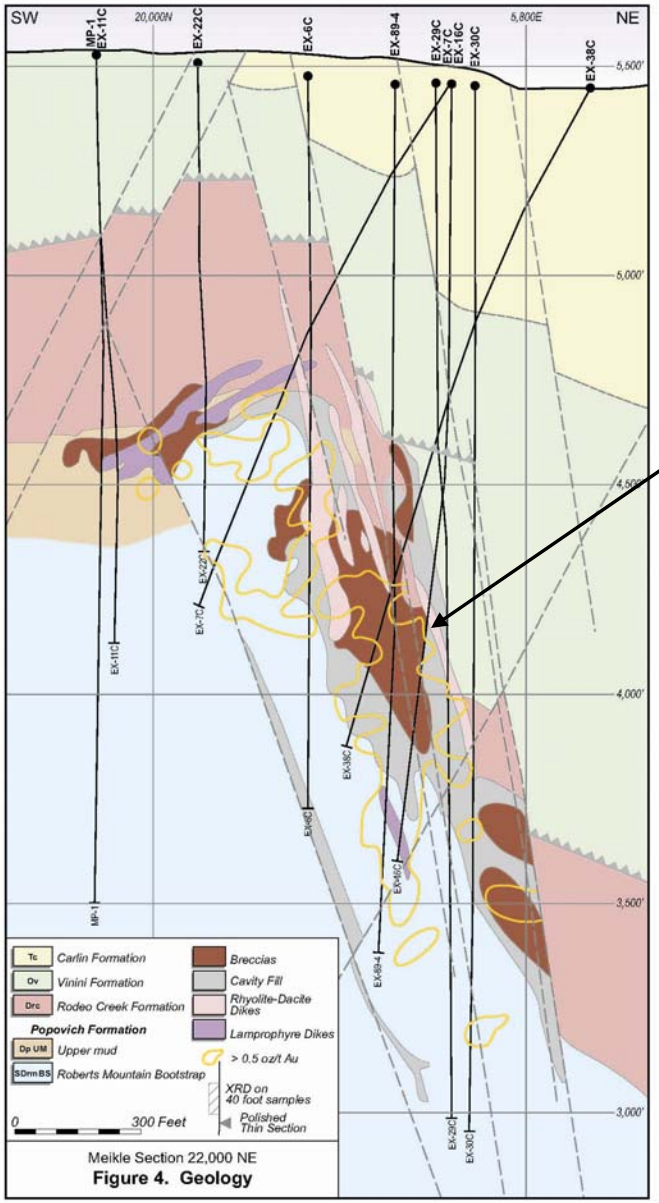
Eocene alteration is similar to Betze-Post though with dominant silicification. Kaolinite/illite alteration is restricted to intrusions.

Dissolution of carbonate produced collapse breccias followed by silicification, sulfidation and gold mineralisation. Then late stage open space filling by quartz, ankerite, siderite, dolomite, pyrite and stibnite.

The ferroan dolomite and the brecciation are key factors for development of high grade ore.

Late silver mineralisation locally occurs with tennantite/tetrahedrite and andorite.

Meikle Section 22,000 NE



Gold outline is .50 oz/t

Drill hole EX-7C

Note association of Au with silicified breccias.

Gold

Quartz

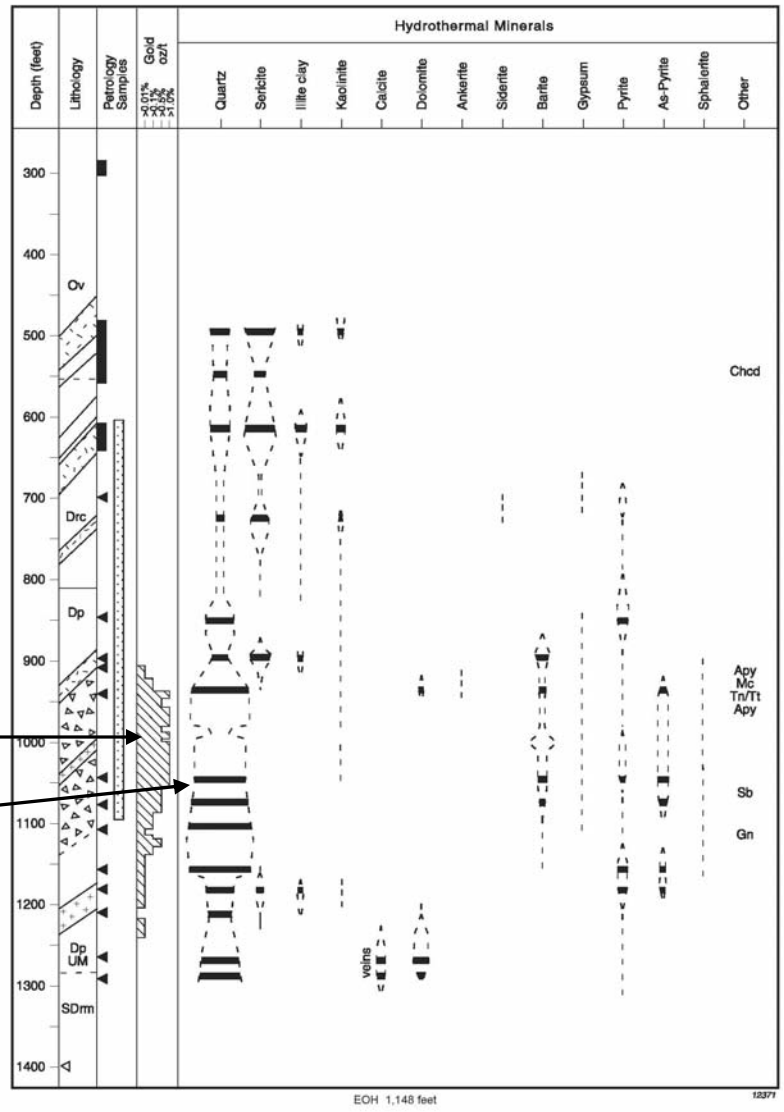
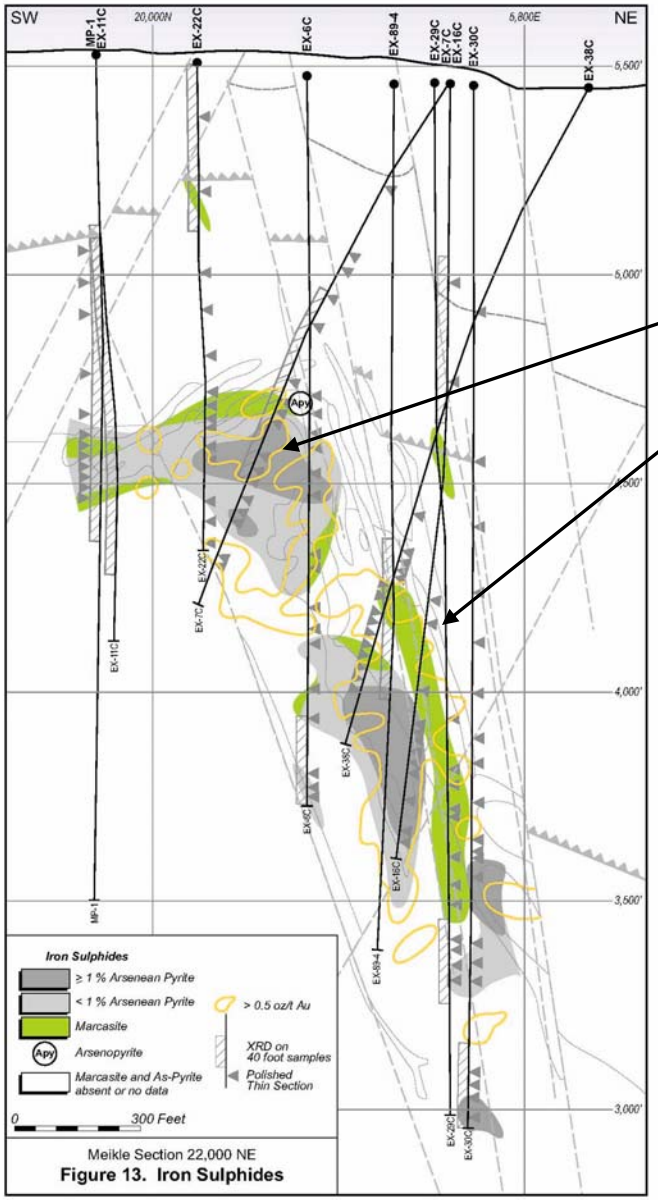


Figure 21 : EX-7C Alteration, Mineralisation and Lithology Log.

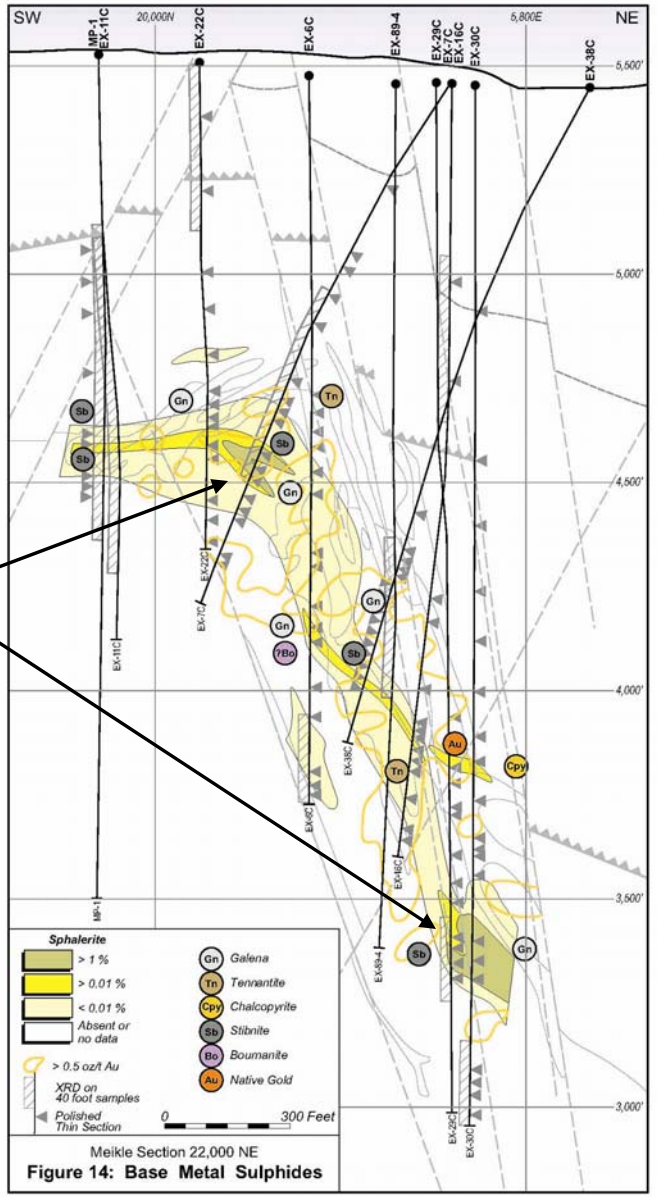
Meikle Sulphides Section 22,000 NE



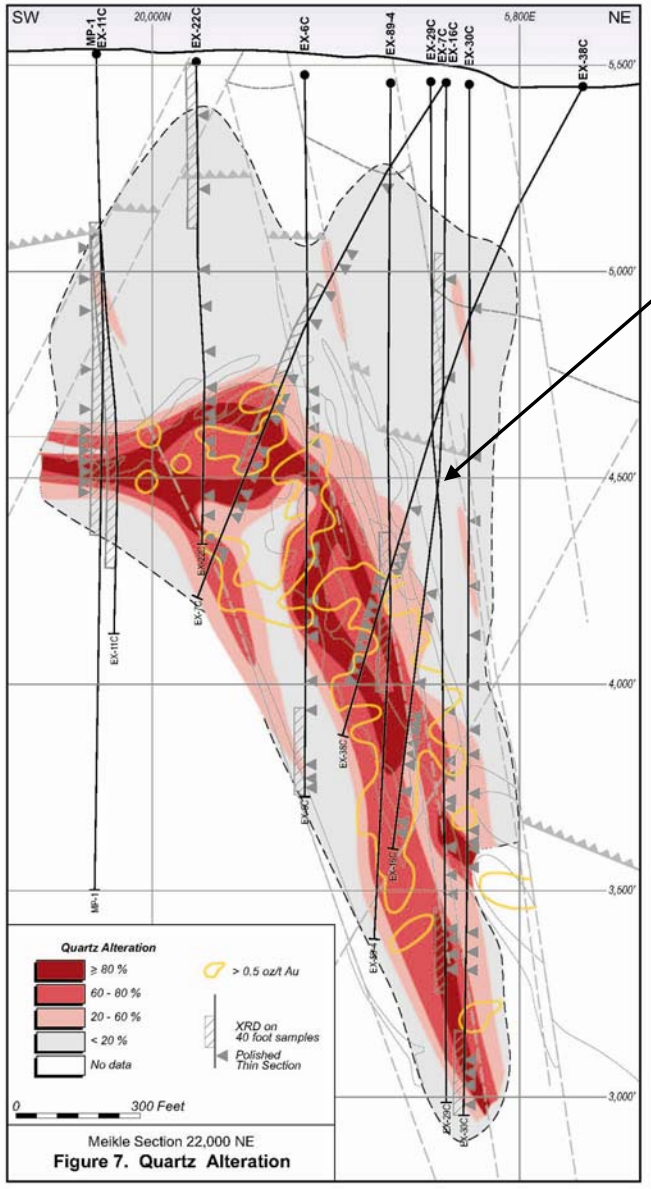
Arsenean Pyrite

Marcasite

Sphalerite rich zones



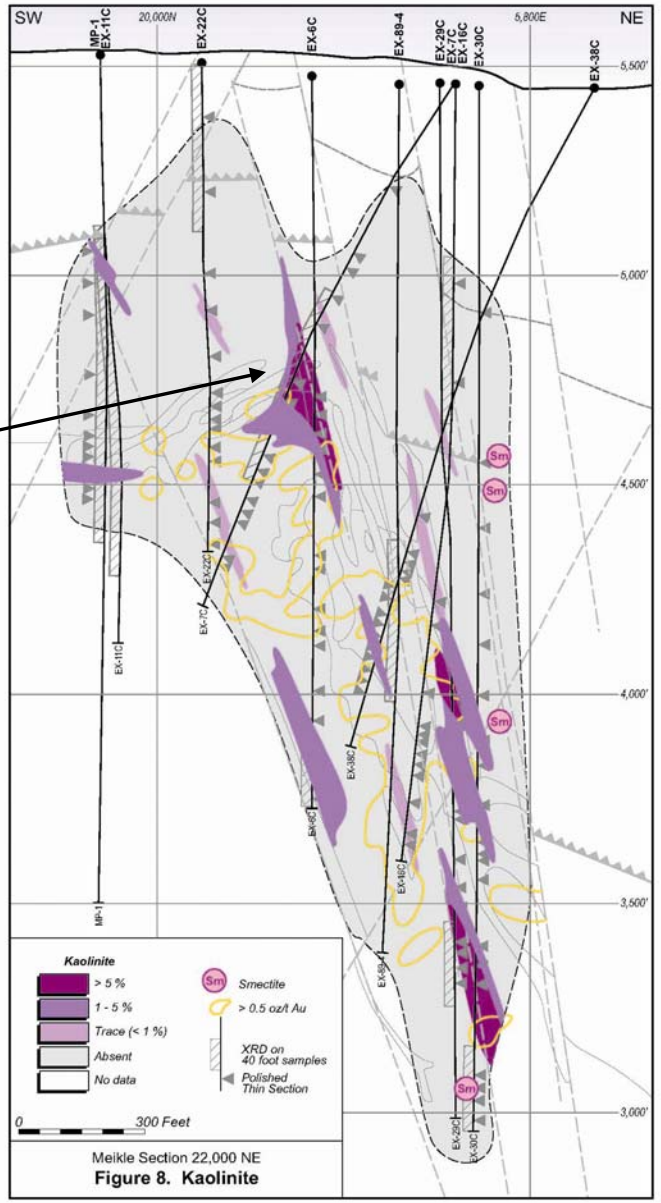
Meikle Quartz – Kaolinite Section 22,000 NE



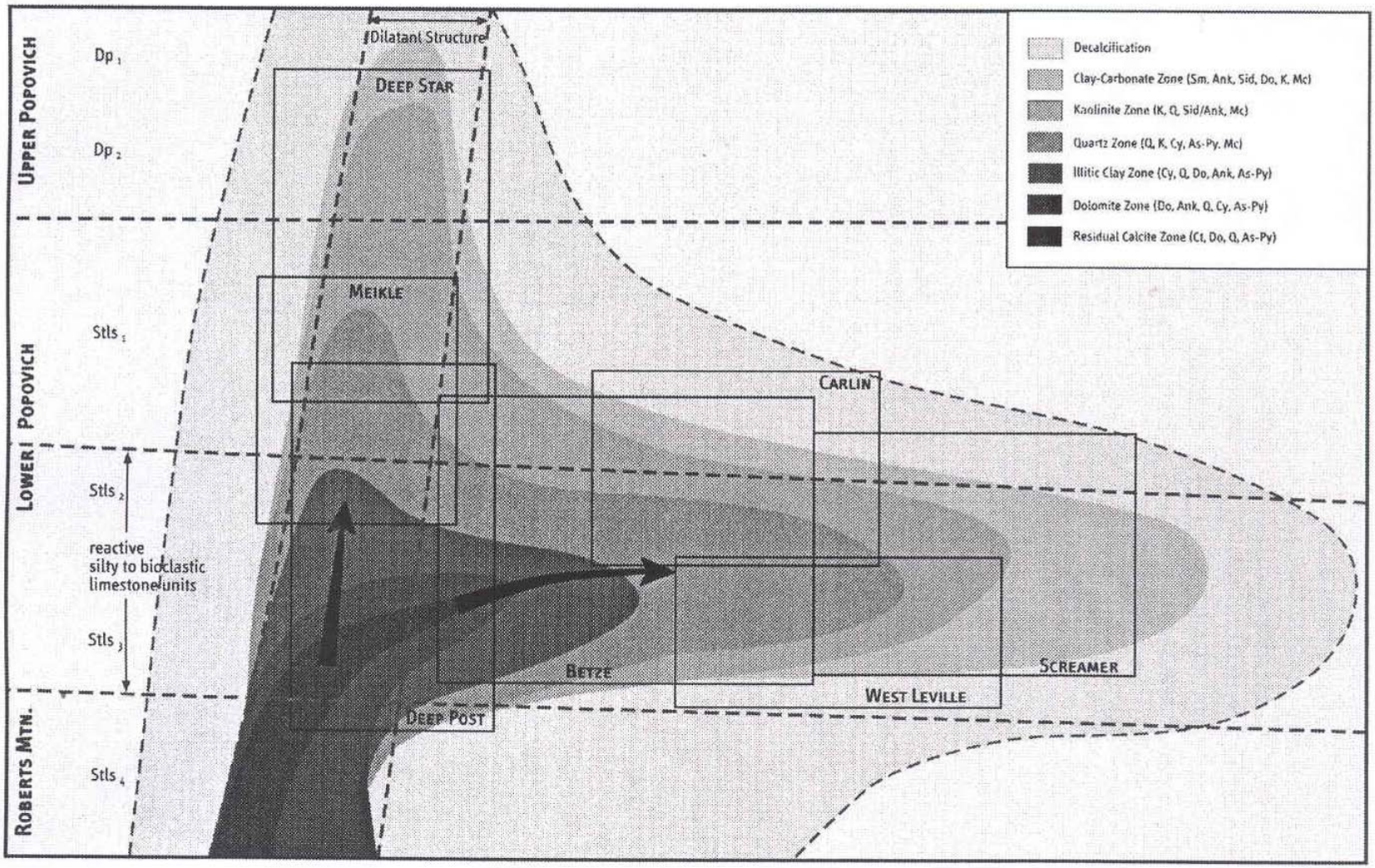
Quartz

Kaolinite

There has been very little leakage of fluids above the ore body. The strongest alteration above the ore body is kaolinite and siderite associated with Jurrasic dikes.

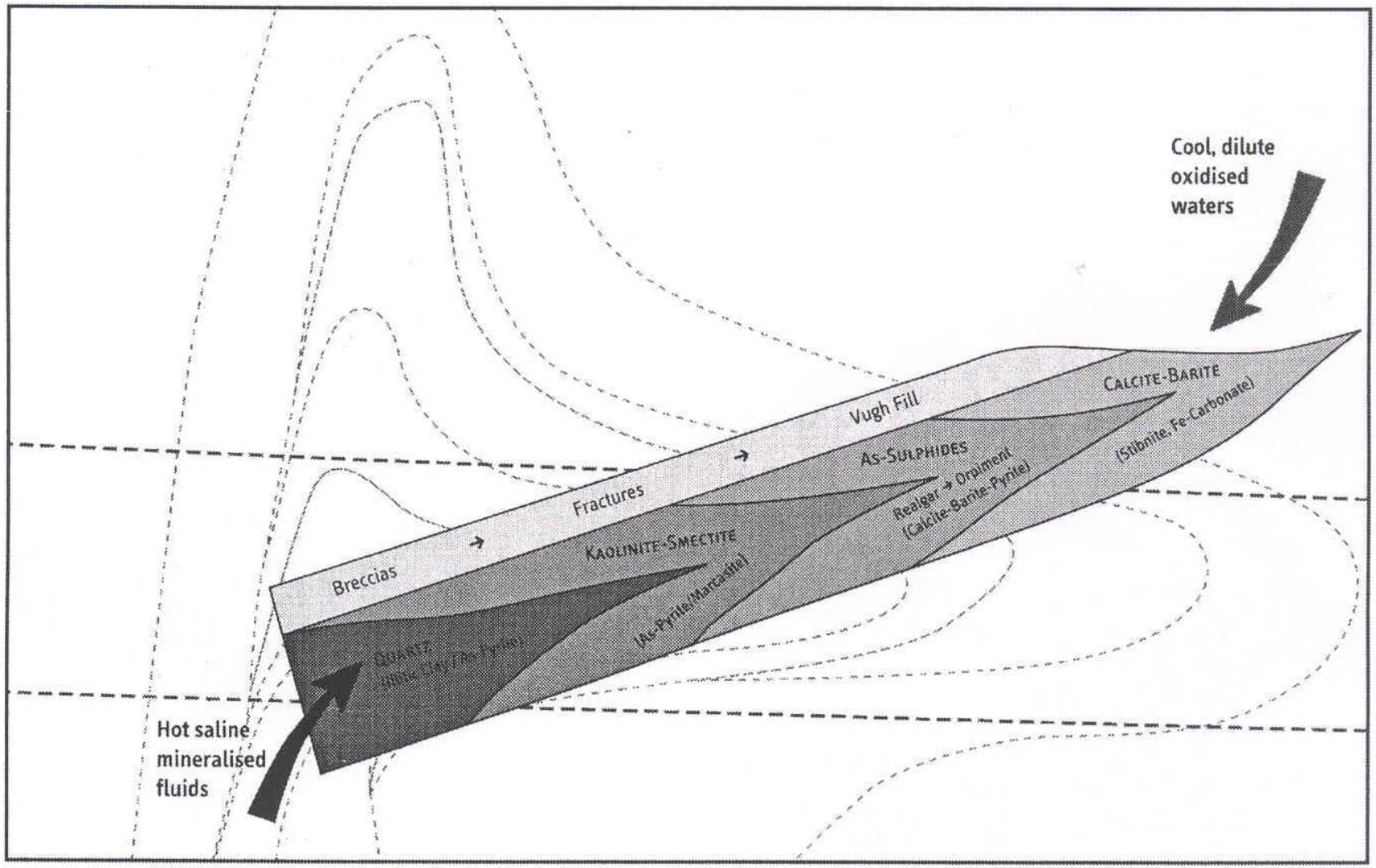


Distribution of Replacement Alteration in Northern Carlin Trend Deposits



From: T M Leach Pacrim '04 Congress

Distribution of Deposition Alteration in Northern Carlin Trend Deposits



From: T M Leach Pacrim '04 Congress

Northern Carlin Trend Deposits
Terry Leach Pacrim'04 Congress

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- "Gold mineralisation is formed in response to sulfidation of available iron, predominately during the argillisation and silicification of replacement events and extends into the early quartz - clay deposition events. However ore zones are not restricted to any of the alteration zonations and may form from proximal carbonate - quartz zones outwards to distal clay – Fe/Mg carbonate zones".
- "Replacement assemblages ... formed in response to the progressive decrease in pH of a moderately cool (200-250 C) fluid...also in response to cooling and sulfidation processes proximal to upflow zones and subsequent neutralisation by wall rock reaction in more distal outflow environments"
- "Depositional zones were caused by cooling of a late stage fluid and possible late stage mixing with surficial waters in distal settings".
- Release of reactive iron is the controlling factor. "in turn controlled by amount of iron originally present in the host rocks and availability of channel ways for the mineralising fluid to access this iron"