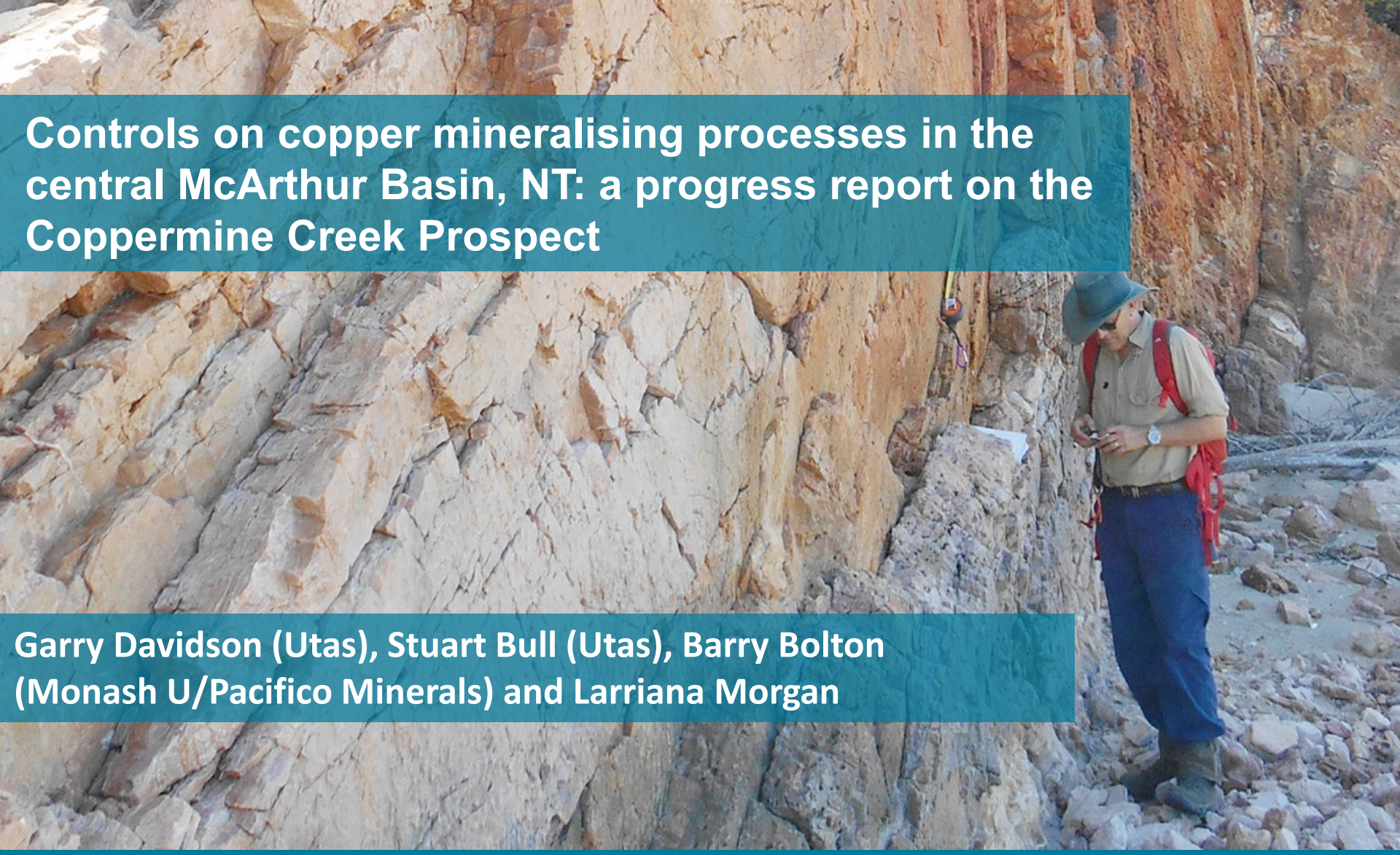
Controls on copper mineralising processes in the central McArthur Basin, NT: a progress report on the Coppermine Creek Prospect



Garry Davidson (Utas), Stuart Bull (Utas), Barry Bolton (Monash U/Pacifico Minerals) and Larriana Morgan

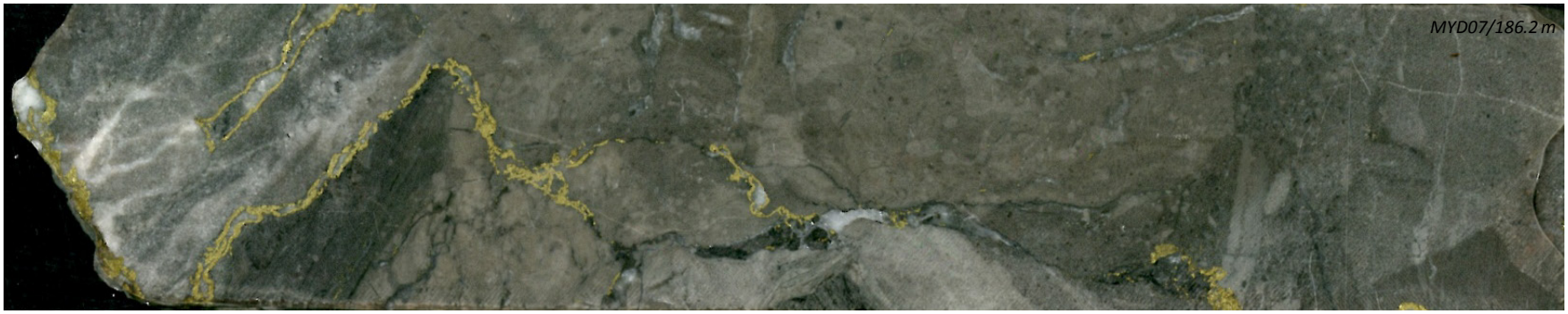
AUSTRALIA'S NORTHERN TERRITORY

NORTHERN TERRITORY GEOLOGICAL SURVEY
AGES2017
ANNUAL GEOSCIENCE EXPLORATION SEMINAR
Alice Springs, 28–29 March 2017, Northern Territory

UNIVERSITY of TASMANIA

CODES
ARC CENTRE OF EXCELLENCE IN ORE DEPOSITS

Controls on copper mineralising processes in the central McArthur Basin, NT: a progress report on the Coppermine Creek Prospect



Presentation to AGES March 29 2017

Garry Davidson (Utas), Stuart Bull (Utas), Barry Bolton (Monash U/Pacifico Minerals) & Larriana Morgan (unaffiliated)

Sponsor: Northern Territory Geological Survey
NTGS Collaborators: Dorothy Close, Andrew Wygralak

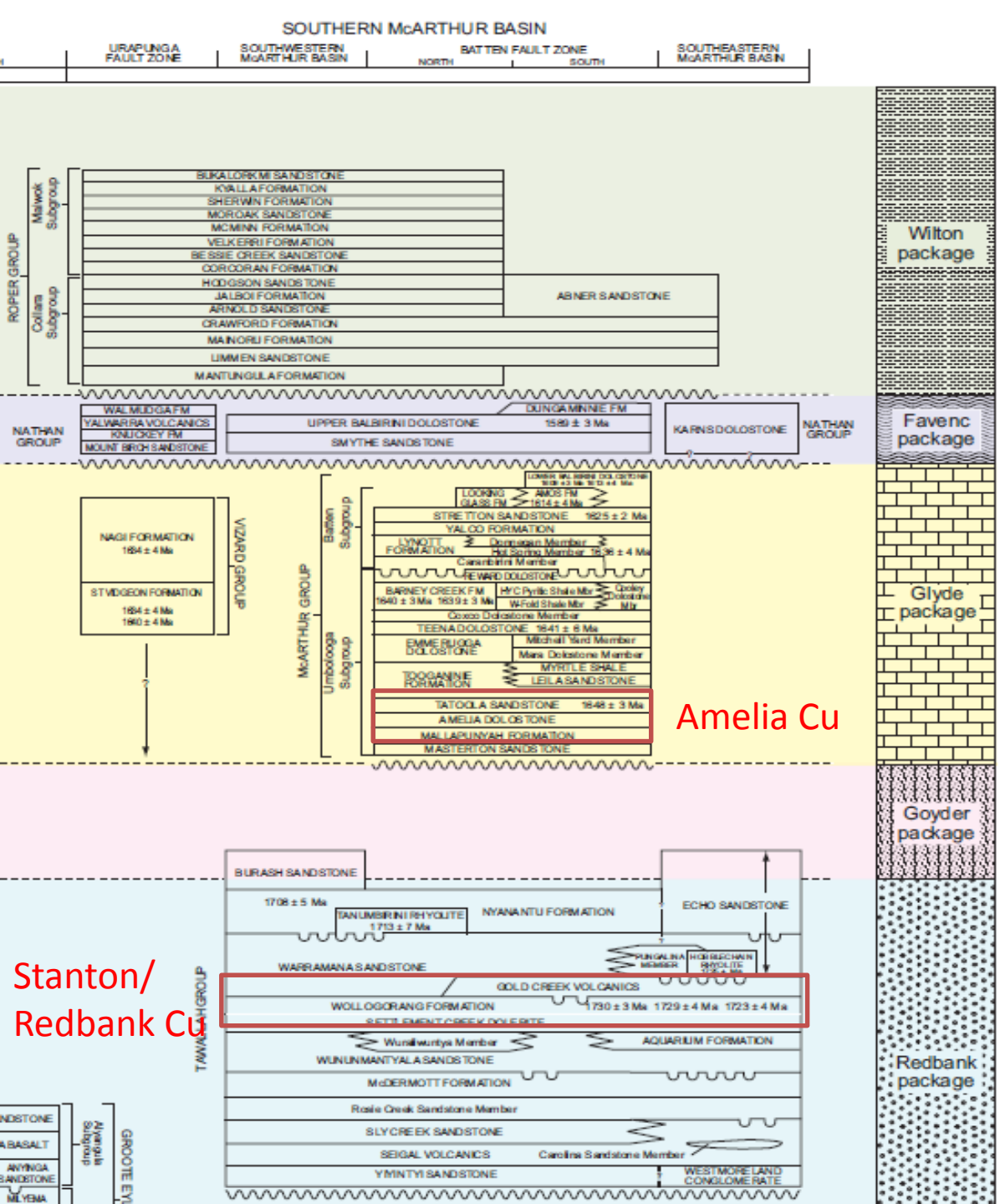
Northern Territory Government

History & aims

- Project was instigated by NTGS as a Utas PhD, to evaluate the characteristics and origin of copper mineralisation away from the well known MacArthur Basin ore deposits.
- The candidate withdrew after 8 months, and the project was reconstituted as a CODES research project using the existing samples
- The revised aim is to evaluate the prospects in and around the Amelia Dolomite, which include the Coppermine Creek project, currently a JV between Sandfire Resources and Pacifico Minerals.
- Coppermine Creek has a large number of drillholes, but the mineralised sections are generally missing. However, NTGS hold MYD7, drilled by BHP in 1996, a complete section through part of the mineralisation, and this has been the early focus of the project. Pacifico have supplied some samples from recent drilling.

McArthur Cu background

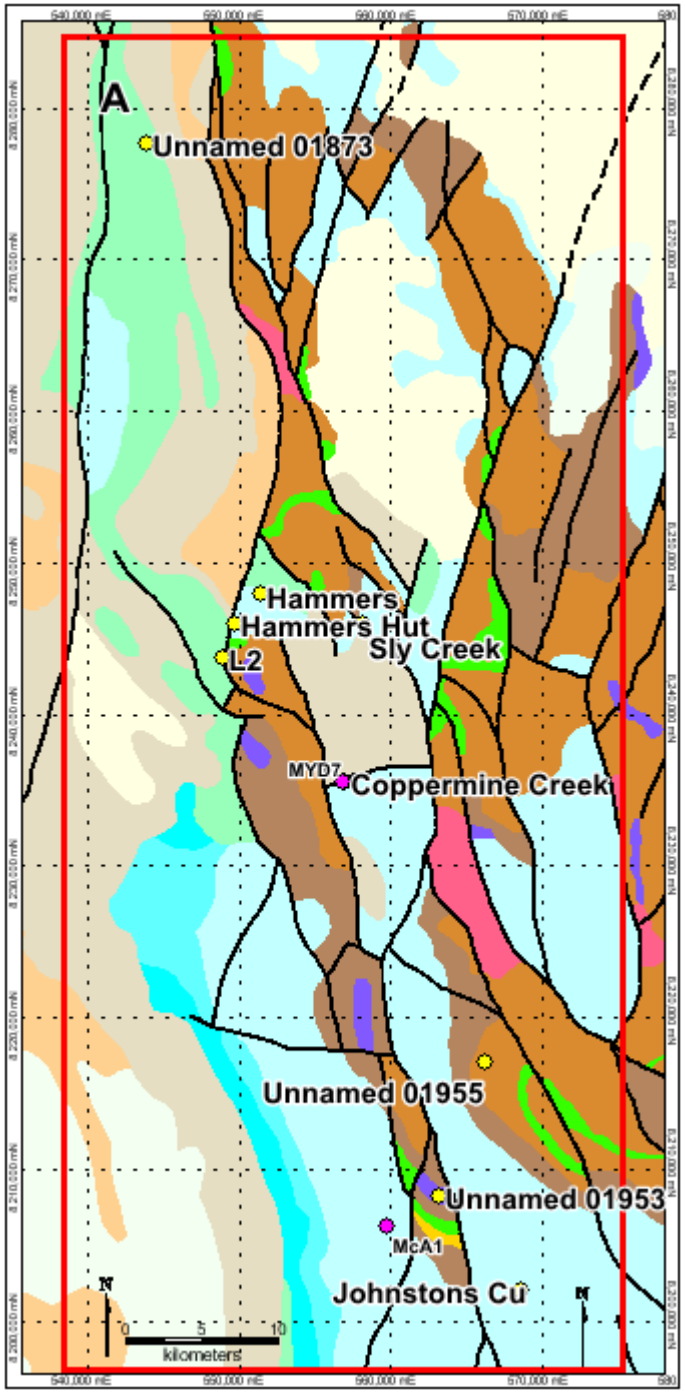
- Amelia style Cu mineralisation
  - Host formed at 1648 ± 3 Ma
  - McArthur Group
  - Batten & Emu Fault Zones
  - First major reduced sediments above the oxidised Redbank Package
- Stanton/Redbank style Cu mineralisation
  - Host formed at 1729 ± 4 Ma
  - Tawallah Group
  - Eastern McArthur Basin
- Wollogorang Formation
  - Tawallah Group
  - associated with Stanton & Redbank Co/Cu deposits



Stratigraphy taken from Rawlings 1999

Slide from previous presentation

Amelia Style Cu Stratigraphy - BFZ



Roper Group (Limmen SS / Mainoru Fm / Abner SS)

Nathan Group (Balbarini Dolomite)

Glyde Package - McArthur Group

Batten Subgroup - Lynott Fm (Hot Spring Member)

Umbolooga Subgroup - Reward Dolomite / Barney Ck Fm

Umbolooga Subgroup – Amelia Dolostone / Mallapunyah Fm

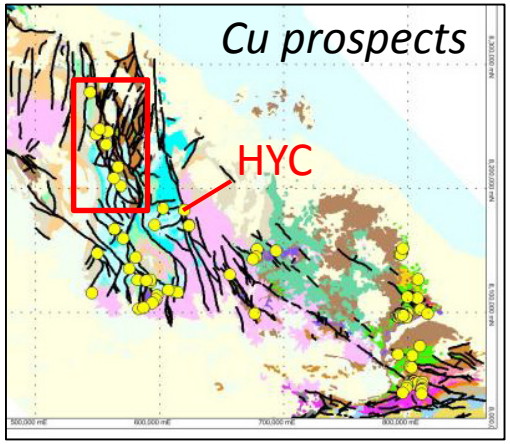
Redbank Package - Tawallah Group

Settlement Creek Dolerite

Wununmantyala Sandstone

Seigal Volcanics

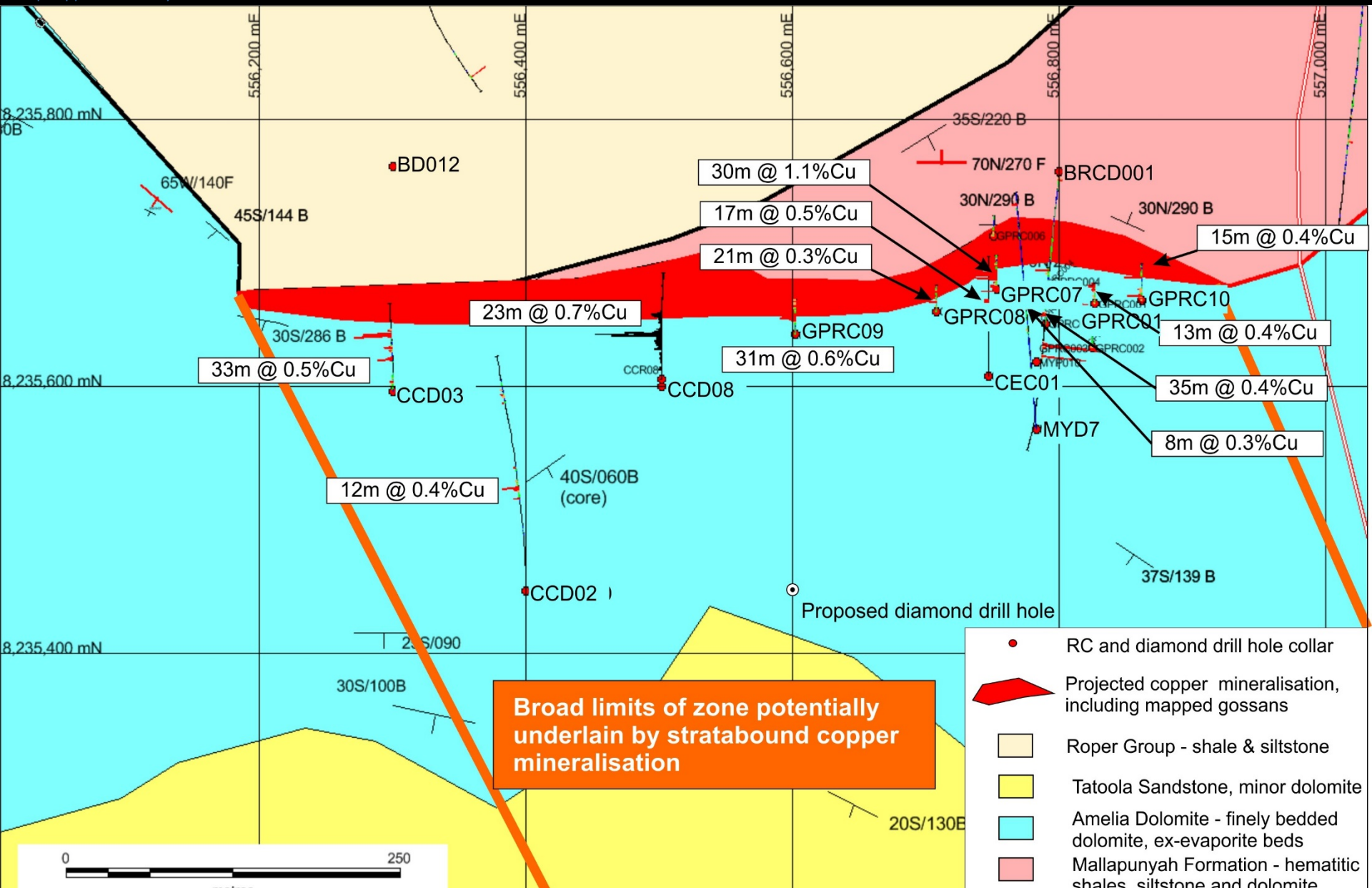
Yiyintyi Sandstone



Slide from previous presentation

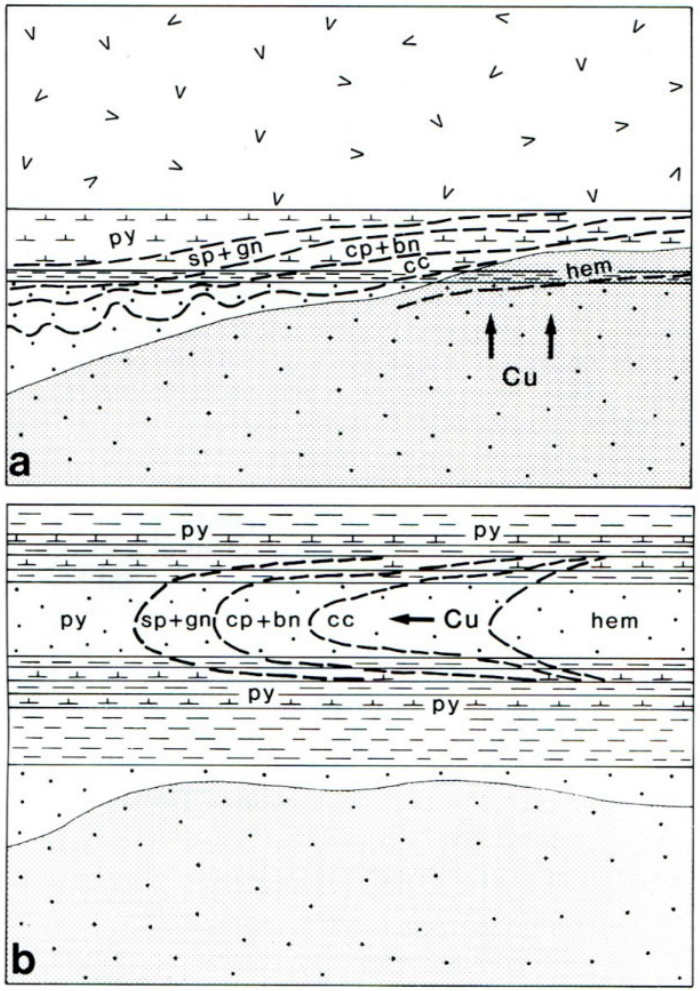
Coppermine Creek geology and drilling

Map supplied courtesy of Pacifico



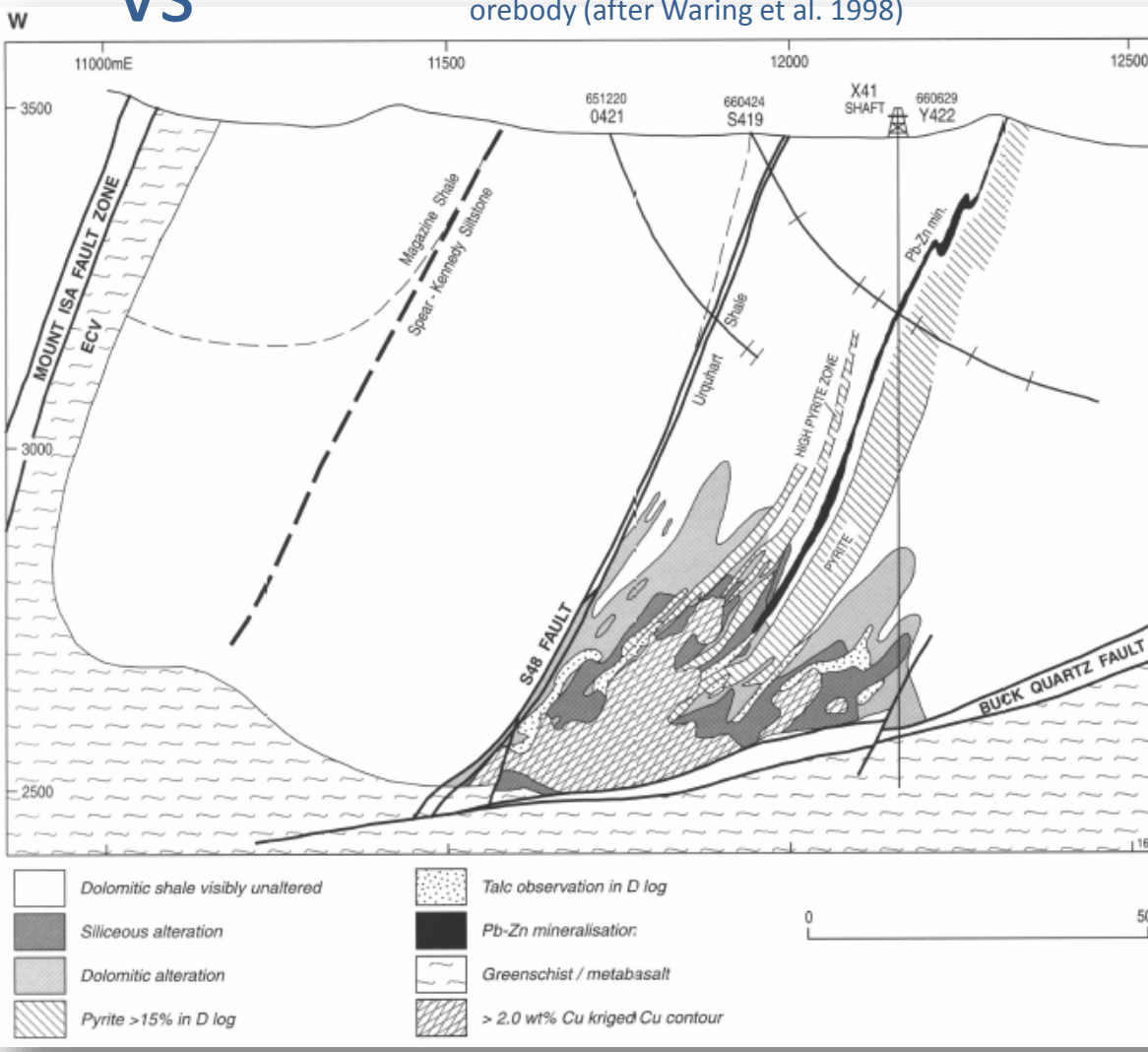
Geological dilemma: the Amelia-style systems show some stratabound character, but are they oxidised sedimented-hosted Cu style, or metamorphic Mt Isa Cu-style systems?

Examples of idealised sediment-hosted copper models (after Kirkham 1989)



VS

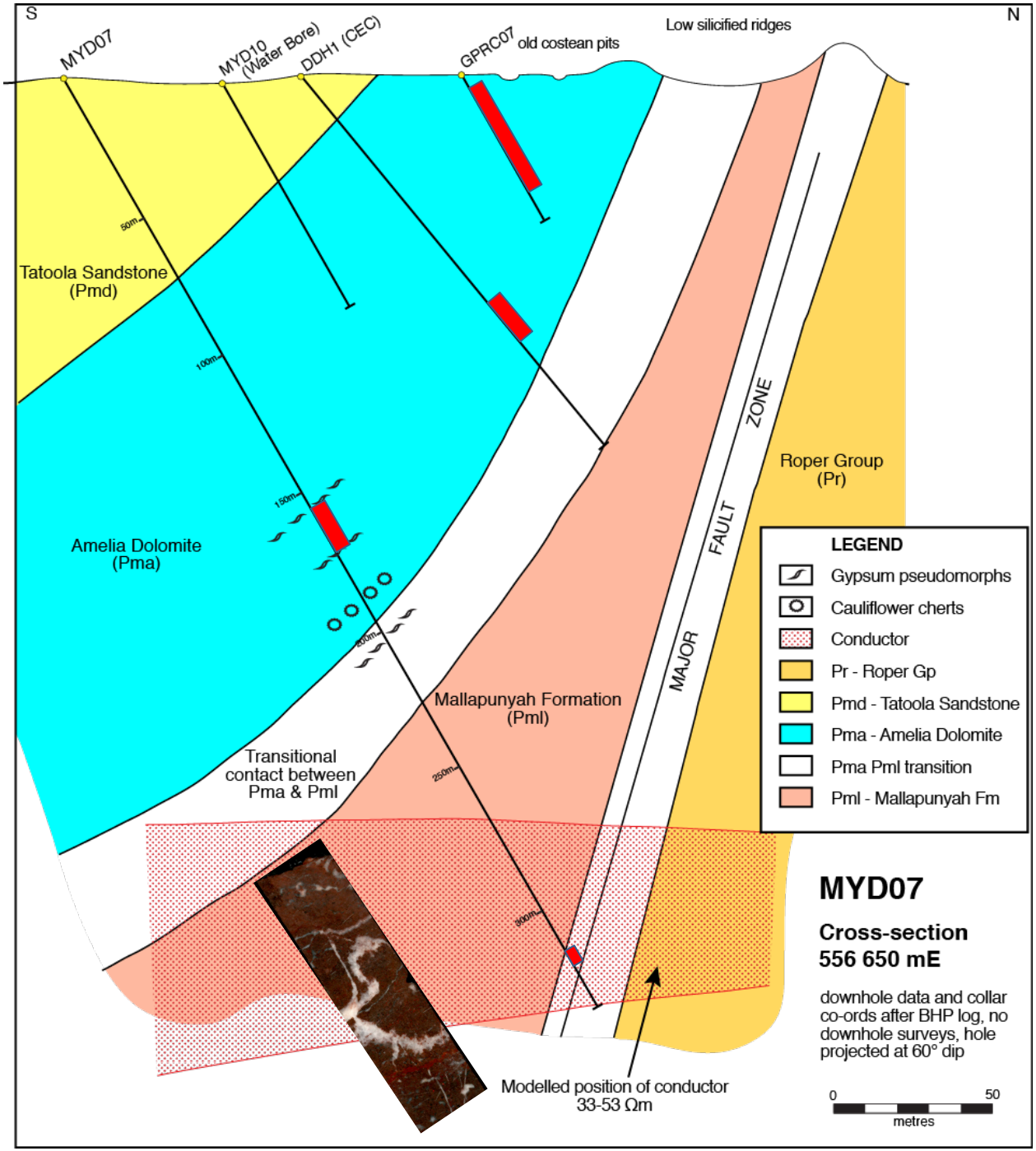
Metamorphic Cu: cross section of the Mt Isa copper orebody (after Waring et al. 1998)



The geological model as at Sept 2015 (Pacifico Minerals Quarterly statement) prior to drilling CCD04

Supporting the opportunity for the presence of a major copper mineralised system of the Mount Isa Copper (approximately 250Mt of 3% Cu) or Nifty (approximately 100Mt of 2% Cu) style are the following key geological factors:

- Distinctive ex-evaporite beds in the overlying Amelia Dolomite contain disseminated copper mineralisation.
- The mineralisation lies close to the redox contact between hematitic siltstones (oxidised) of the Mallapunyah Formation, and the overlying Amelia Dolomite.
- Reverse faulting at Coppermine Creek indicates that copper mineralisation could be related to a compressive regional event.
- The copper mineralisation appears to be spatially related to a major north-south trending regional fault system that may provide access to copper-bearing basin fluids.
- Intense fracturing, brecciation and dolomite (– silica) alteration is widespread and related to the copper mineralisation.
- Coppermine Creek lies within the McArthur Basin, where there are known large base metal mineralised systems, in an area that has only been patchily explored previously.



MYD07

modified from the original BHP X-section

This hole was examined petrographically and isotopically in this study.

MYD07 important textures:
ALTERATION
Dolomitisation over evaporites within dololutite forms a large halo

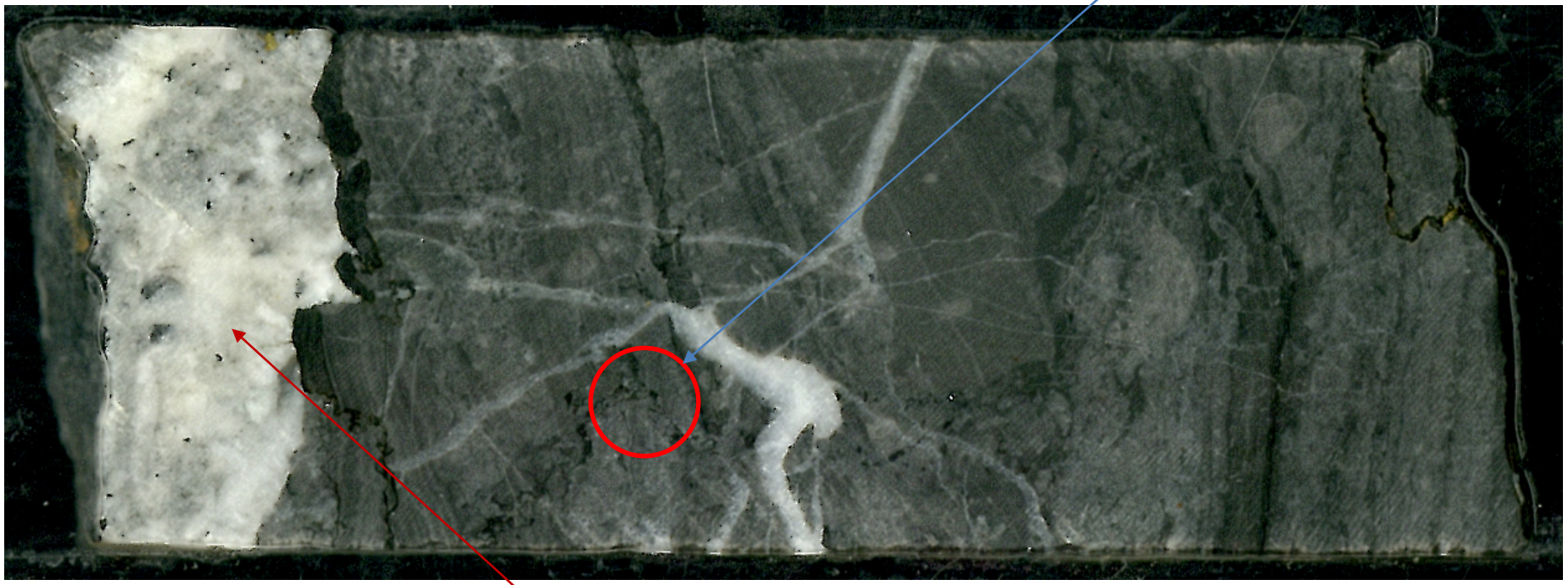
Dolomite replacement of tabular crystals (gypsum?).

A039/159.00 m

Hole: MYD7

BRITTLE DEFORMATION, WEAK TO MODERATE BRECCIATION AND CARBONATE VEINING

Bitumen-filled stylolites sub-parallel bedding, but one set also occurs at a high angle to bedding. This set controls the extent of some pervasive dolomitisation, and also the location of some Cu mineralisation

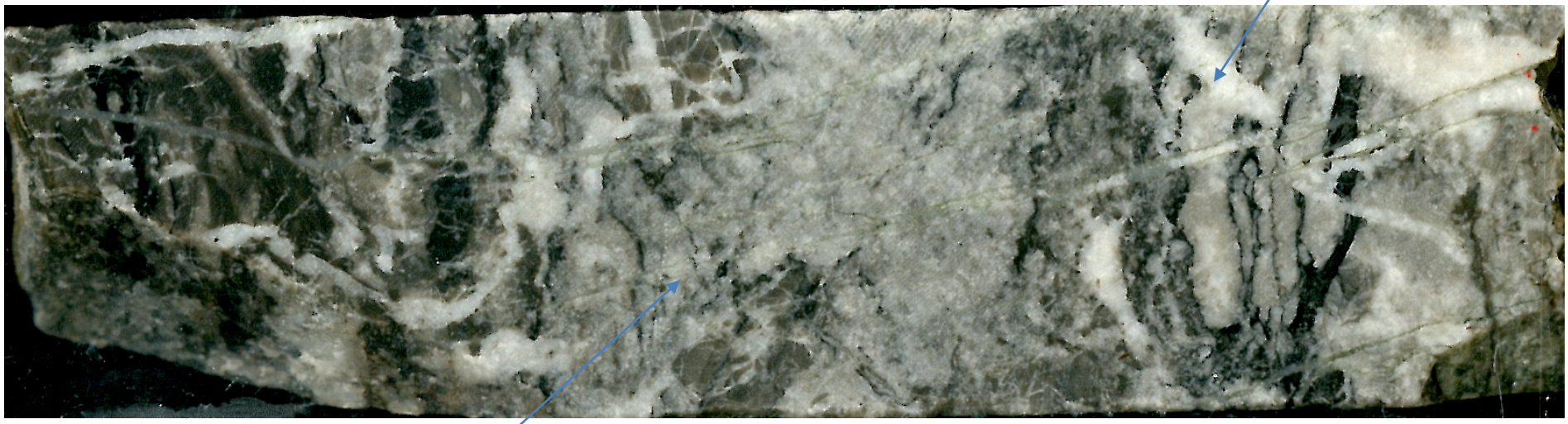


A051/176.8 m

Hole: MYD7

VEIN NETWORKS DISRUPT RECRYSTALLISED AND STYLO-LAMINATED CHLORITE ALTERED SHALE:
These textures indicate significant multiple episodes of fault-related fluid flow with attendant vein carbonate formation.

Intense vein infill, with associated severe replacement of stylolitised black shale;

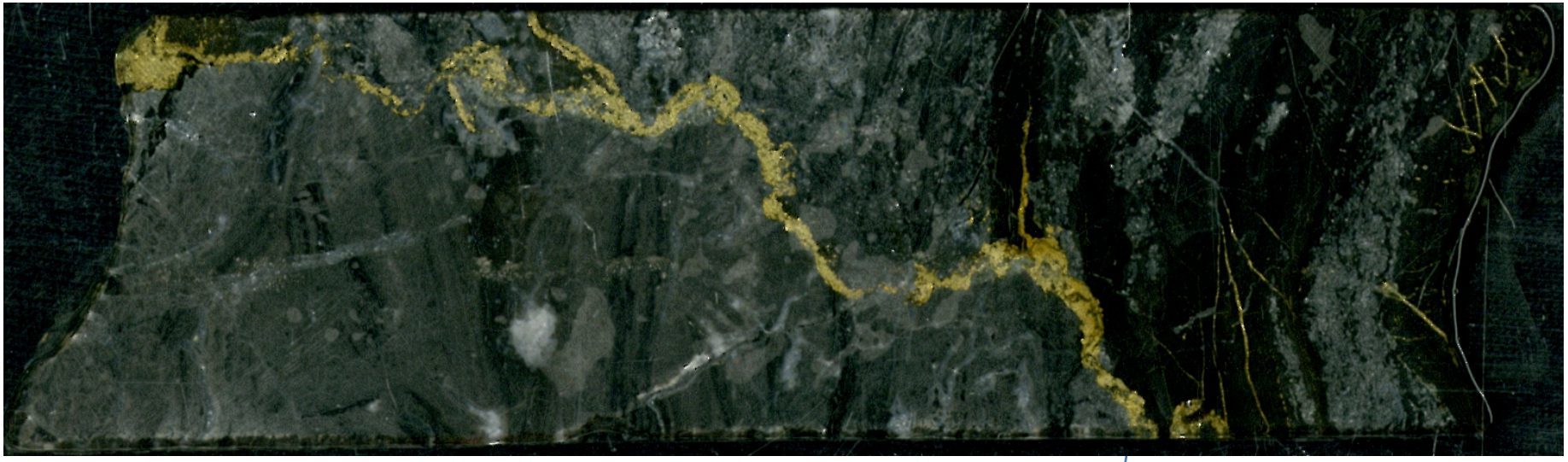


Intense replacive Fe-dolomite

Hole: MYD7

A076/271.8 m

In mineralised zone, steep sub-vertical bitumen-filled stylolites have been partly replaced by chalcopyrite.

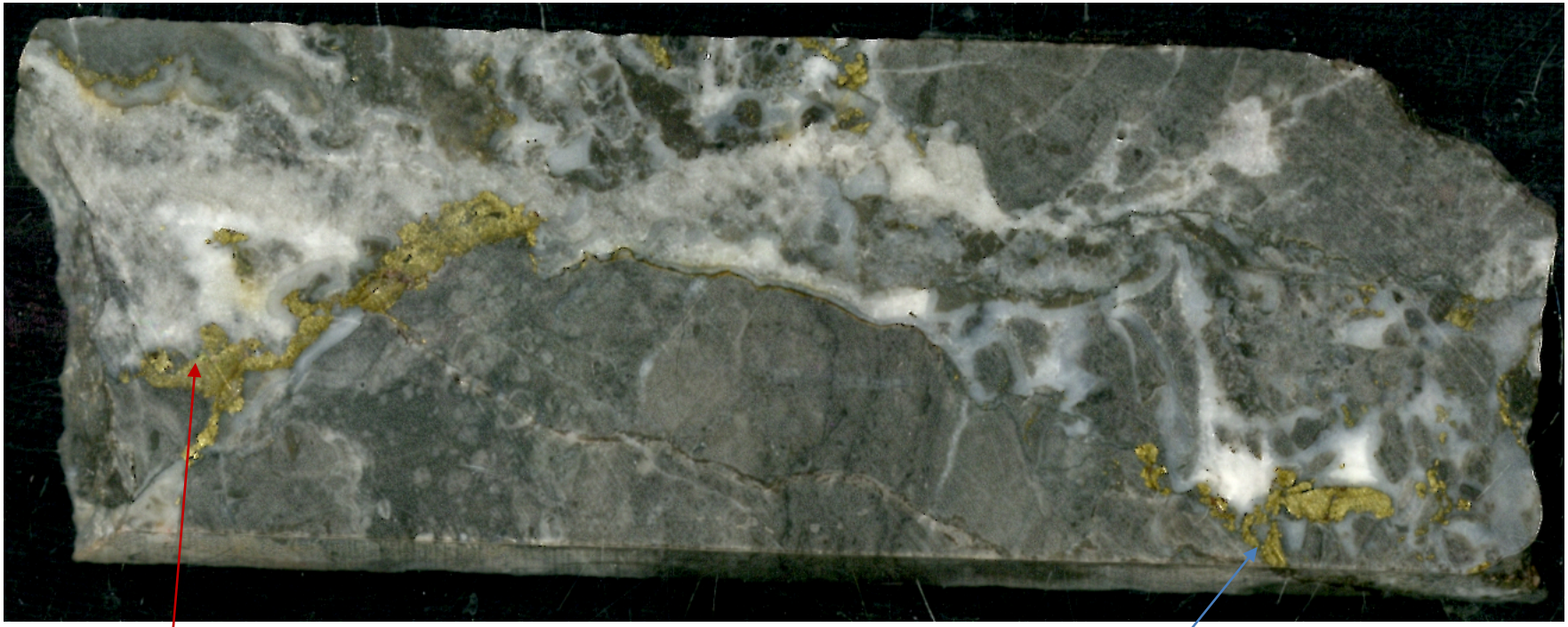


Chalcopyrite-replaced stylolite, giving rise to sinuous forms

Hole: MYD7

A056/184.8 m

In the mineralised zones, steep calcite veins replace along sub-vertical stylolites, and are themselves partly replaced by chalcopyrite. The dolomitised hostrock displays brecciation. This suggests a late timing within the history of the unit.



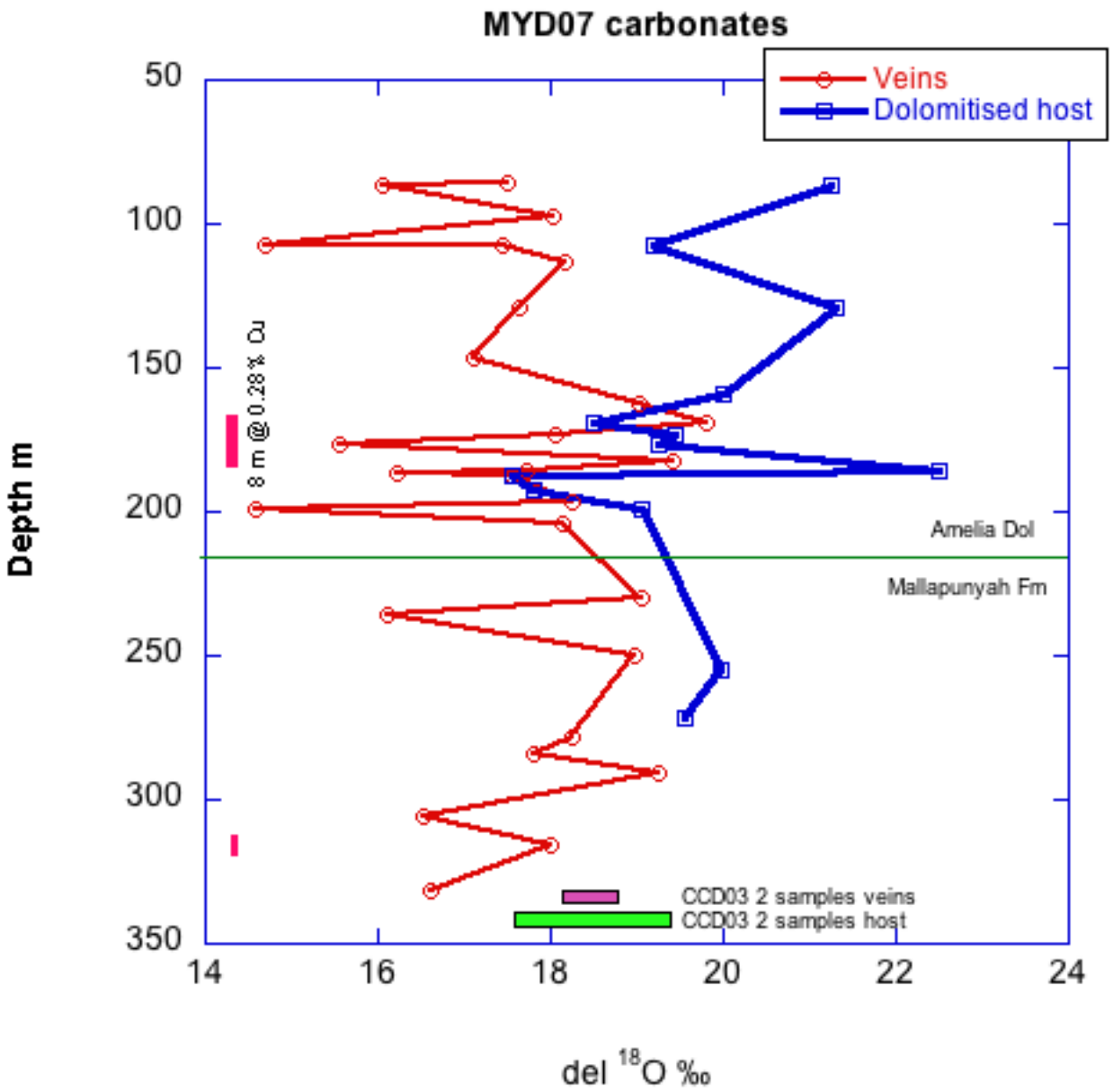
Dissem py, replac'd by cpy?

Dolomite vein network. CPY clumps appear to replace sparry vein material AND stylolites, giving rise to sinuous forms

Hole: MYD7

A054/182.5 m

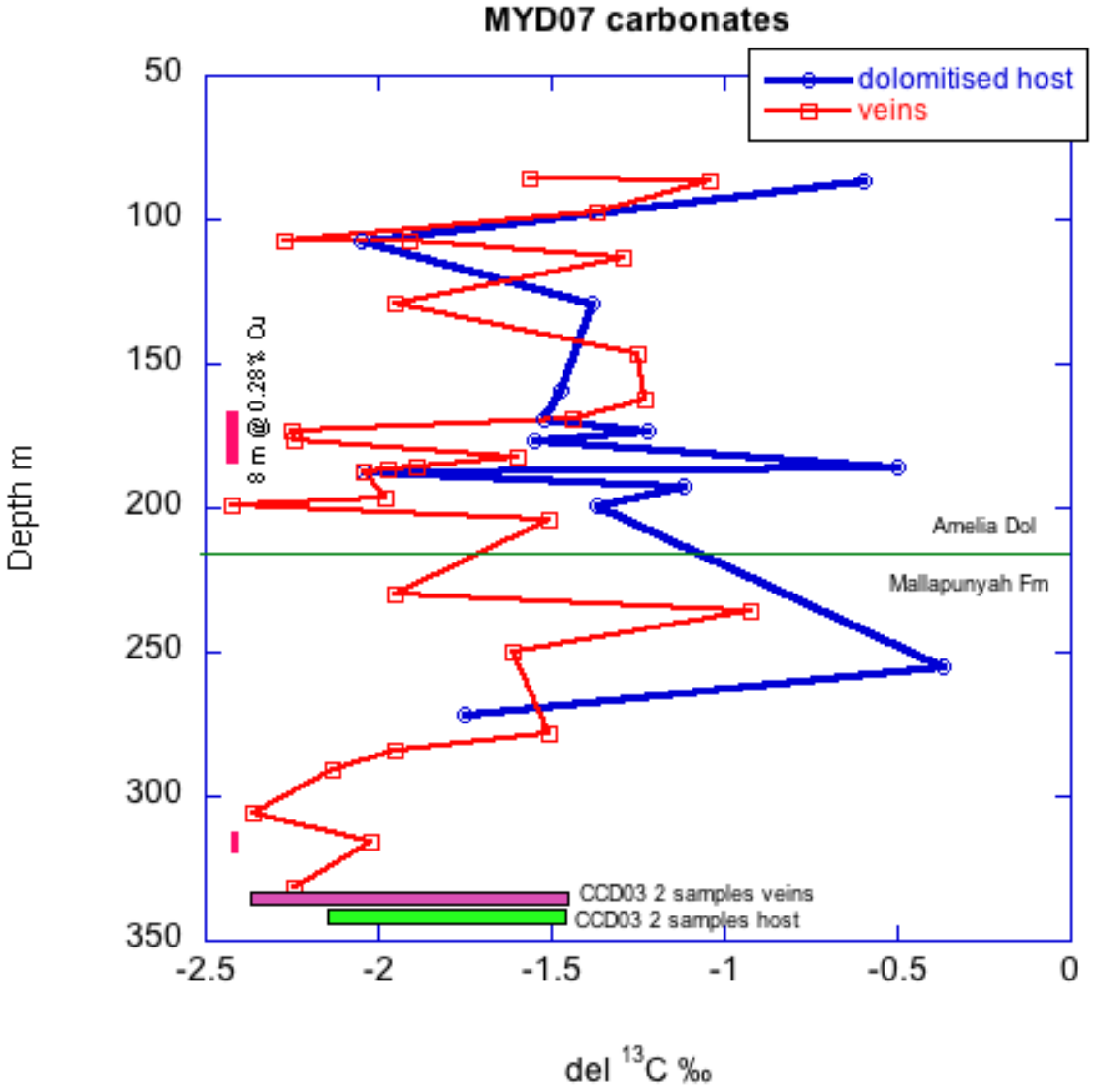
Oxygen isotope variation in carbonate



A C-O isotopic study was undertaken, given that MYD7 transects the mineralised package, and this method is useful for delineating fluid flow patterns in carbonate hostrocks. We preferentially sampled veins because they are a pure medium with no organic C or other phase.

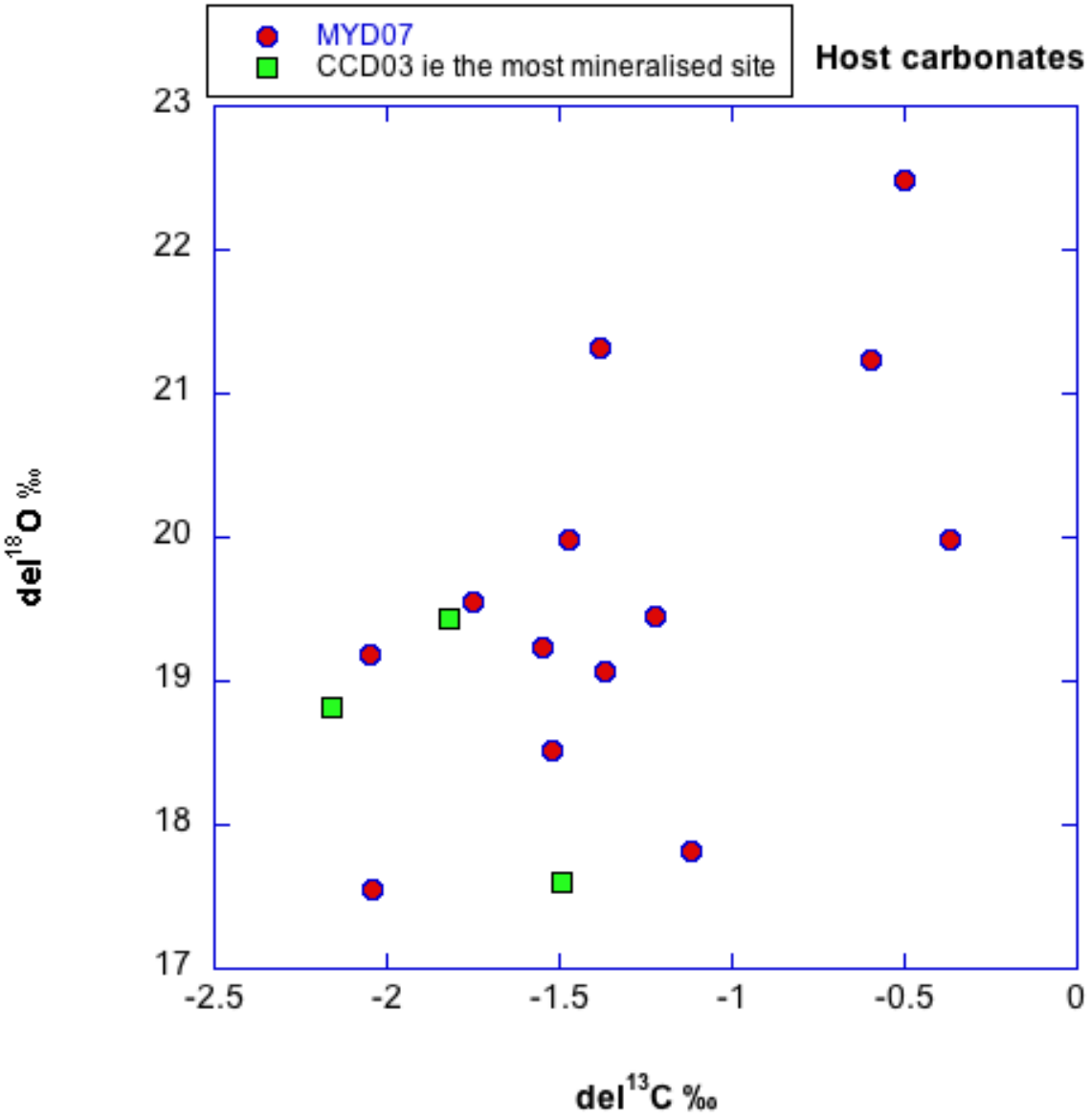
We also obtained values for two more highly mineralized samples from CCD03.

Carbon isotope variation in carbonate

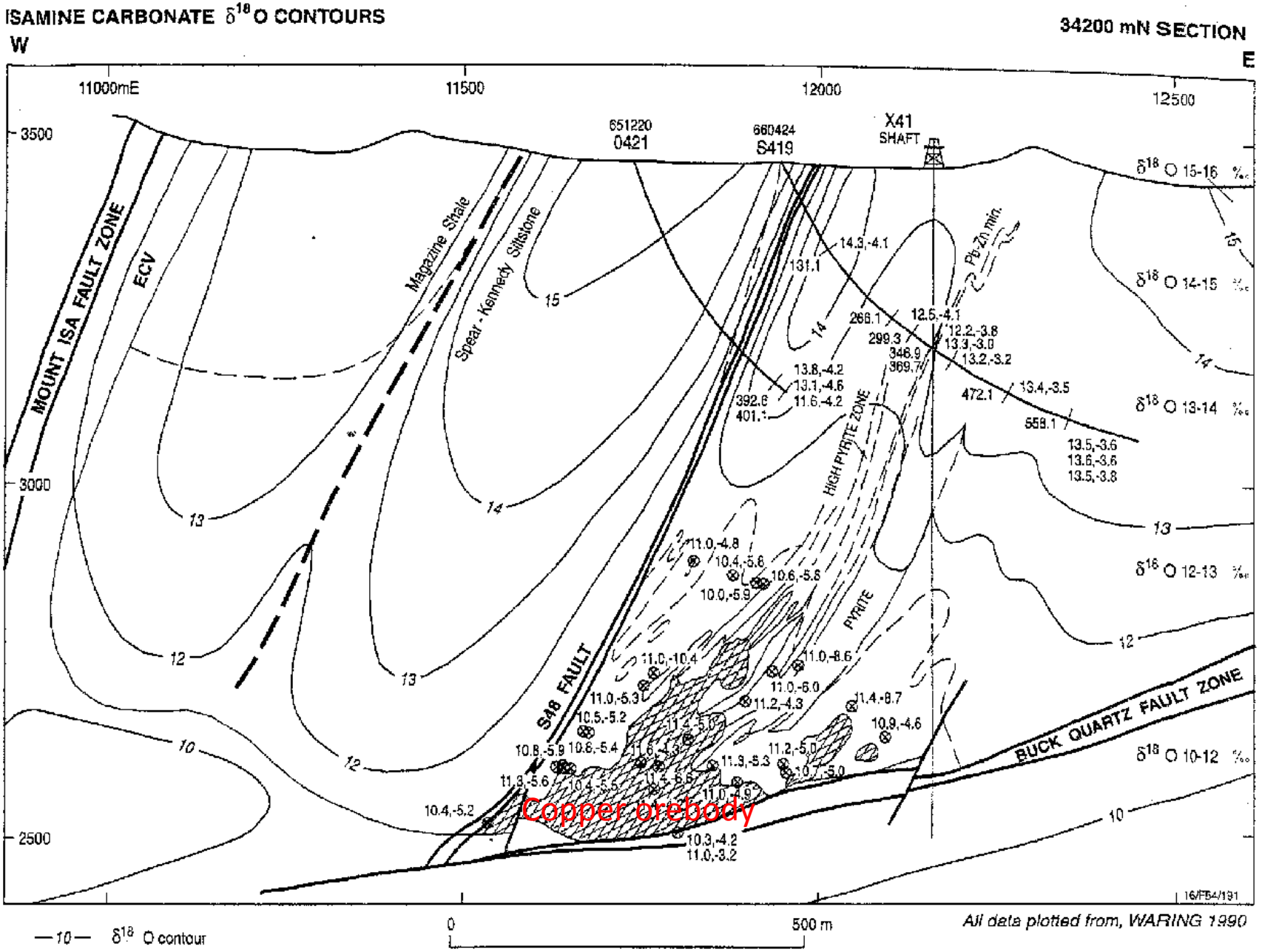


- Host samples might be expected to be more negative because they likely contain some organic C (which is very negative)
- However, instead, most host veins are more negative than the nearby host dolomite
- No clear trend around the mineralised zone in either vein or hostrock populations, although a cluster of more negative values occur in veins near the Cu zones.
- At this point the isotopes don't appear to be giving clear spatial patterns downhole.

Now it gets interesting (a bit)



- When plotted as C vs O for hostrock, a trend is observed, in the MYD07 data
- One endmember coincides with the samples from CCD03, in which Cu grades are the highest in the prospect
- This merits comparison to the positively correlated trend of the Mt Isa copper ore halo (next slides), but comparisons to other sed-hosted Cu systems will also be undertaken in coming months



- **Source: Waring et al 1998**

Mt Isa Copper C-O isotope halo, with a fluid-rock interaction exchange line shown

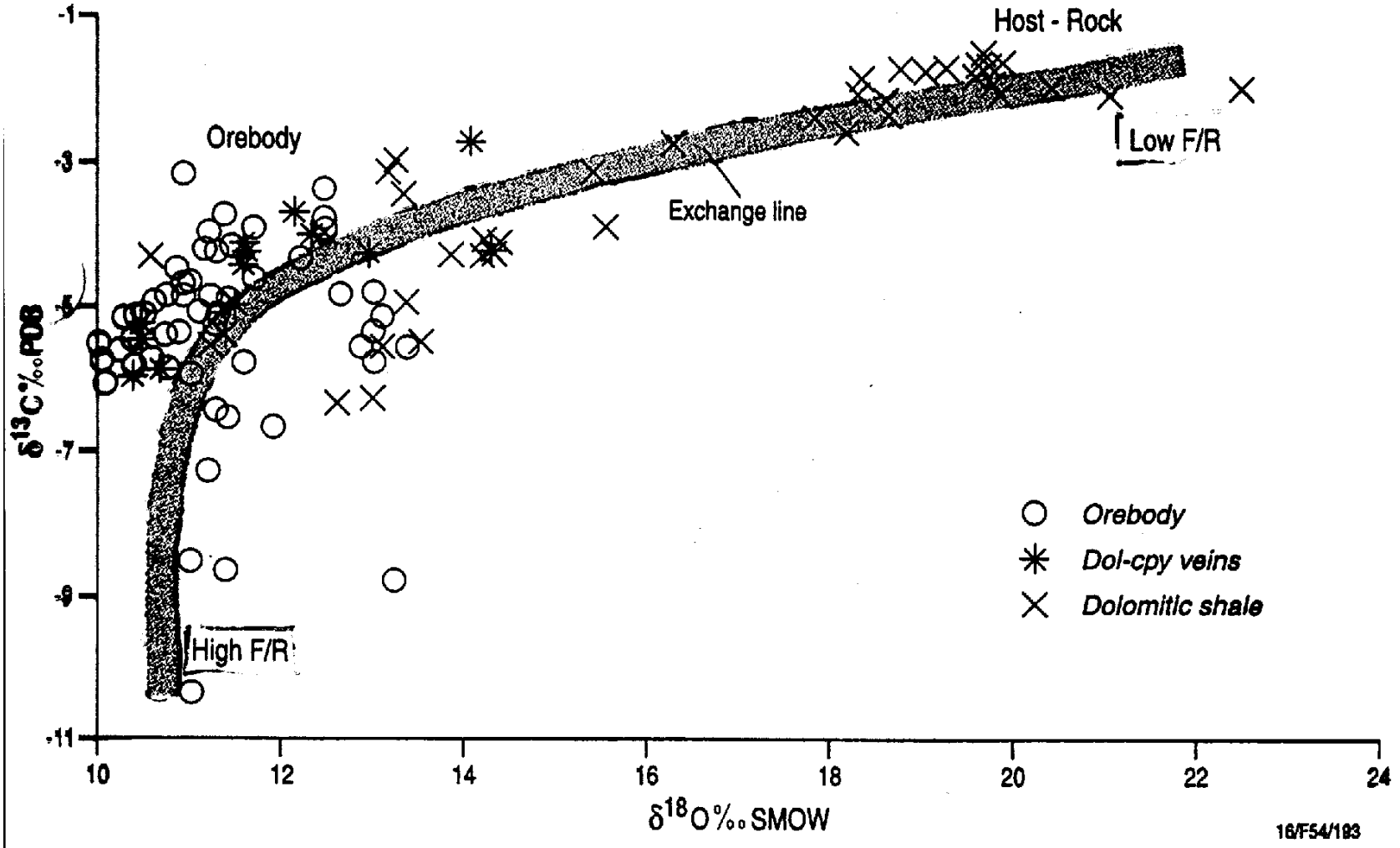
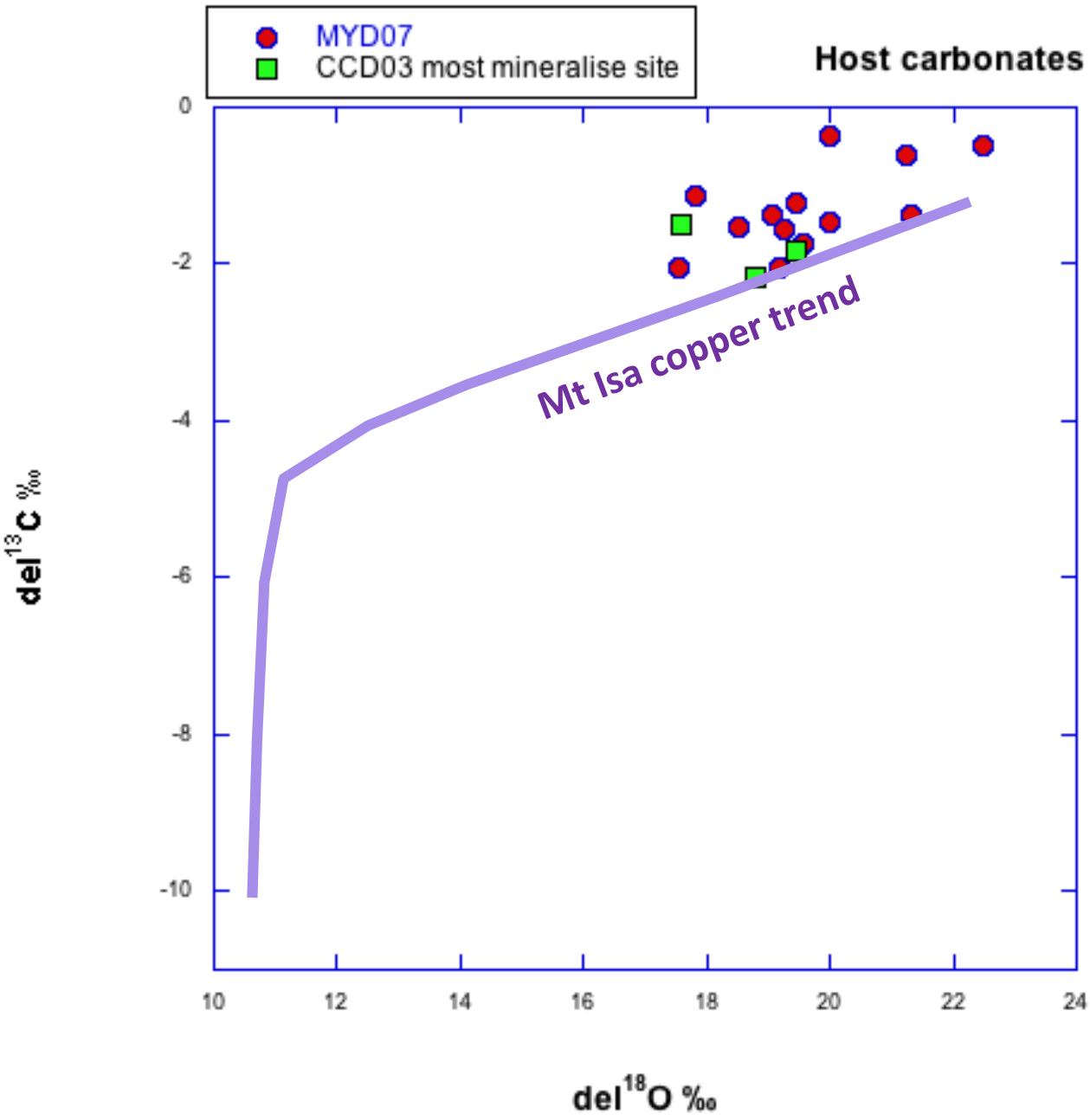


Figure 4. Mount Isa Mine environs carbonate isotopic data, from Smith et al. (1978), corrected Heinrich et al. (1989), and Waring (1990a).

- Source: Waring et al 1998

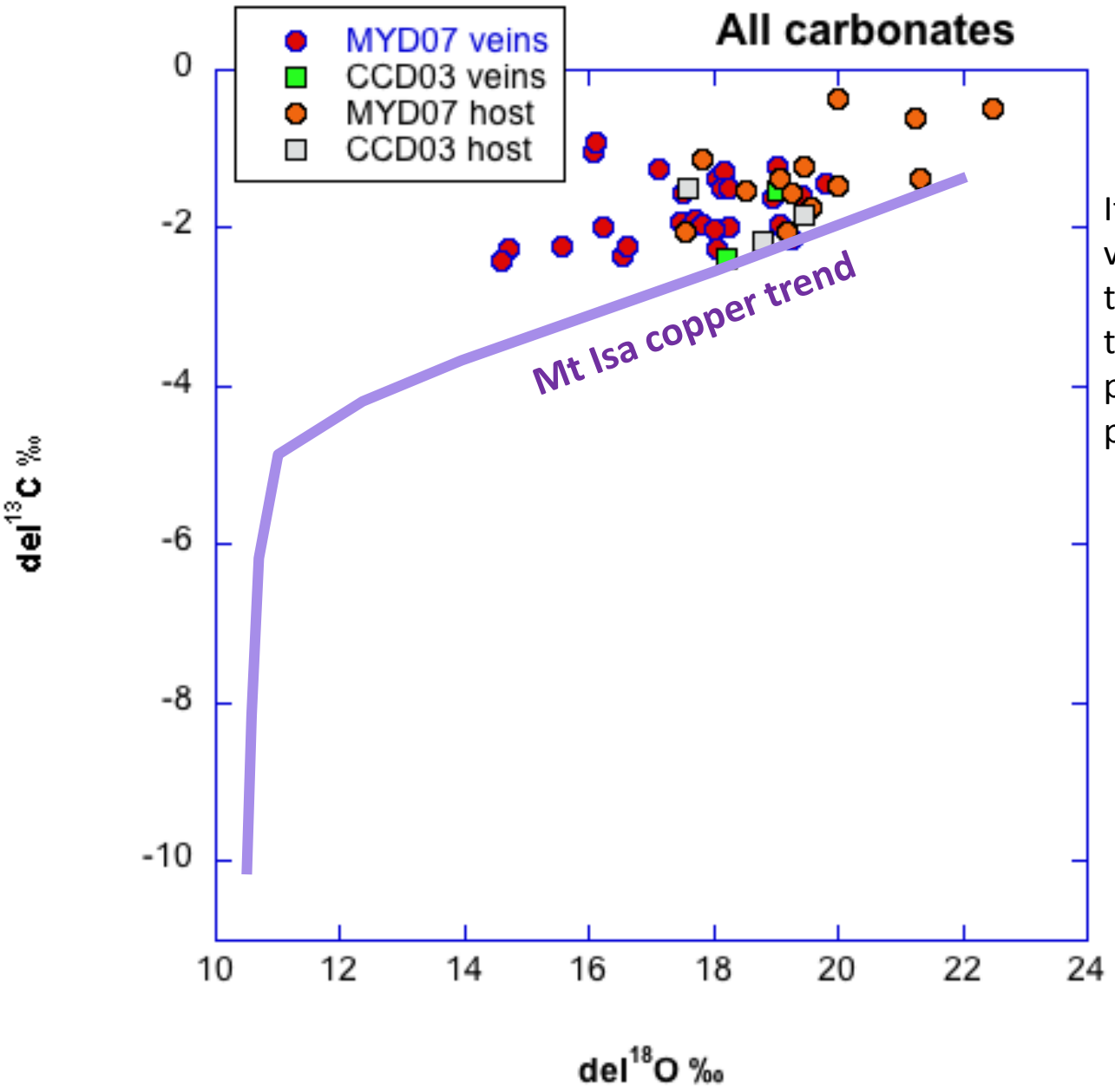
Comparison to the Mt Isa copper system



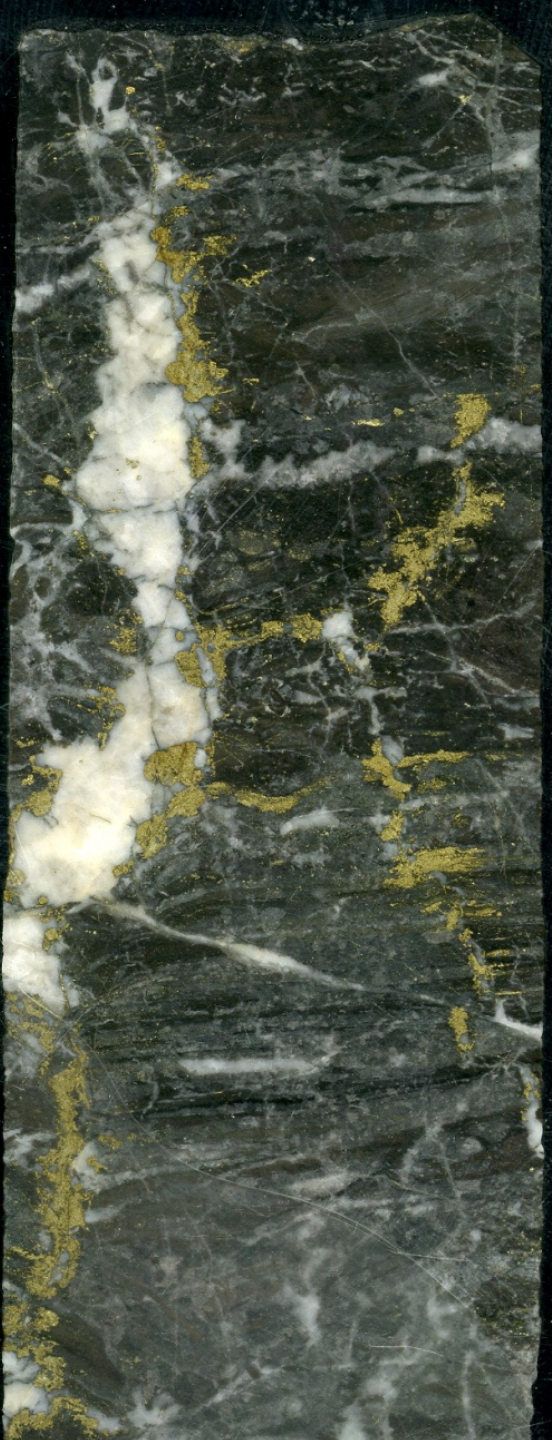
The trend of the Coppermine Creek hostrock data is similar to the low water-to-rock portion of the Mt Isa Cu trend, and is consistent with an external fluid with light O and C values having reacted with the sequence. Neither the carbonate veins nor the dolomitisation of the hostrock appear to be syn-copper in individual samples, but could still all have been part of one evolving hydrothermal system (theory). Alternatively, earlier formed carbonates were susceptible to further alteration by the later Cu-forming fluid.

This suggests that delineation of the shape of the isotopic contours may give a guide to Cu-related fluid flow, as it does at Mt Isa

First comparison to the Mt Isa copper system II



It is evident that adding in the vein data does reveal an overall trend which is even more similar to the Mt Isa Copper trend, parallel to it but with more positive C values.



CCD03/55.3m

Summary

- The Amelia Dolomite in the Coppermine Creek mineralisation halo shows significant dolomite replacement, varying from disseminated to near-complete (see left). There are also cherty sections, but their extent and associations need to be determined.
- Mineralisation is all chalcopyrite +/- pyrite, with some interesting sections of Pb-Zn (a feature also seen at Nifty). There is no evidence of zoning of copper minerals.
- Sub-horizontal and sub-vertical carbonate veins mainly predate chalcopyrite
- Some chalcopyrite has developed along the outer margins of these veins, partly having replaced vein carbonate, bitumen in stylolites, and wallrock alteration carbonate. Replacement of carbonate is considered to be the main depositional mechanism in metamorphic Cu systems; ie they are not redox traps, instead they are pH traps, forming at the first intersection of acidic copper-rich fluid encountering limestone
- The C-O isotope patterns resemble the pattern seen in the outer part of the Mt Isa Cu orebody halo
- Overall the timing of Cu formation appears to be well after lithification, and most likely during a period of vertical stresses along a large E-W fault system, perhaps channeling fluids from the Four Archers Fault. The features conform to the Pacifico model of a metamorphic Cu system, but in lower grade rocks, and raises the questions of the timing and conditions of such a system in the McArthur Basin.

Acknowledgements

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- Drafting by Susan Belford
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