Applications of volcanology to mineral exploration: examples from the Kalgoorlie Terrane

Patrick Hayman

Queensland University of Technology

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GOLD FIELDS

KCGM

silverlake RESOURCES

Orogenic Gold

Aerial photo of the Super Pit, the mine contains 1670 t of Au (Vielreicher et al 2016). The main gold host, the Golden Mile Dolerite

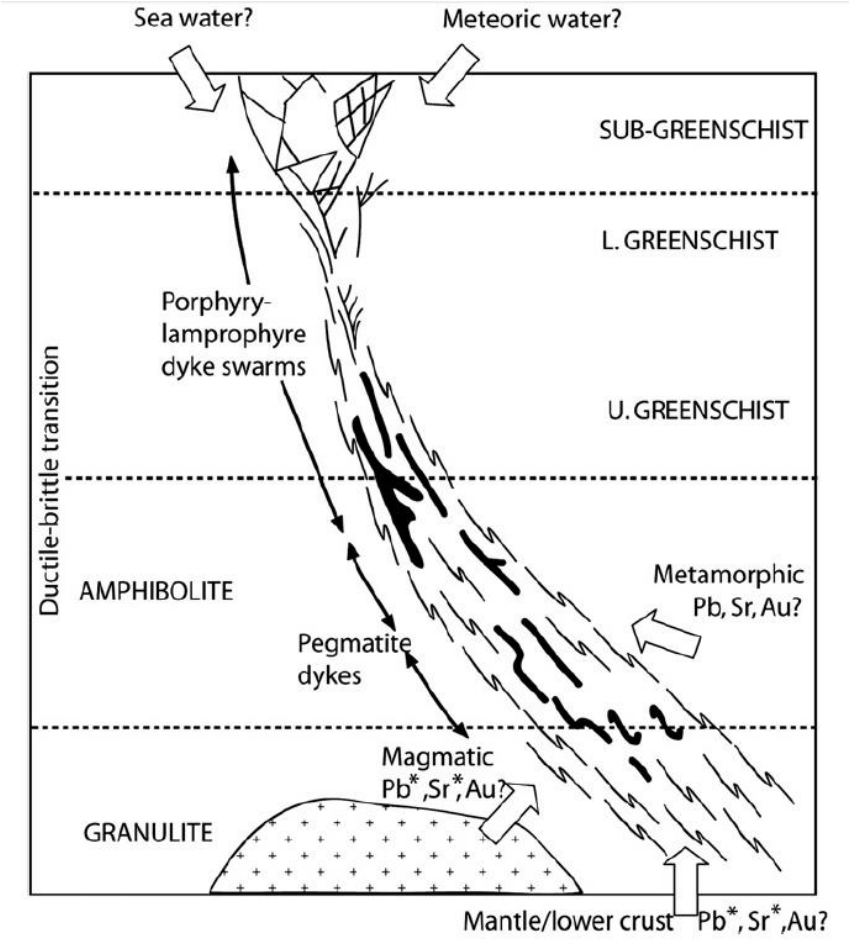
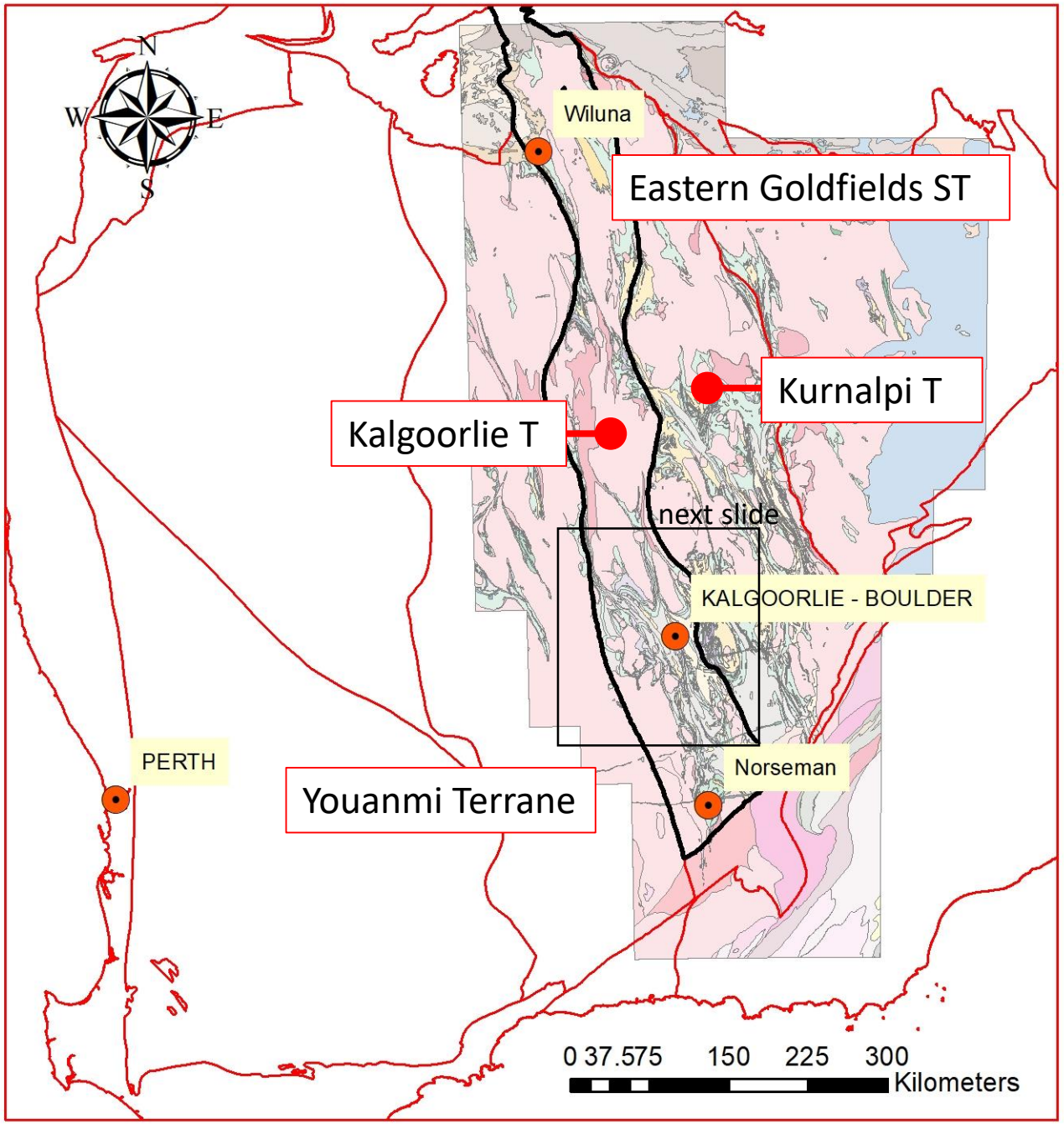


Fig. 2. Schematic representation of the continuum model showing the formation of gold deposits through a 20–25 km vertical interval of the Earth's crust from conditions within the granulite facies to those of sub-greenschist facies grade (after Groves, 1993).

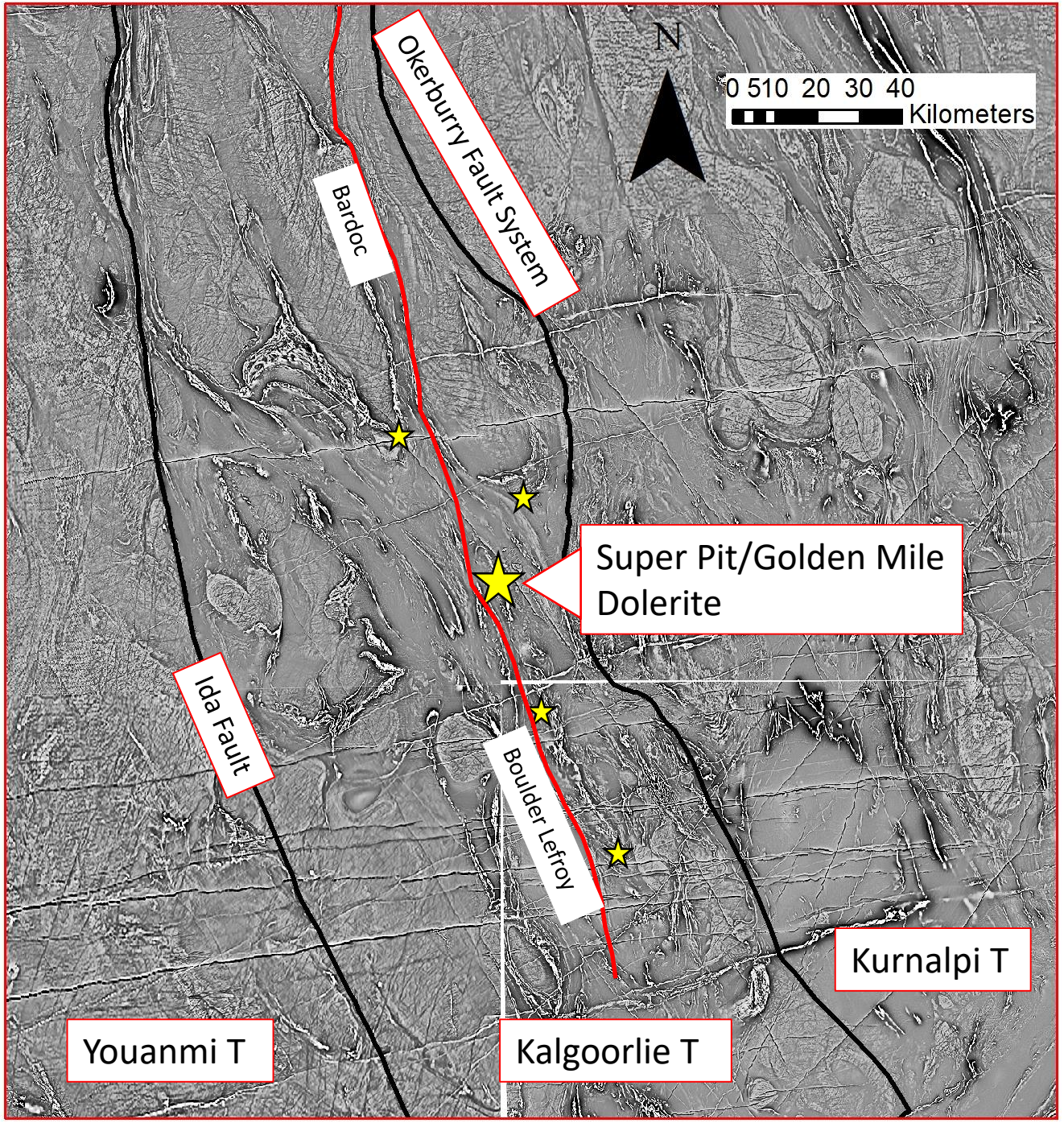
Phillips and Powell 2010.

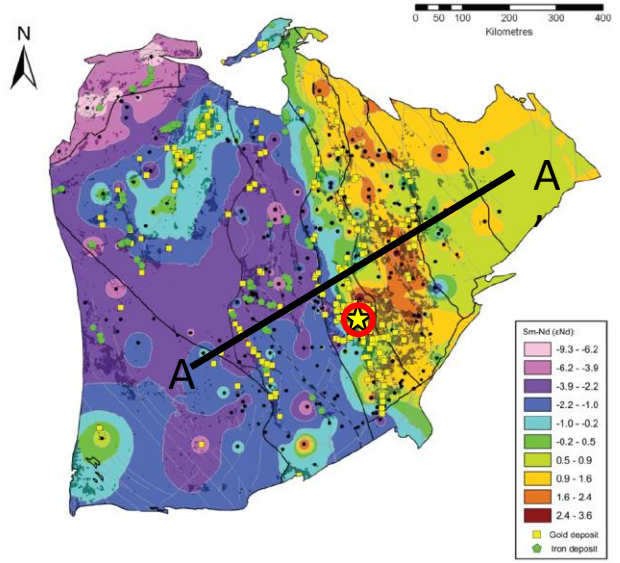


Location of the Kalgoorlie Terrane

- 2.7 Ga NNW-SSE trending westernmost block of the Eastern Goldfields Superterrane
- Dimensions 60-90 km wide x ~800 km long

Kalgoorlie Terrane and Gold

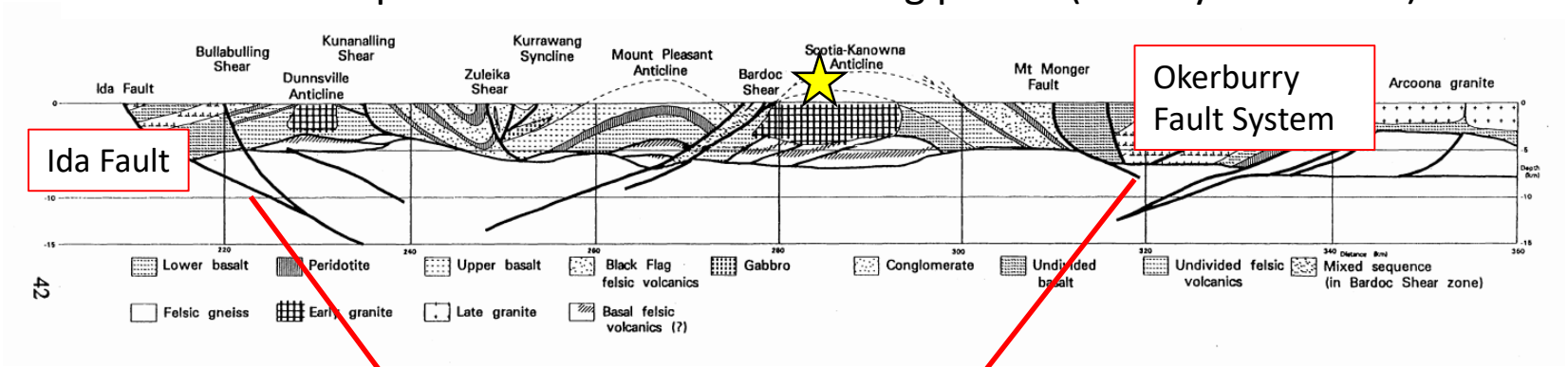




Sm-Nd isotopic map of the Yilgran Craton with gold deposits (yellow squares) (Mole et al 2013). Super Pit marked by star with red circle.

Terrane Boundaries(?)

Interpretation of seismic reflecting profile (Goleby et al 1993)



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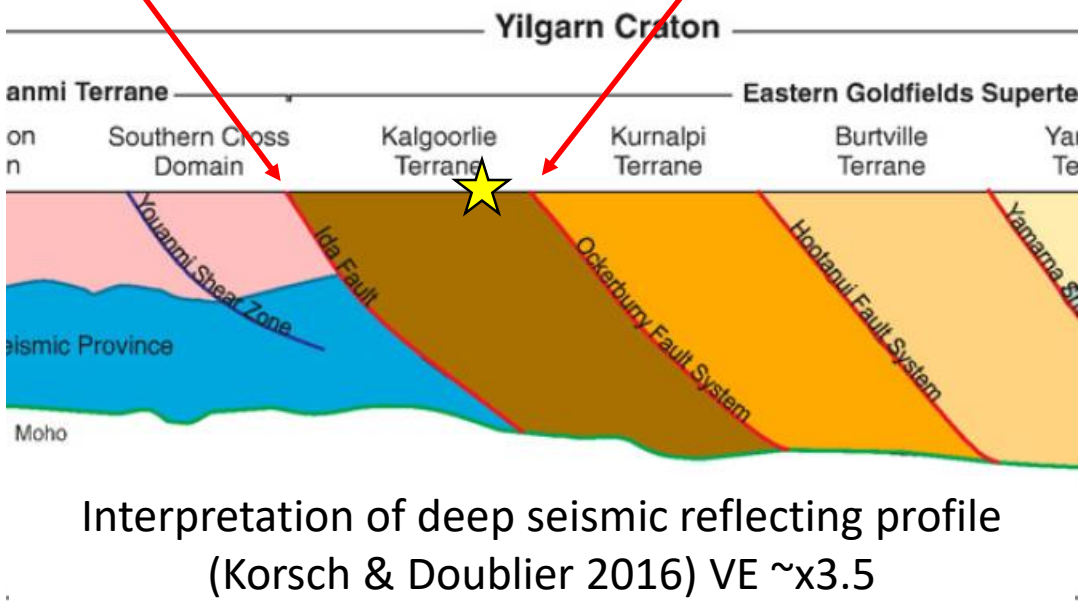


Interpretation of deep seismic reflecting profile (Korsch & Doublier 2016) VE ~x3.5

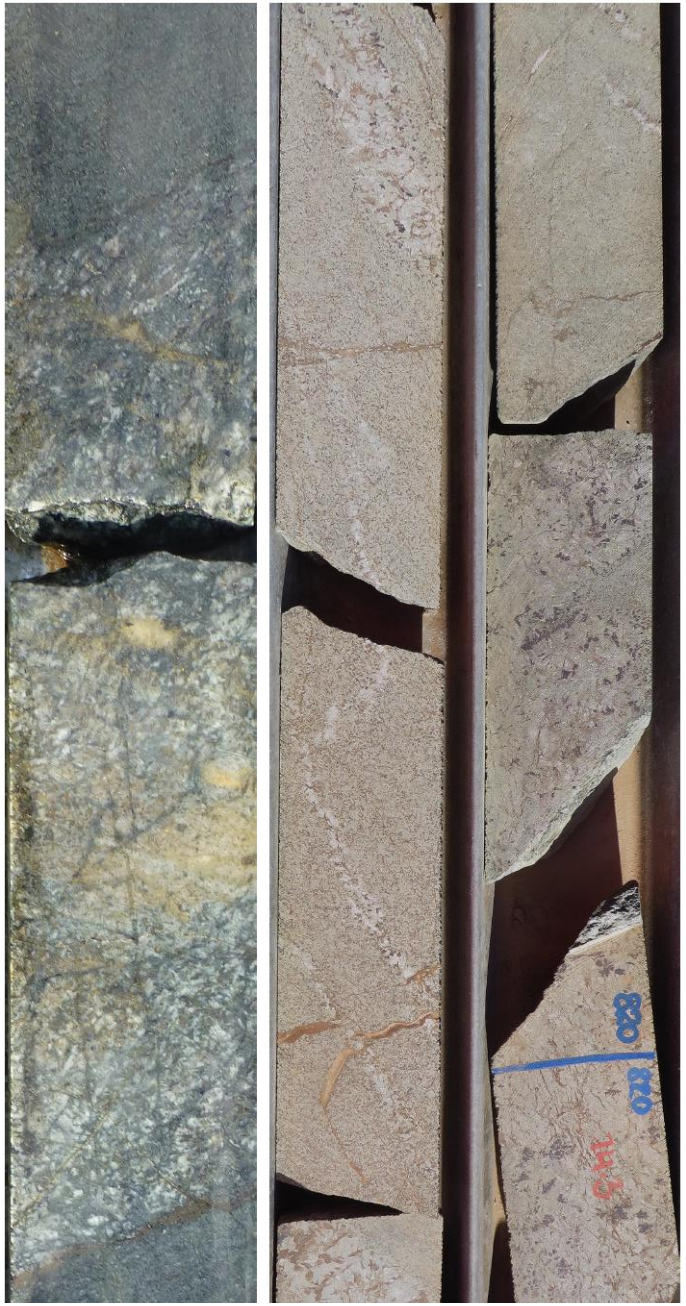
★ Super Pit

Part I: What is special about the Bardoc Fault System within the Kalgoorlie Terrane for gold mineralisation?

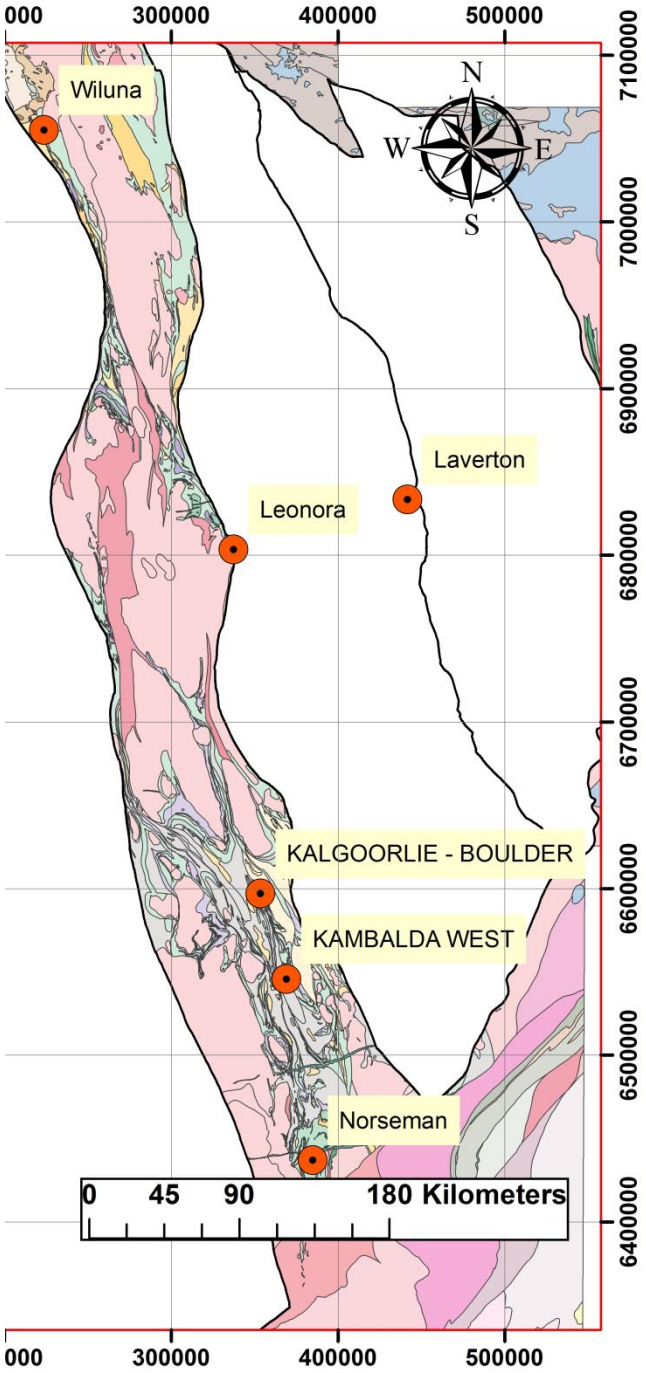
Gold and Granophyres

- There are numerous studies that examine the role of structure on local gold deposition
- Granophyres are common gold hosts:
  - Golden Mile Dolerite (Super Pit, KCGM & Newmont)
  - Paddington Gold Mine (Norton Gold Fields)
  - Cave Rocks and Junction Dolerites (St Ives, Gold Fields)
  - Centenary Mine (Darlot, Big Red)
  - Lake Roe (Breaker Resources)

Part II: Can a better understanding of granophyres inform on why gold occurs where it does on a local scale?



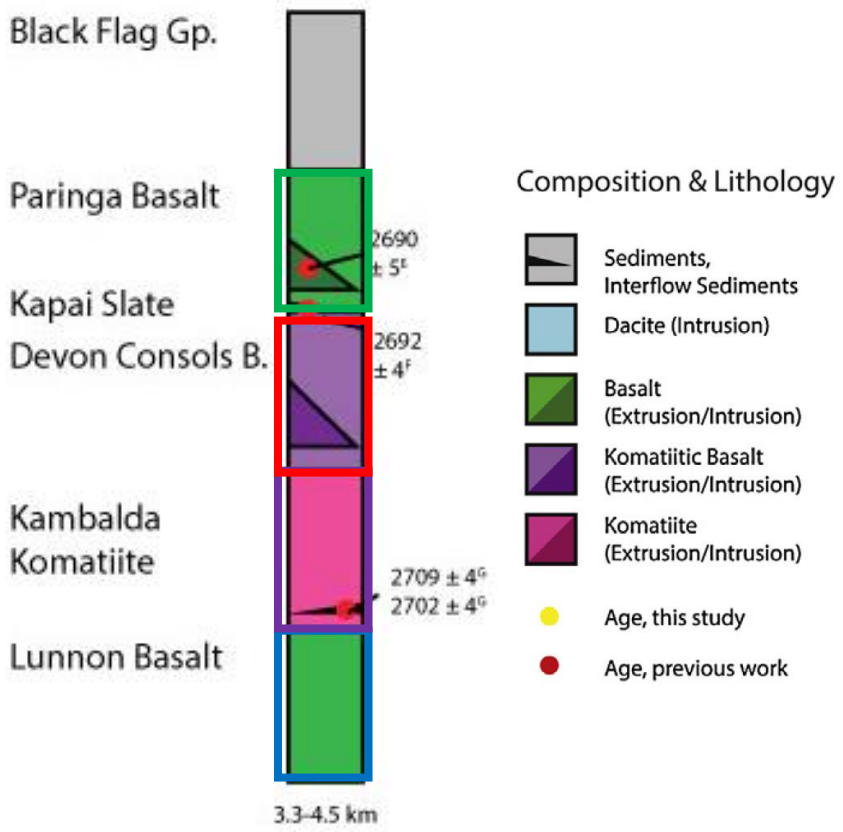
Granpohyric veins,
Golden Mile Dolerite



Kalgoorlie Terrane Background

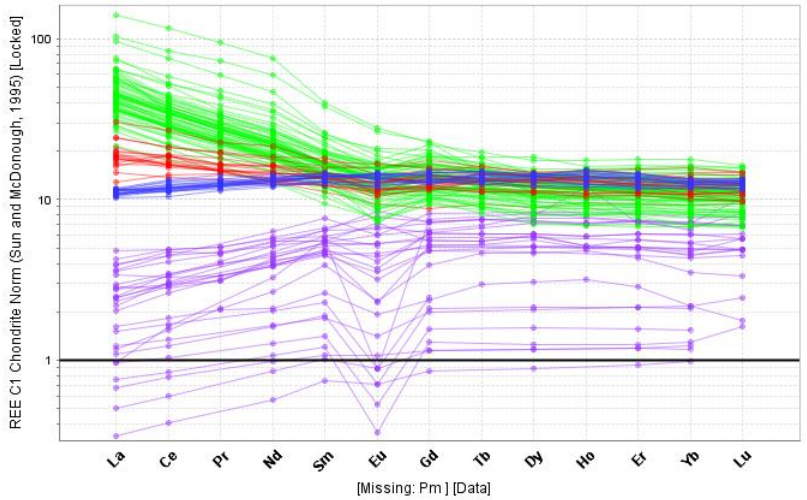
- Although there are older components, stratigraphy consists mainly of:
  1. Lower mafic-ultramafic package
  2. Middle turbidite package associated with intermediate volcanism
  3. Upper qtz-rich sandstone package that is coeval with voluminous granite magmatism
- Well defined sequence at Kambalda, where it is 3.3-4.5 km thick

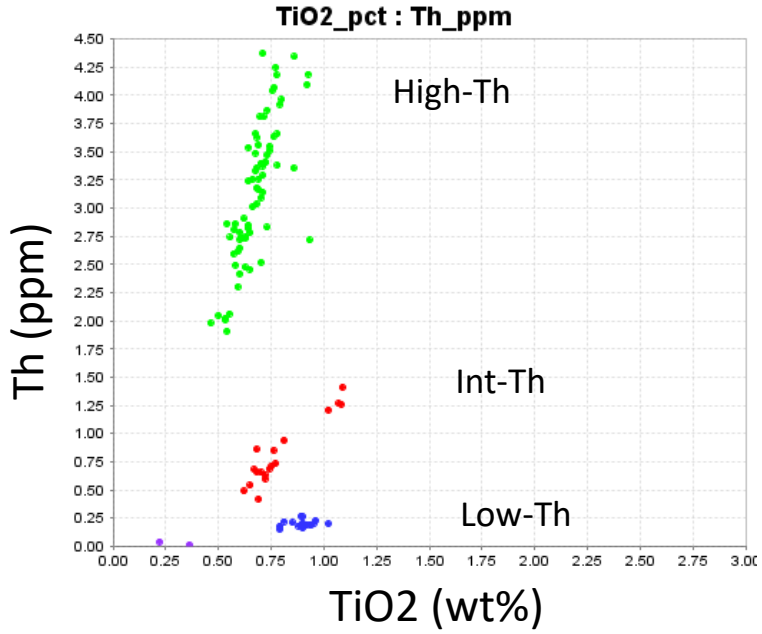
Kambalda Domain



After Connors et al 2005

Main period of mafic-ultramafic volcanism ~20 Ma

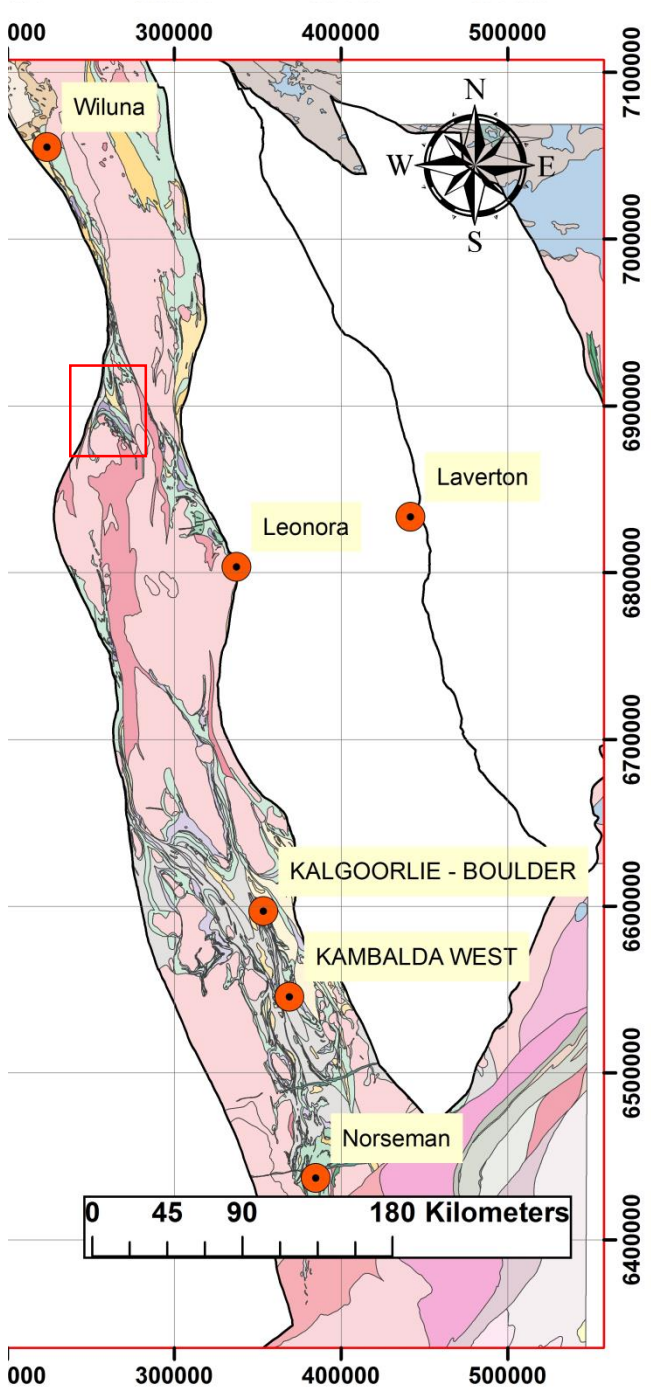


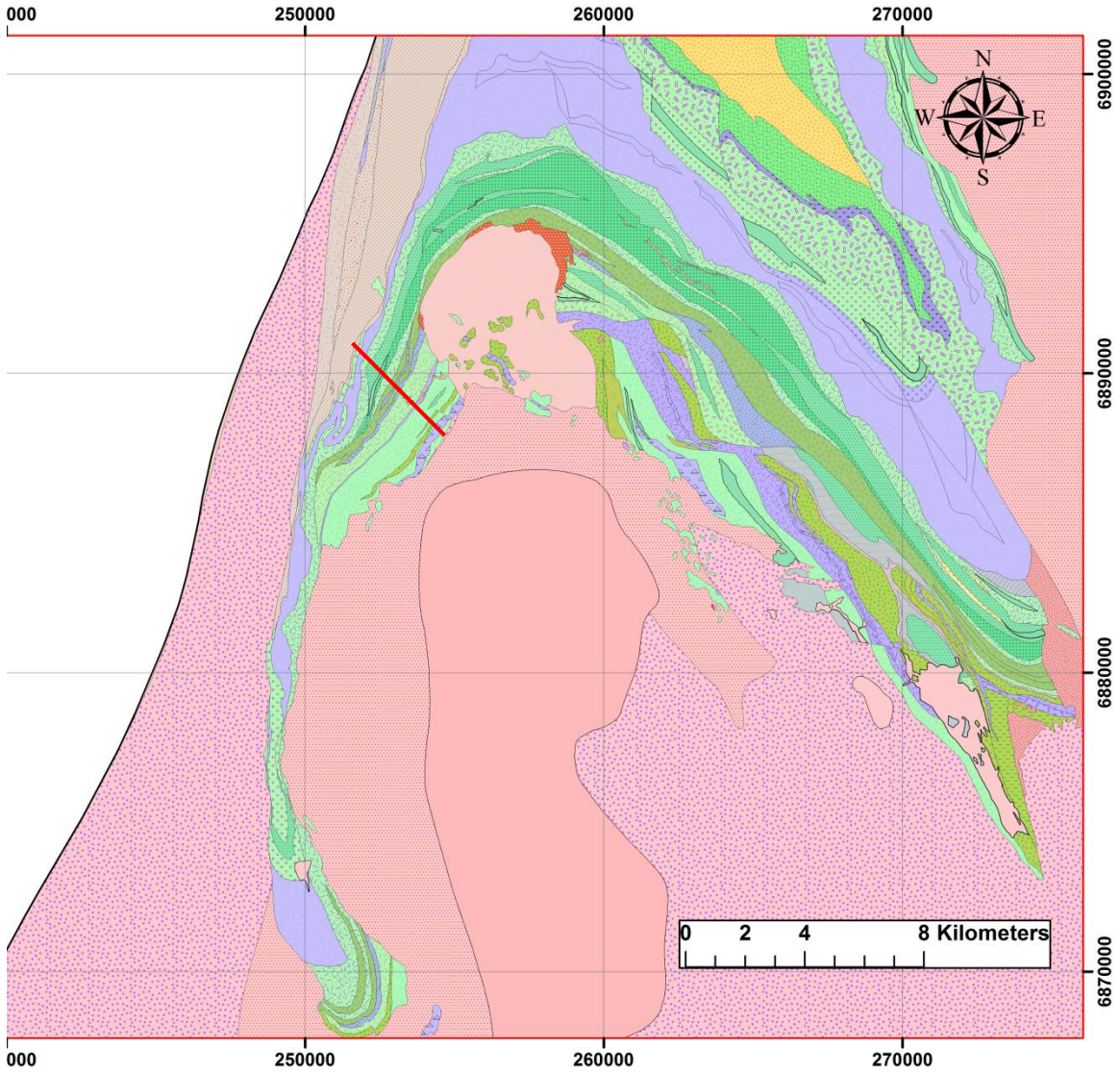


Th-groups after Barnes et al 2012

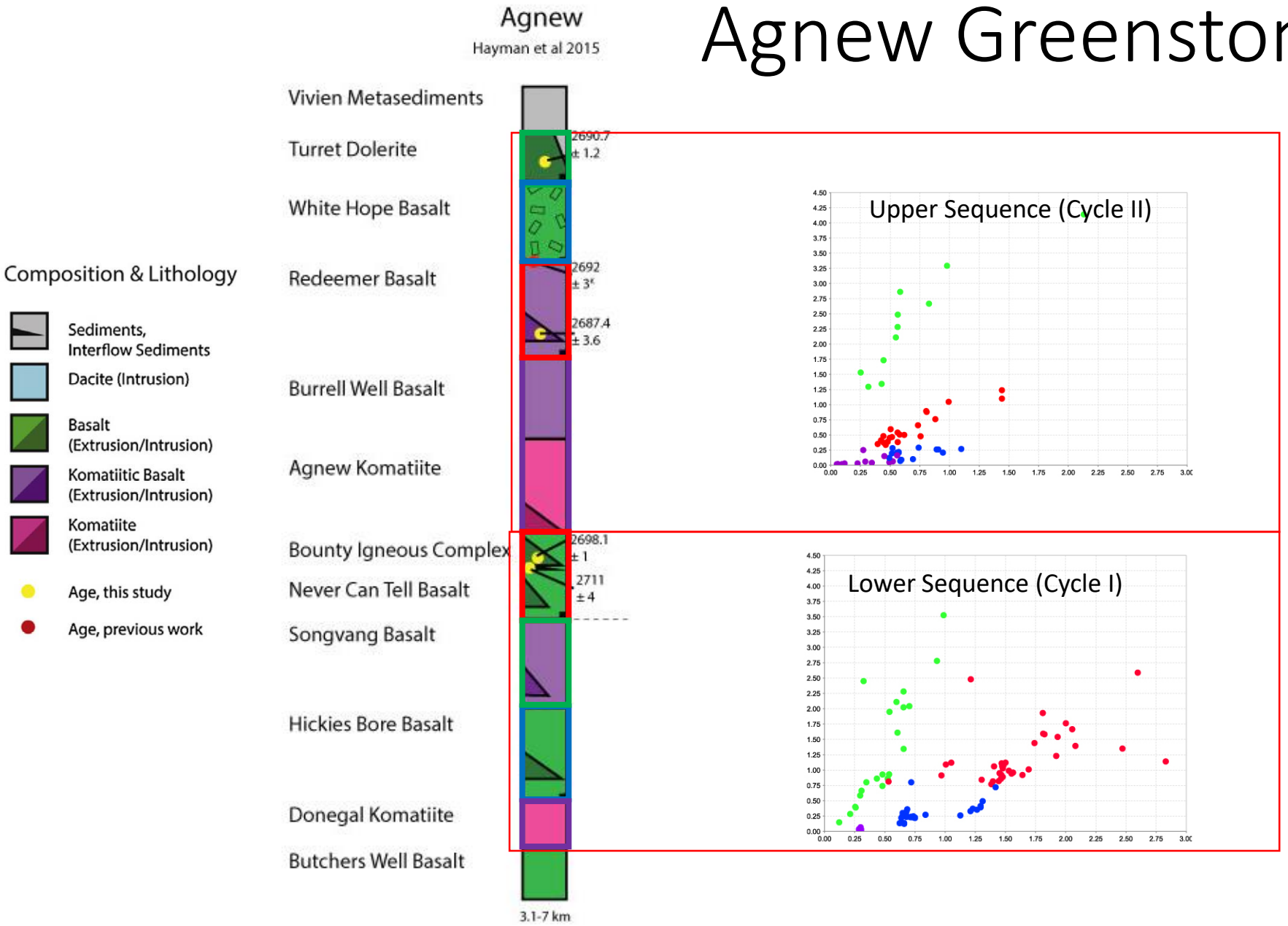
Agnew Greenstone Belt

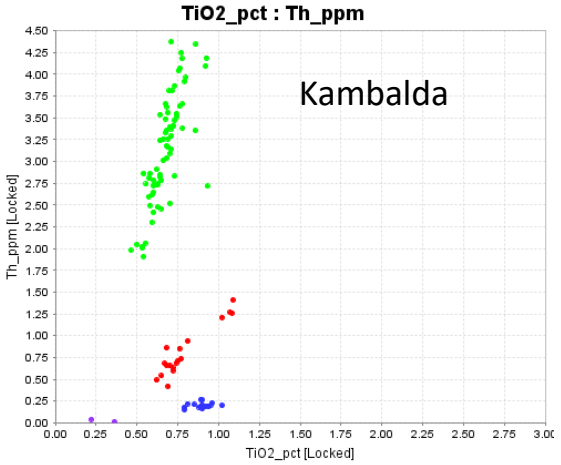
- ~400 km N of Kambalda





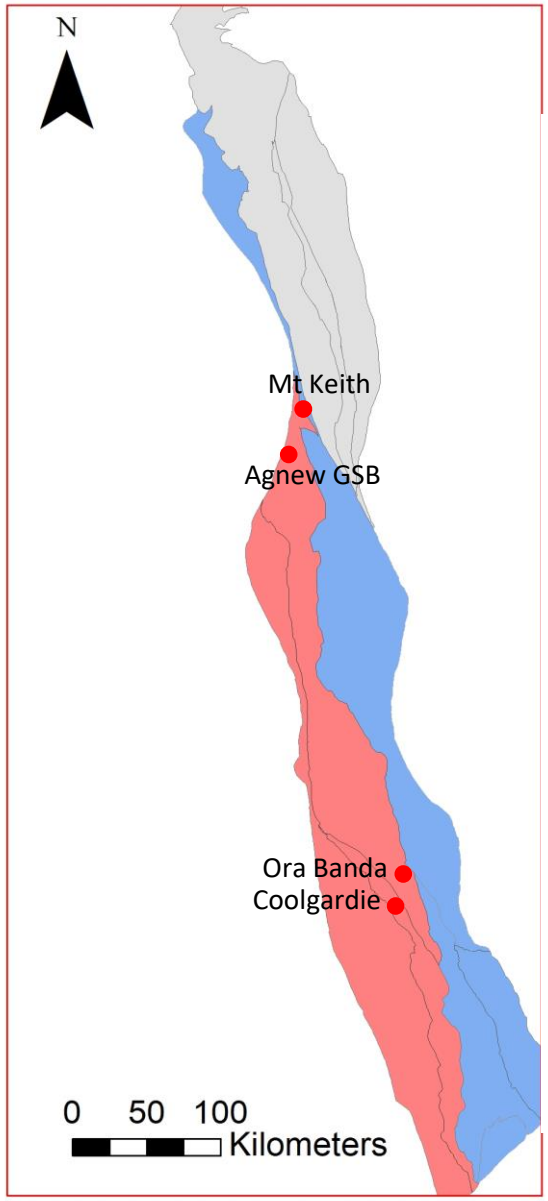
Agnew Greenstone Belt

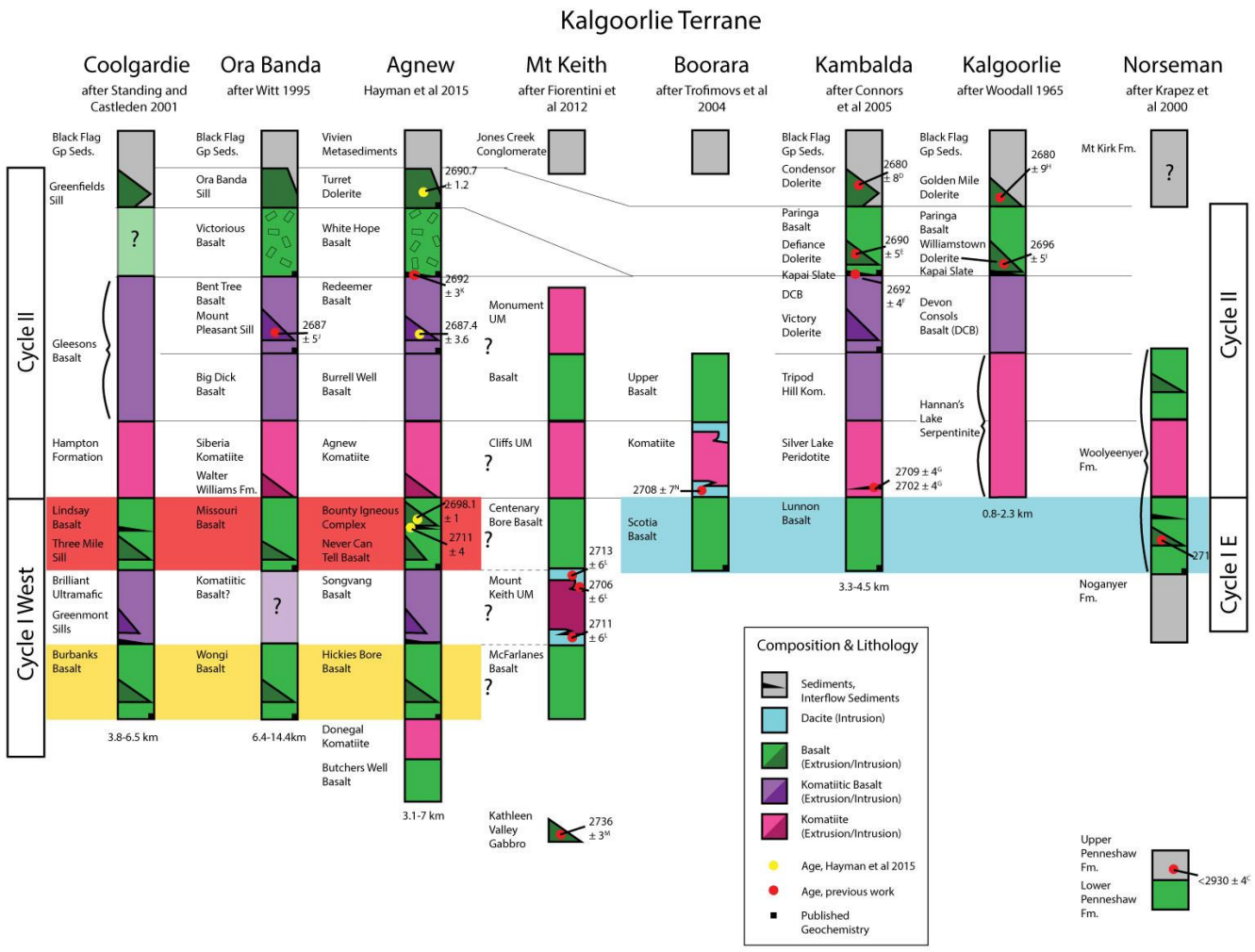




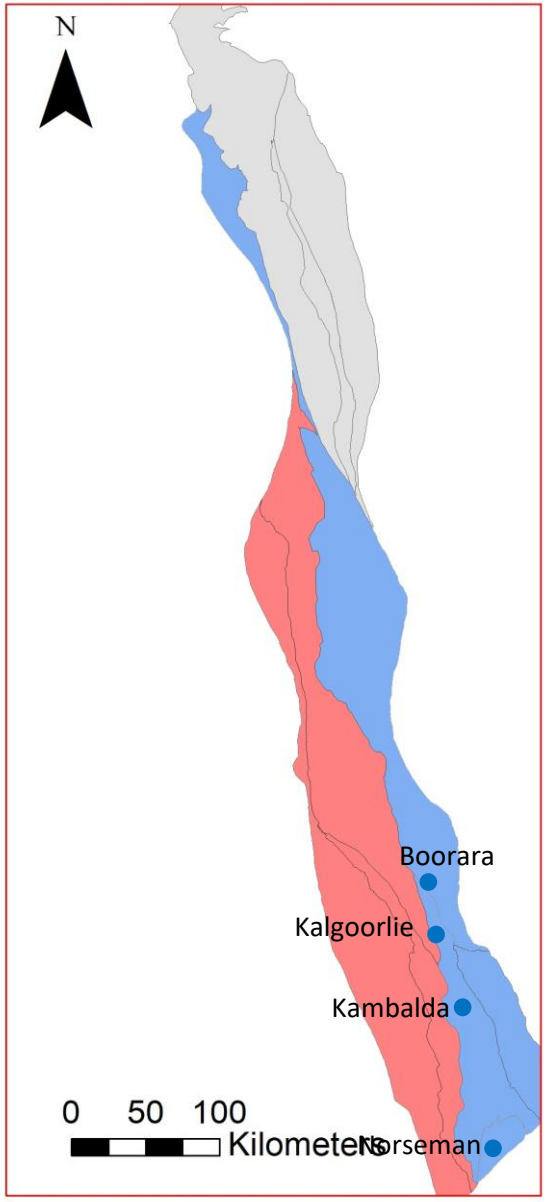
after Hayman et al 2015

~2720-2690 Ma Kalgoorlie Terrane

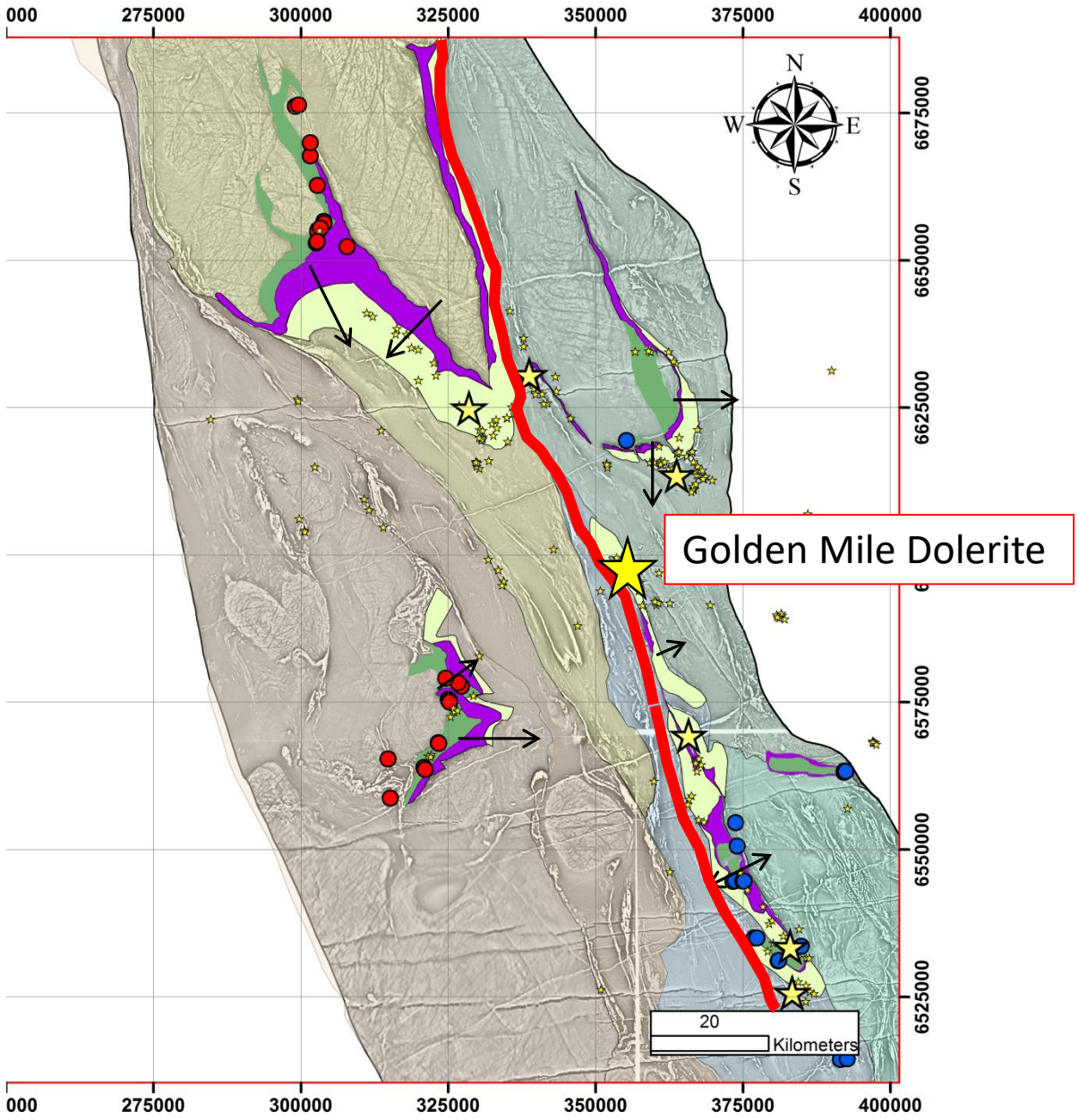




after Hayman et al 2015

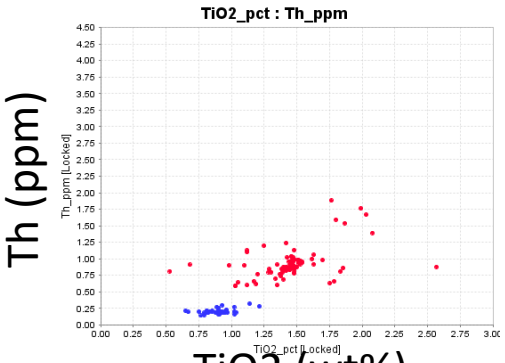


Kalgoorlie Area



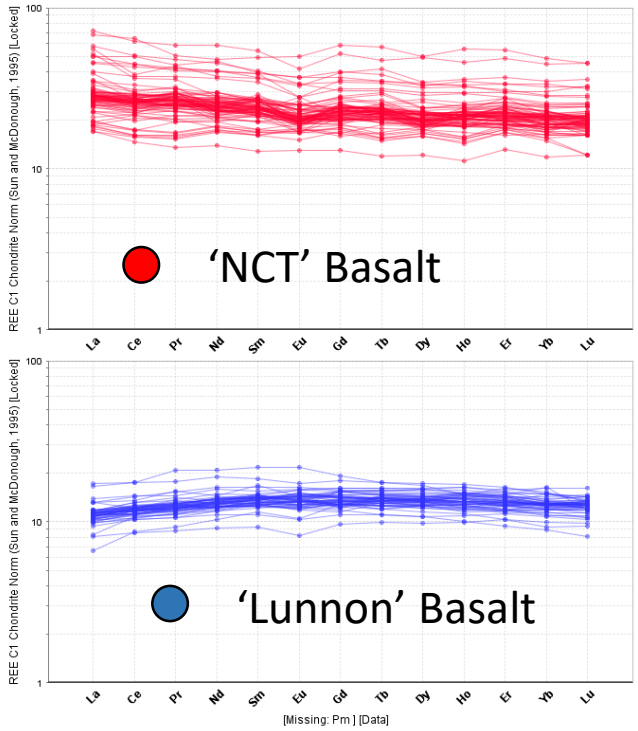
Facing direction

Upper basalts
Komatiite
Lower basalts



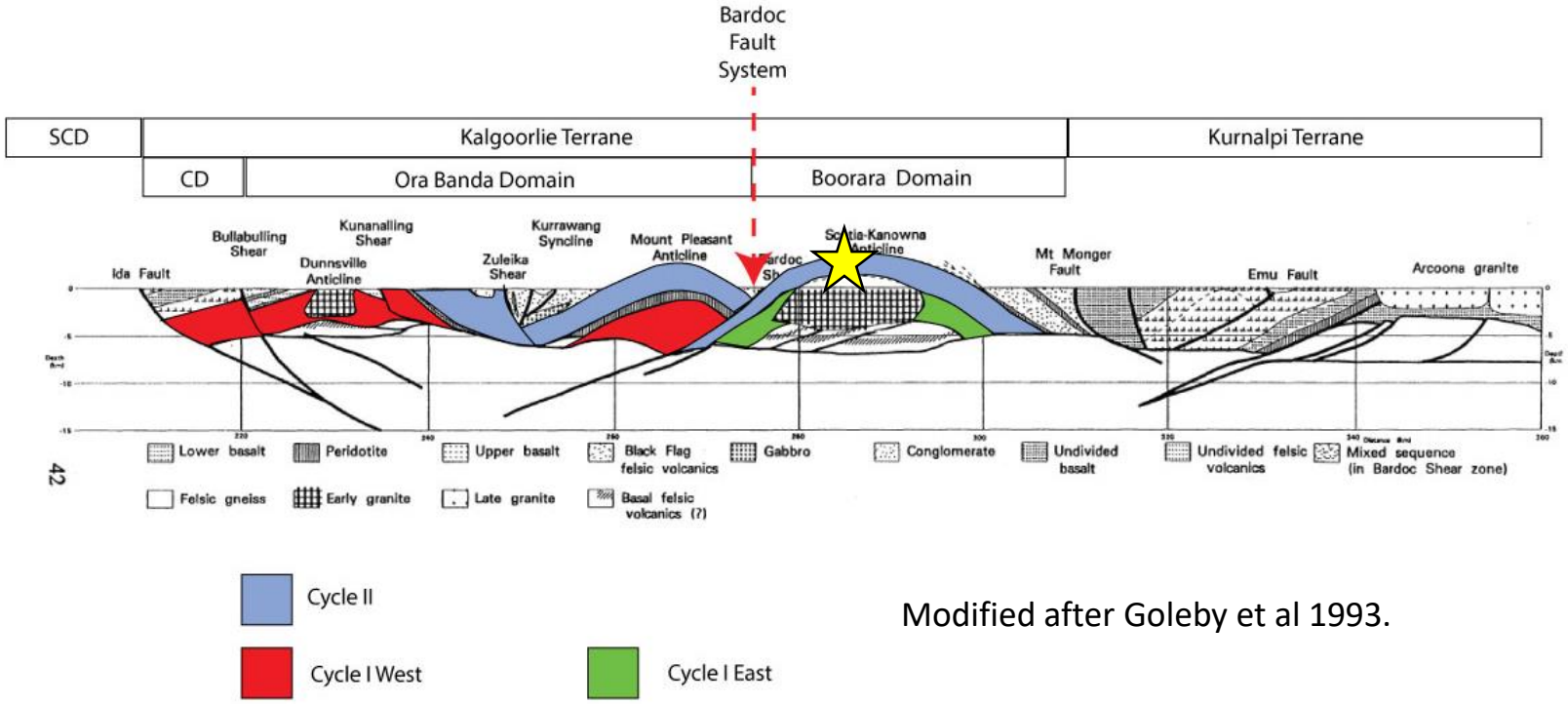
Th (ppm)

TiO2 (wt%)

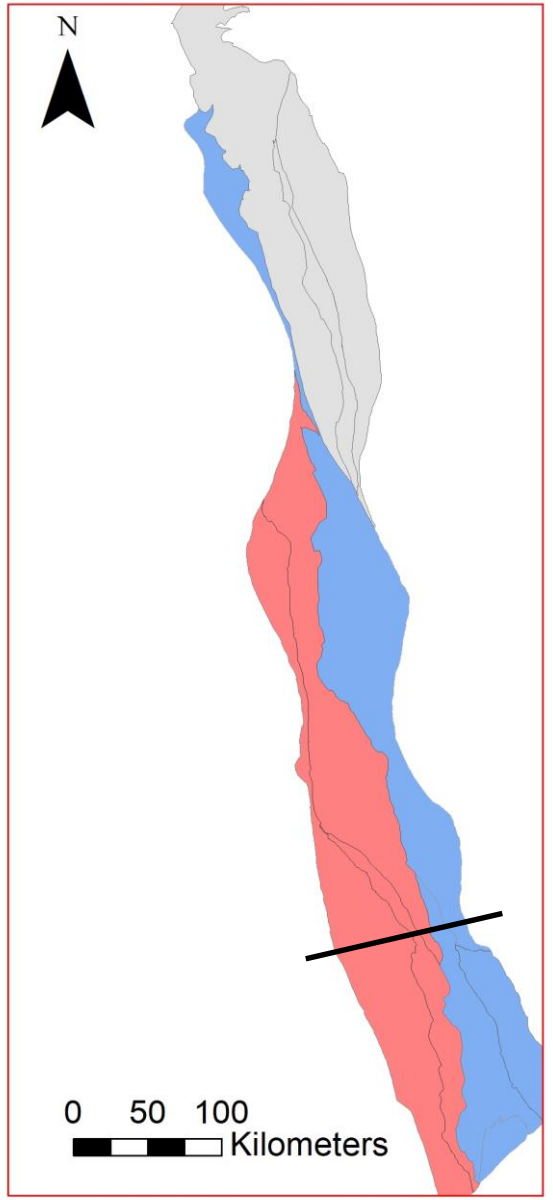


C1 normalised (M&S '95)

Deep Seismic Interpretation

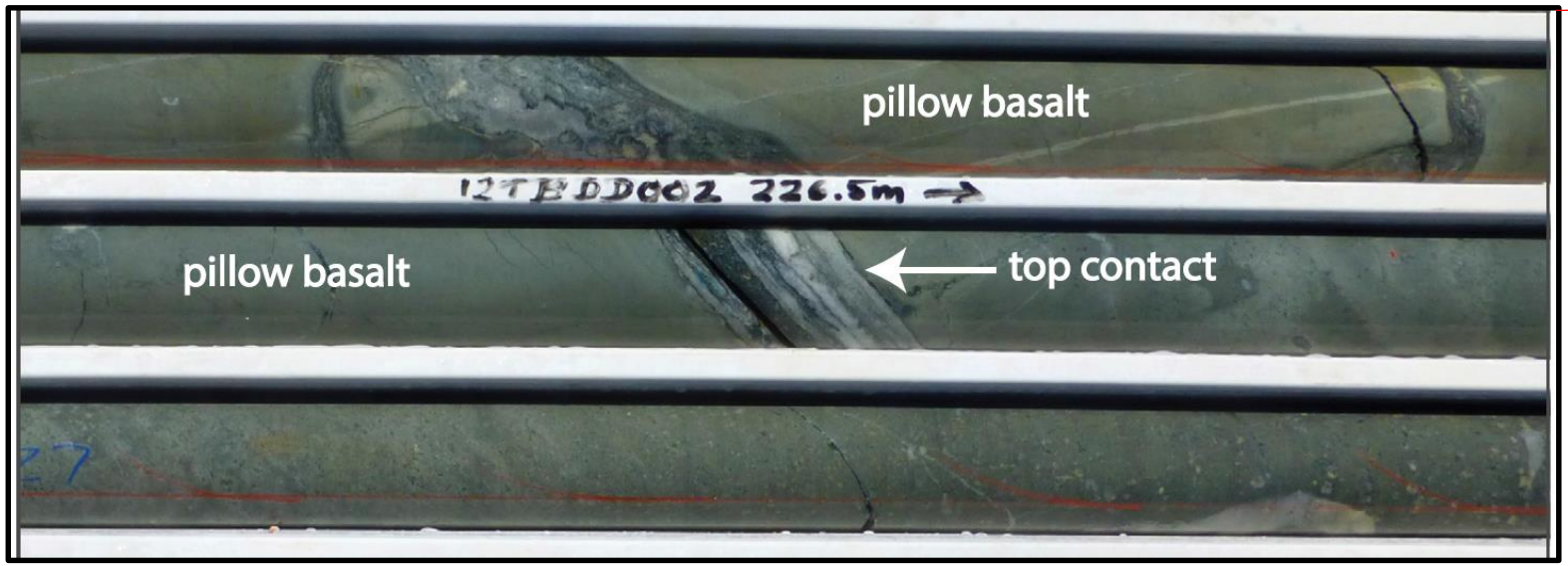


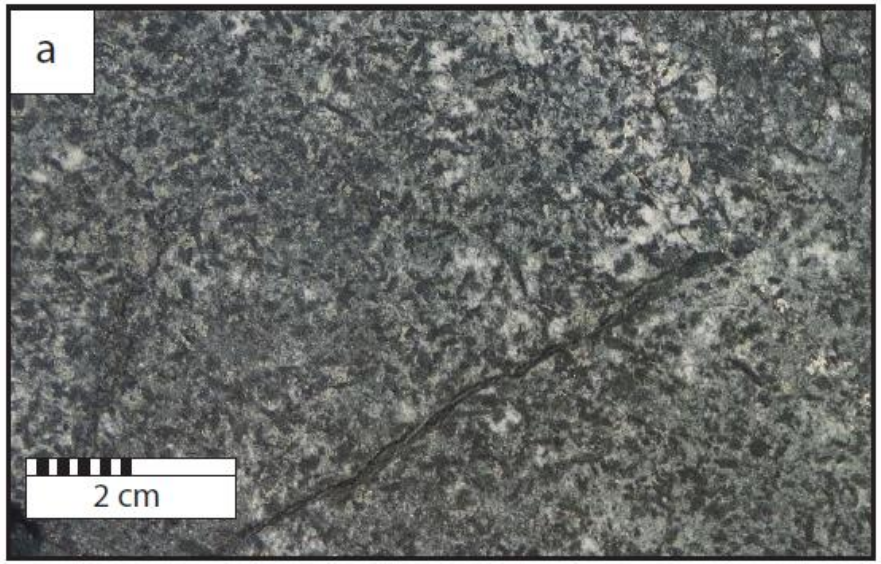
Modified after Goleby et al 1993.

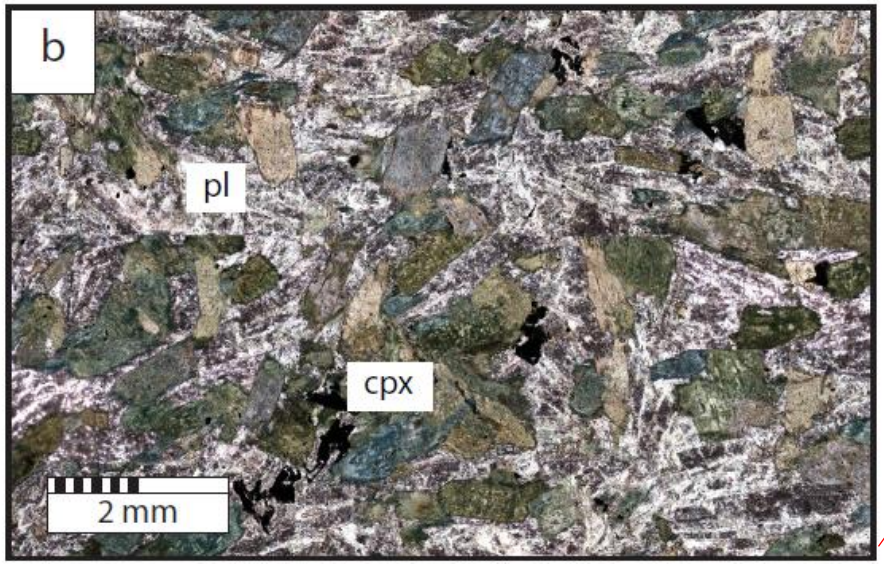


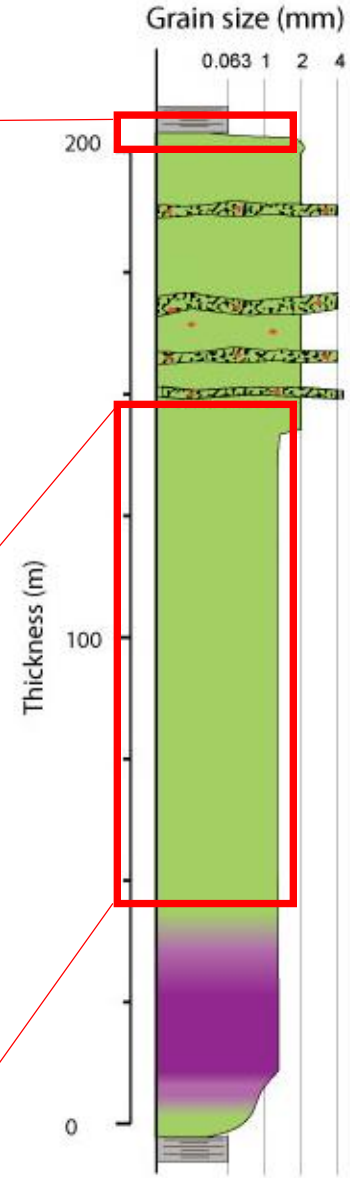
- Stratigraphic discontinuity highlights an important structure – deep tapping basin margin structure
- The important pathway for mineralising fluids

Part II: Host lithology controls on gold deposition

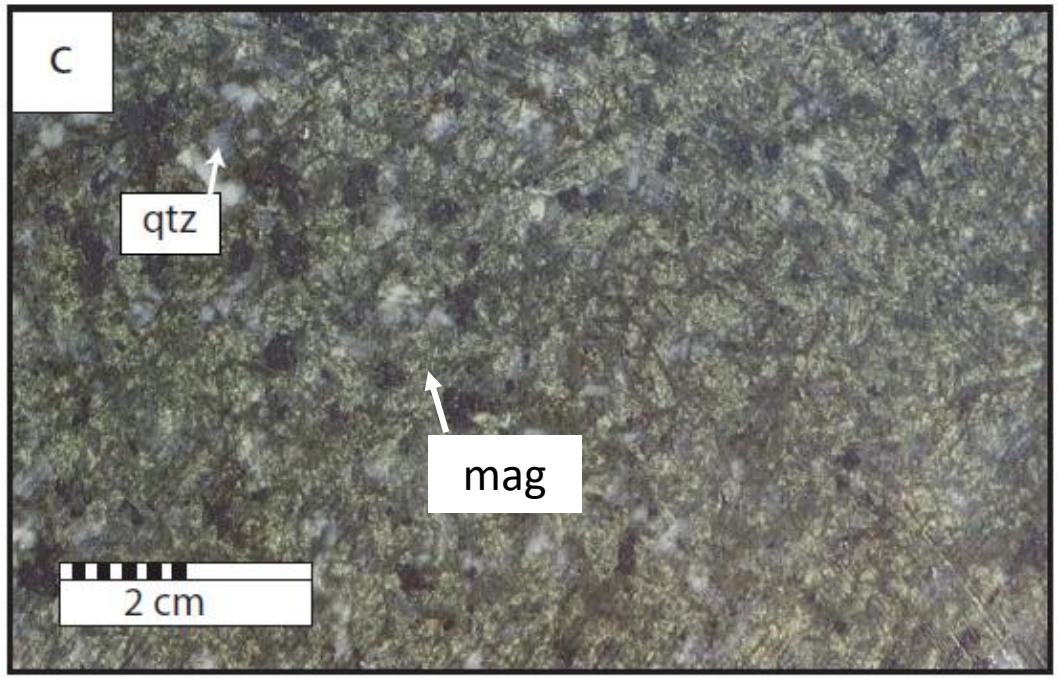


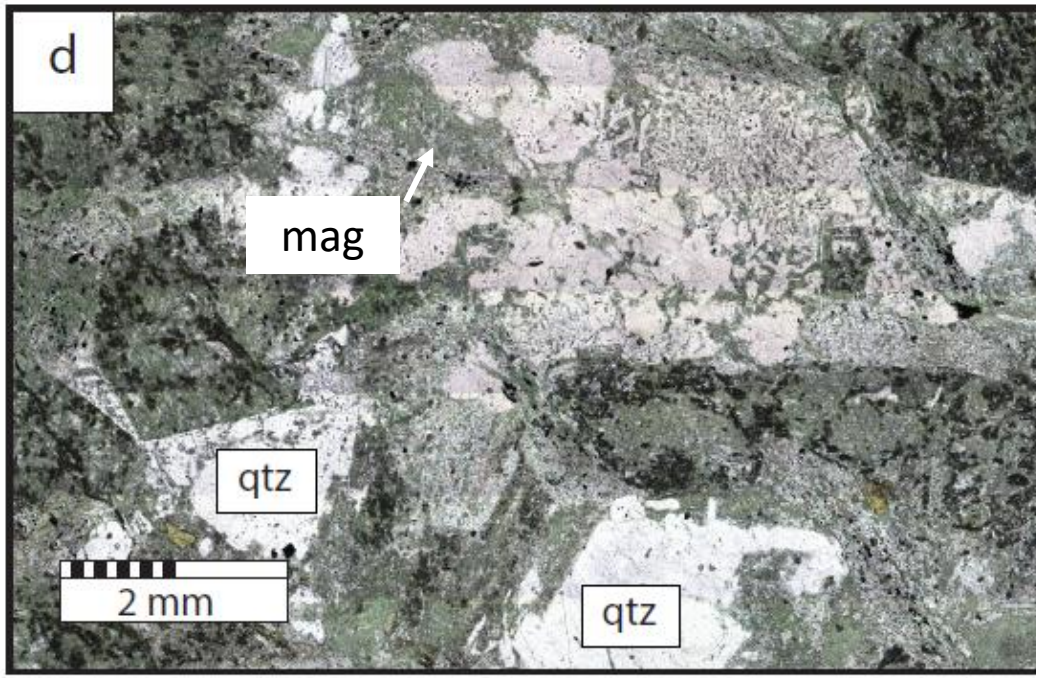


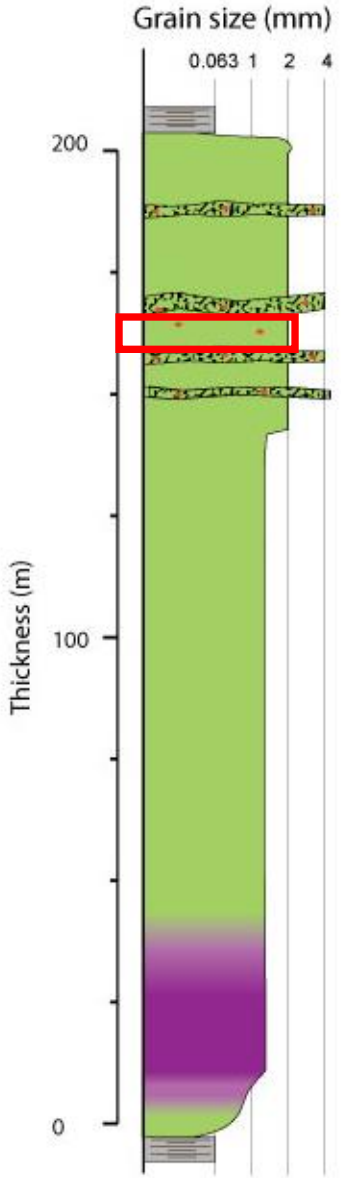




Quartz Dolerite/Gabbro



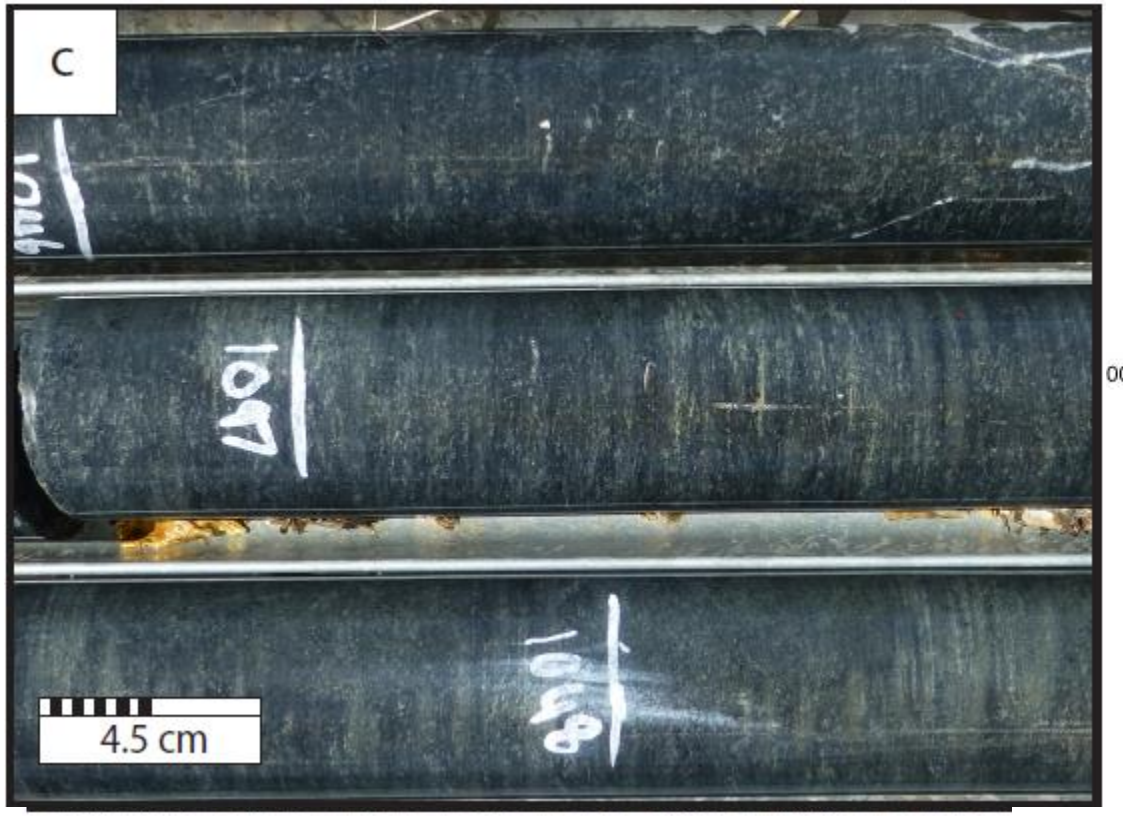




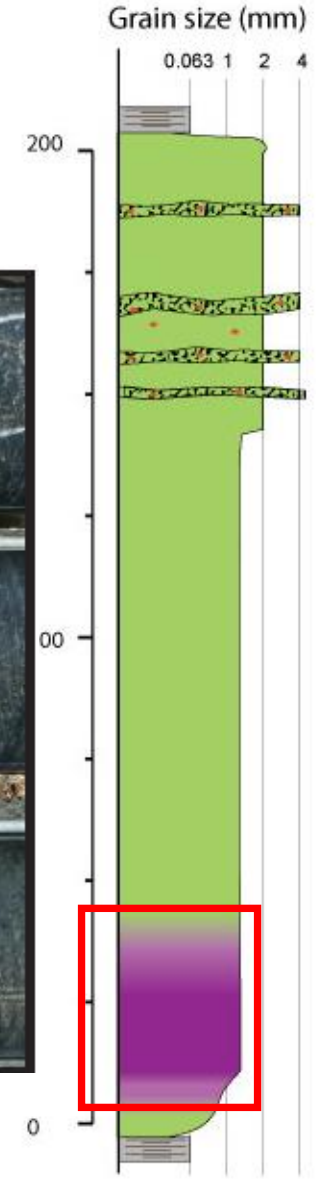
- Gabbro – average groundmass >5 mm
- Dolerite – average groundmass 1-5 mm
- (Basalt – average groundmass <1 mm)

Pyroxenites & Peridotites

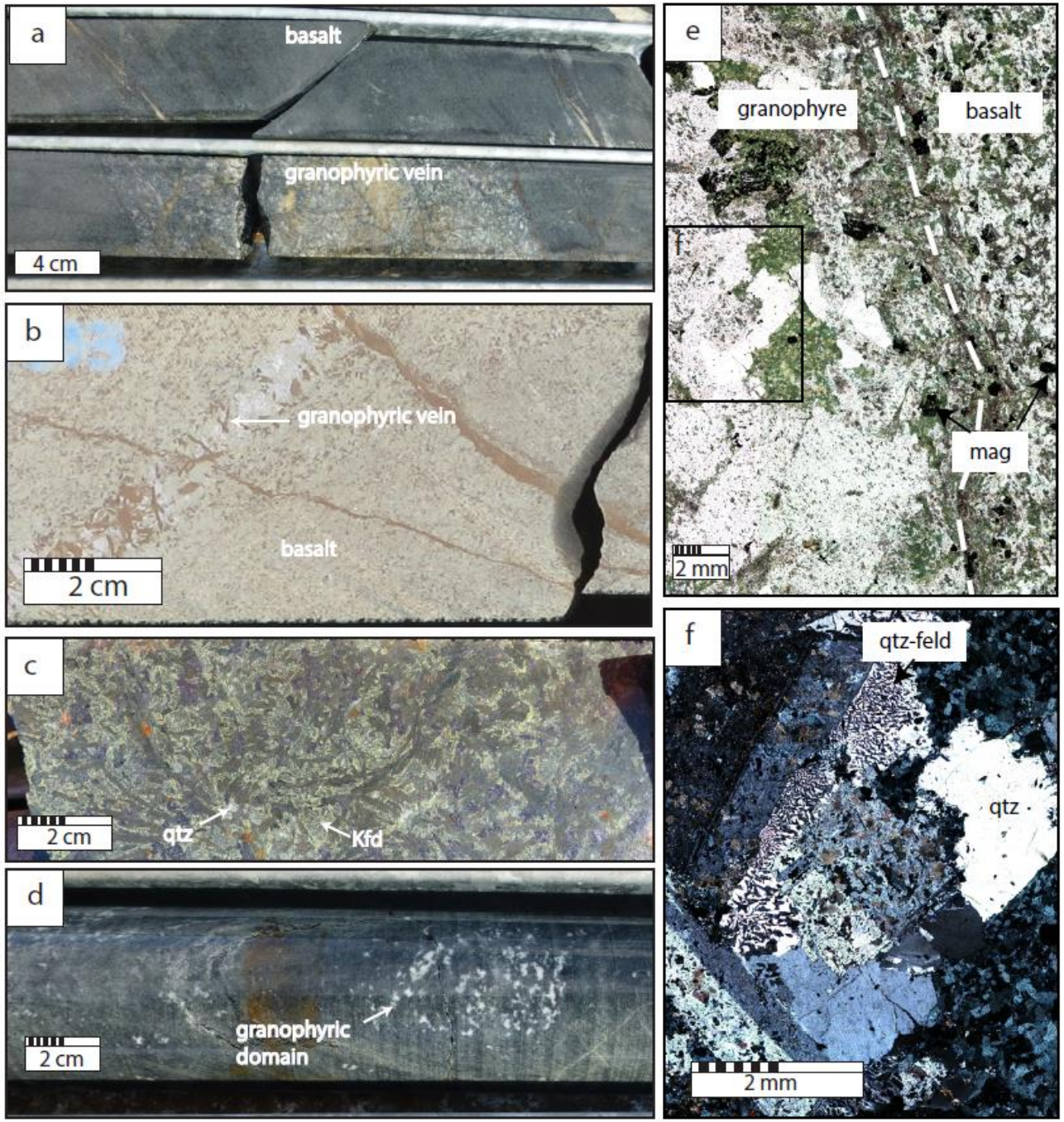
Pyroxenite

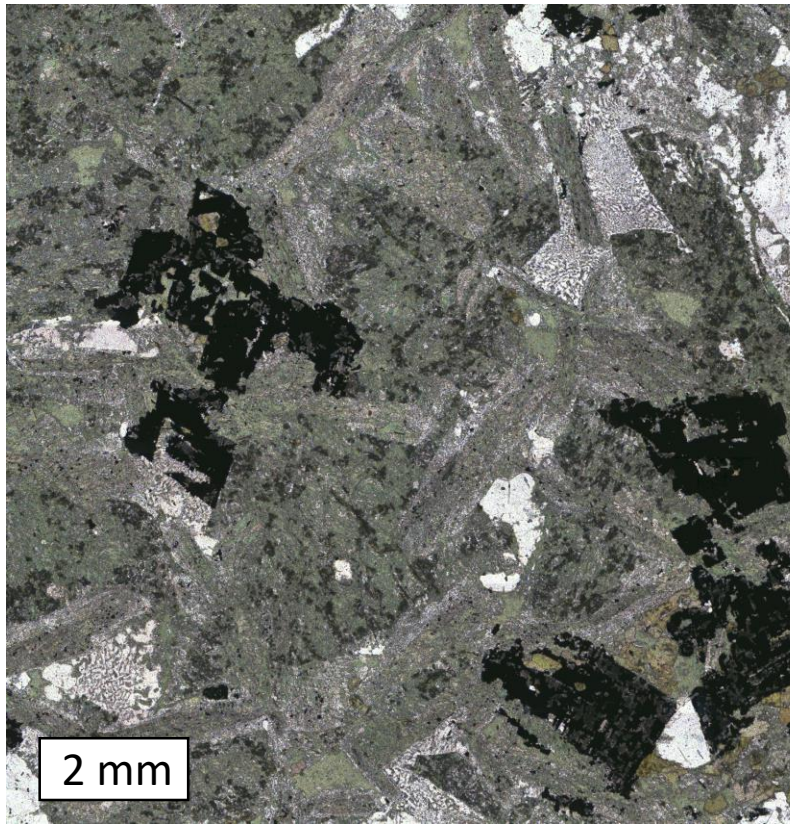


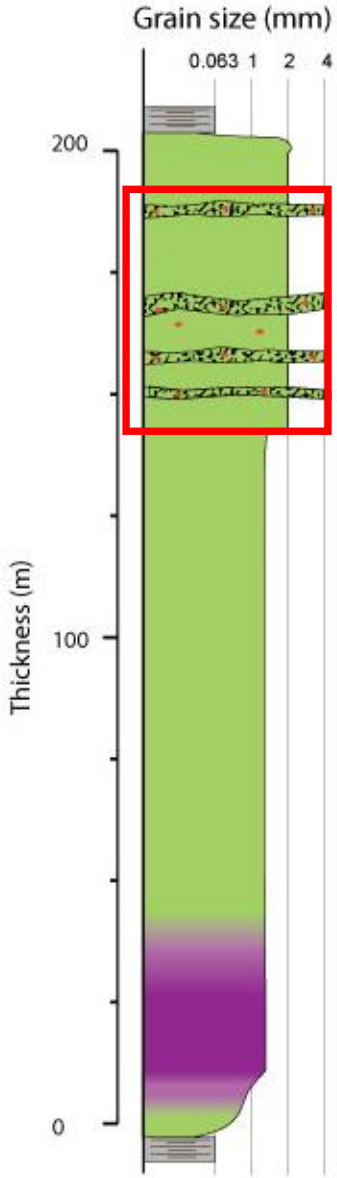
Peridotite

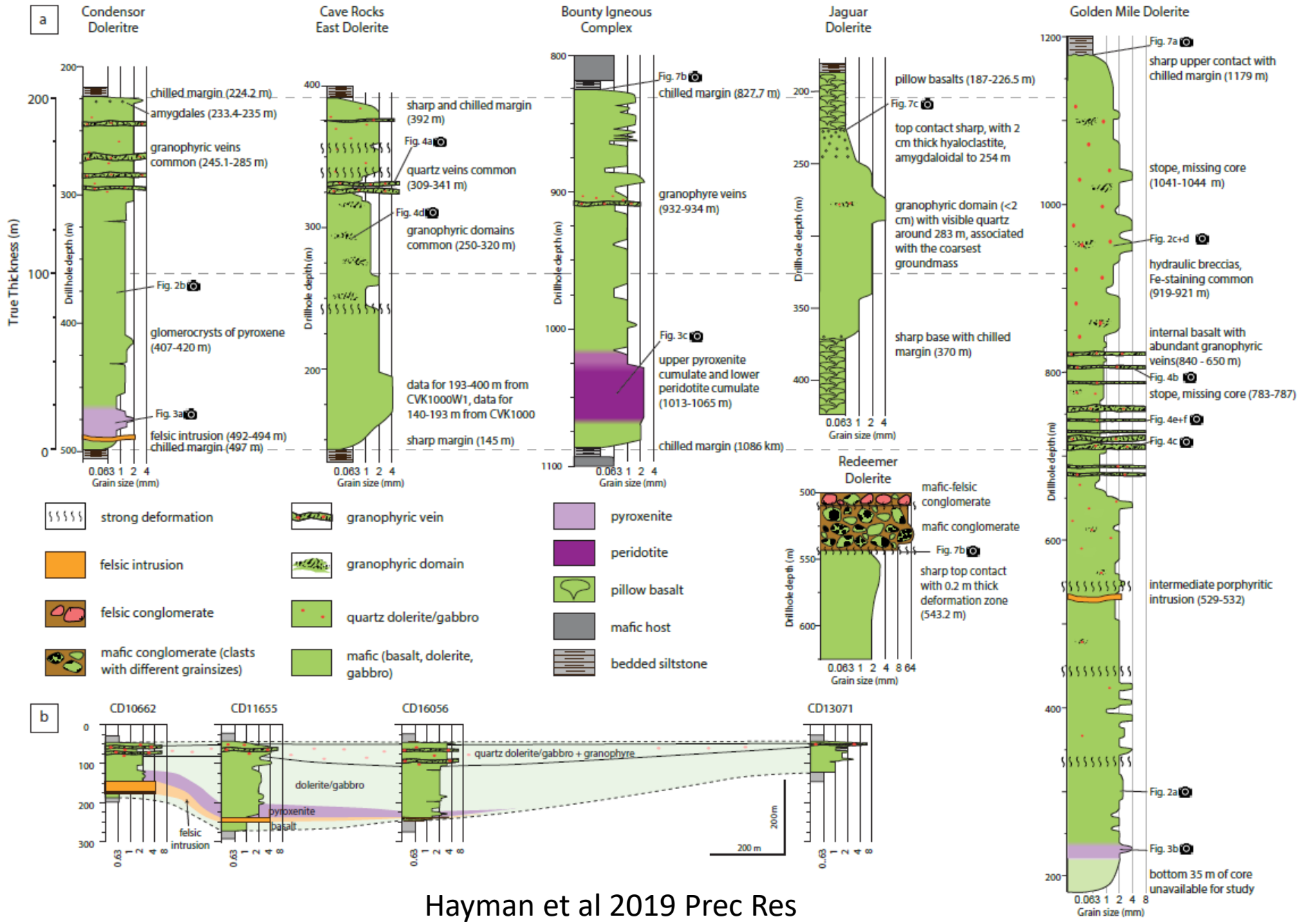


Granophyric veins



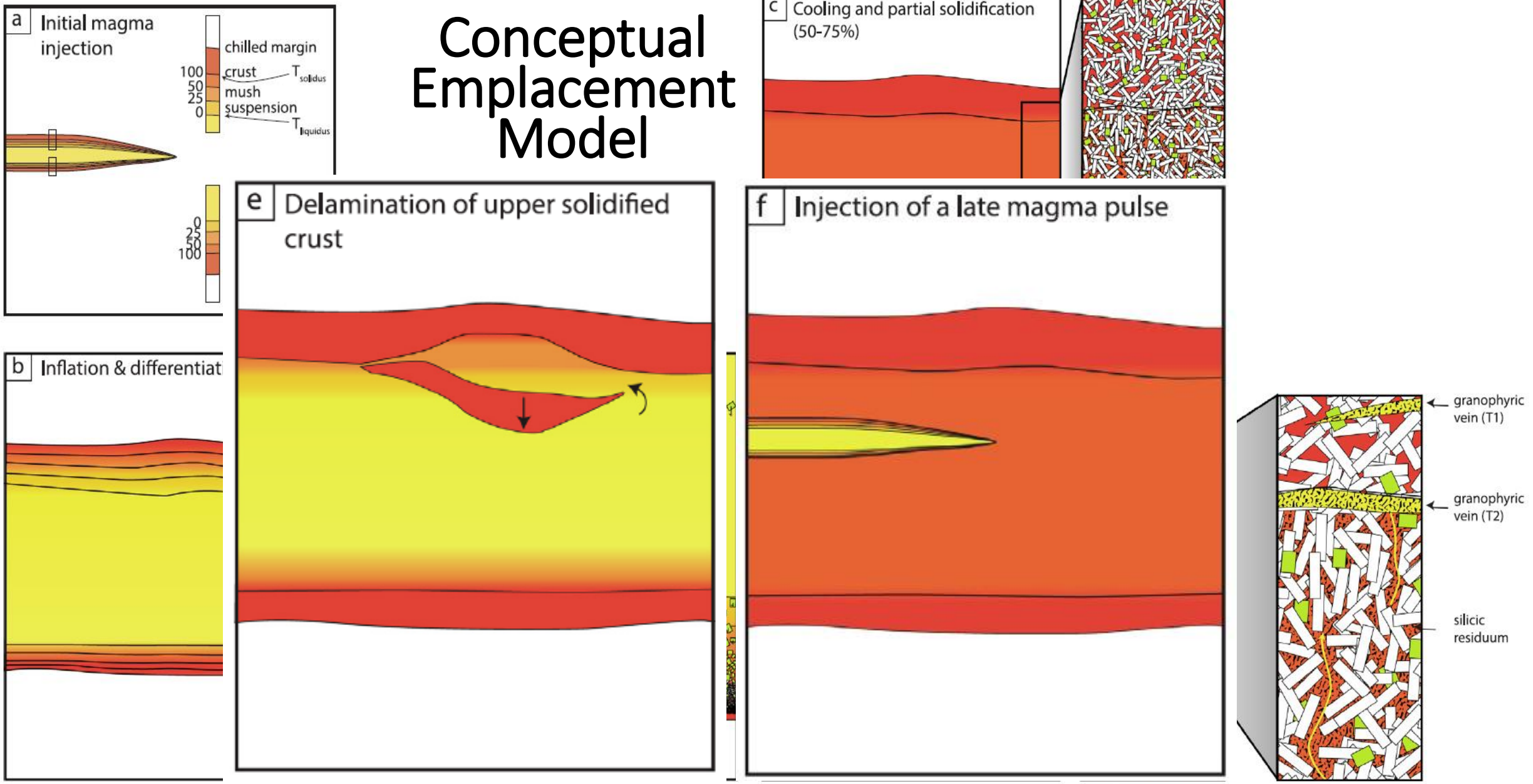






Hayman et al 2019 Prec Res

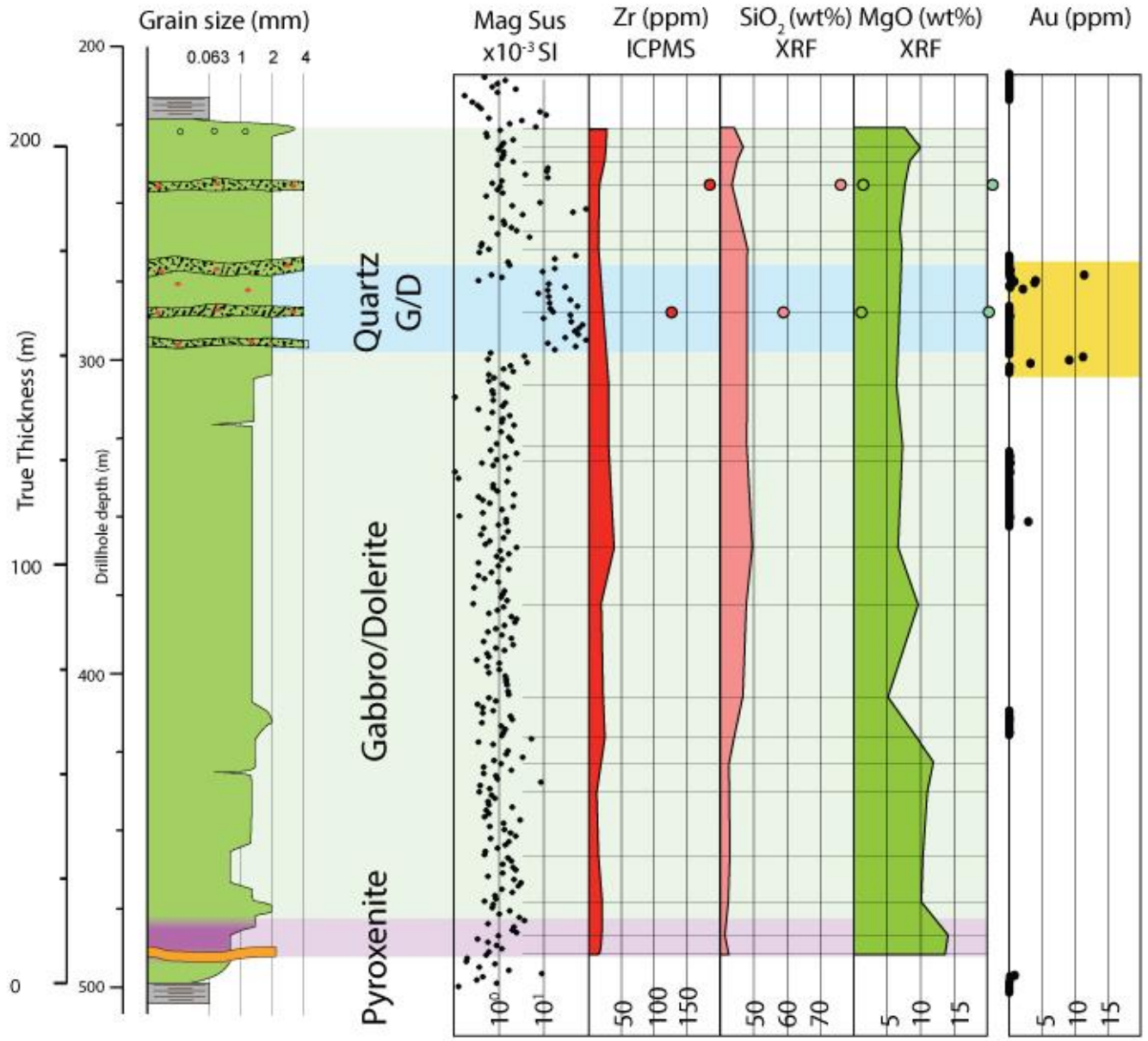
Conceptual Emplacement Model



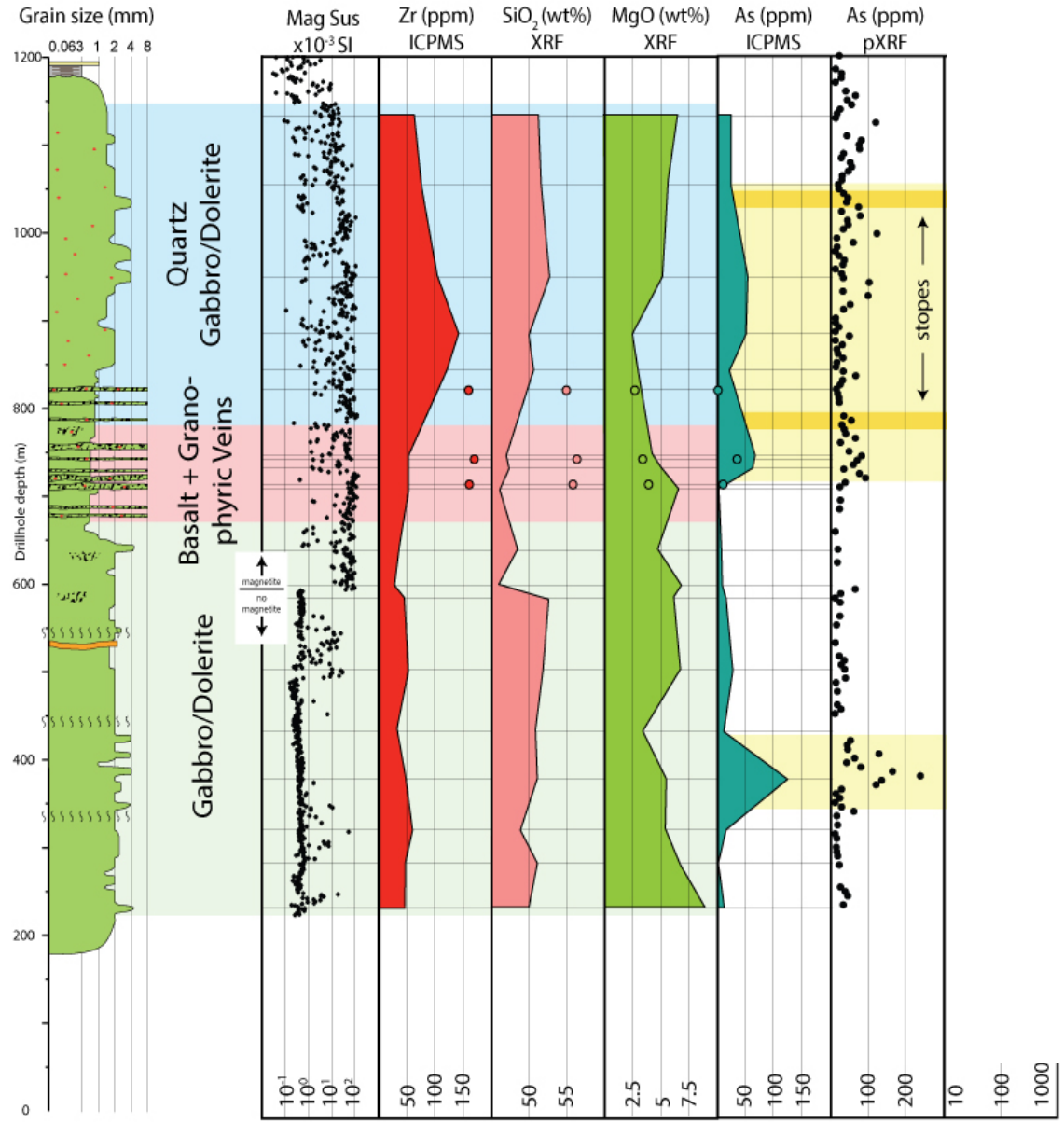
Hayman et al 2019 Prec Res

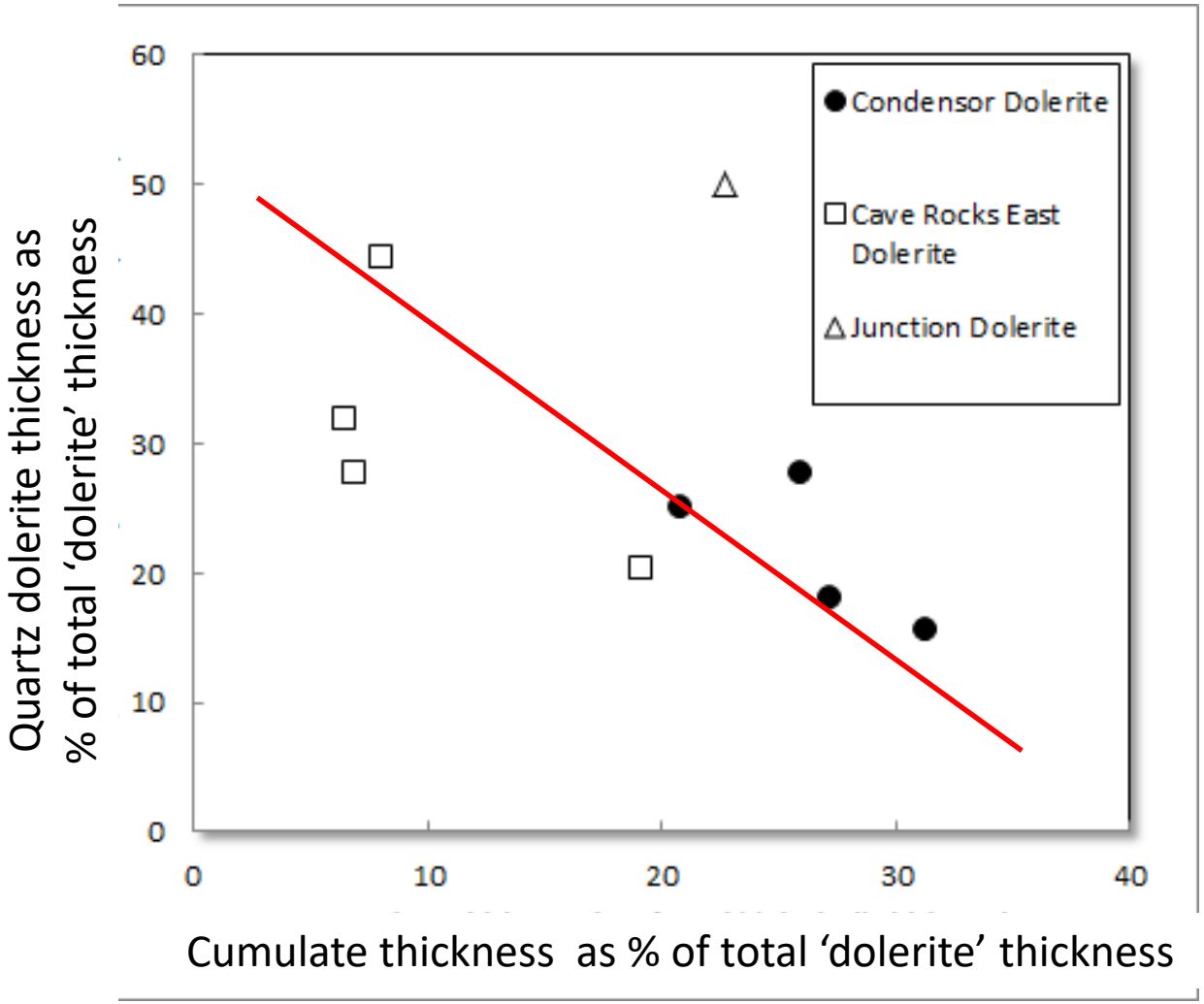
Gold comes later…

Barren: Condensor Dolerite (St Ives)



Mineralised 1: Golden Mile Dolerite





a)

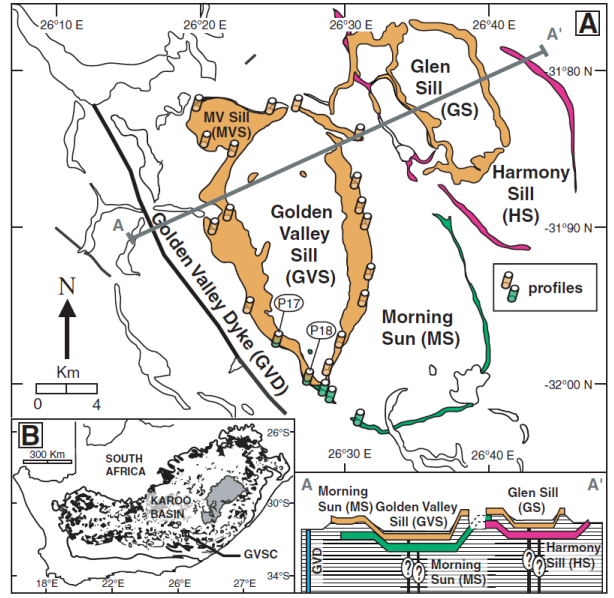
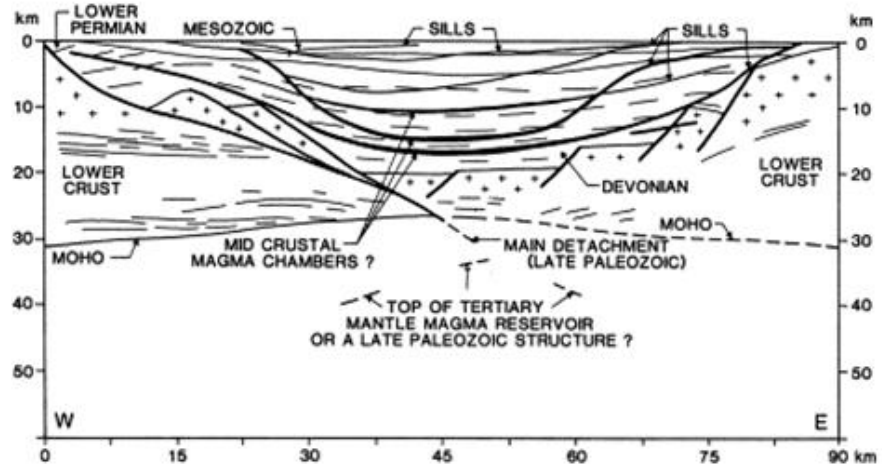
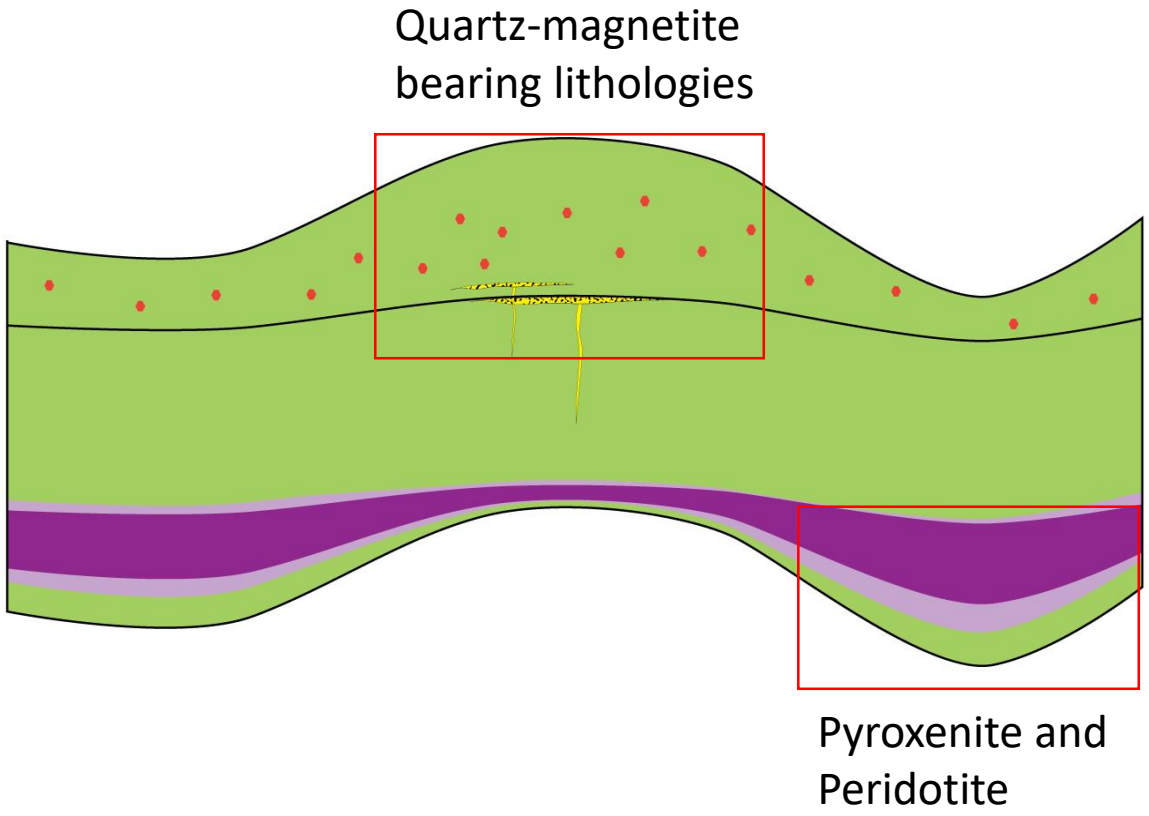


Figure 2. Summary of the geochemical architecture of the Golden Valley Sill Complex

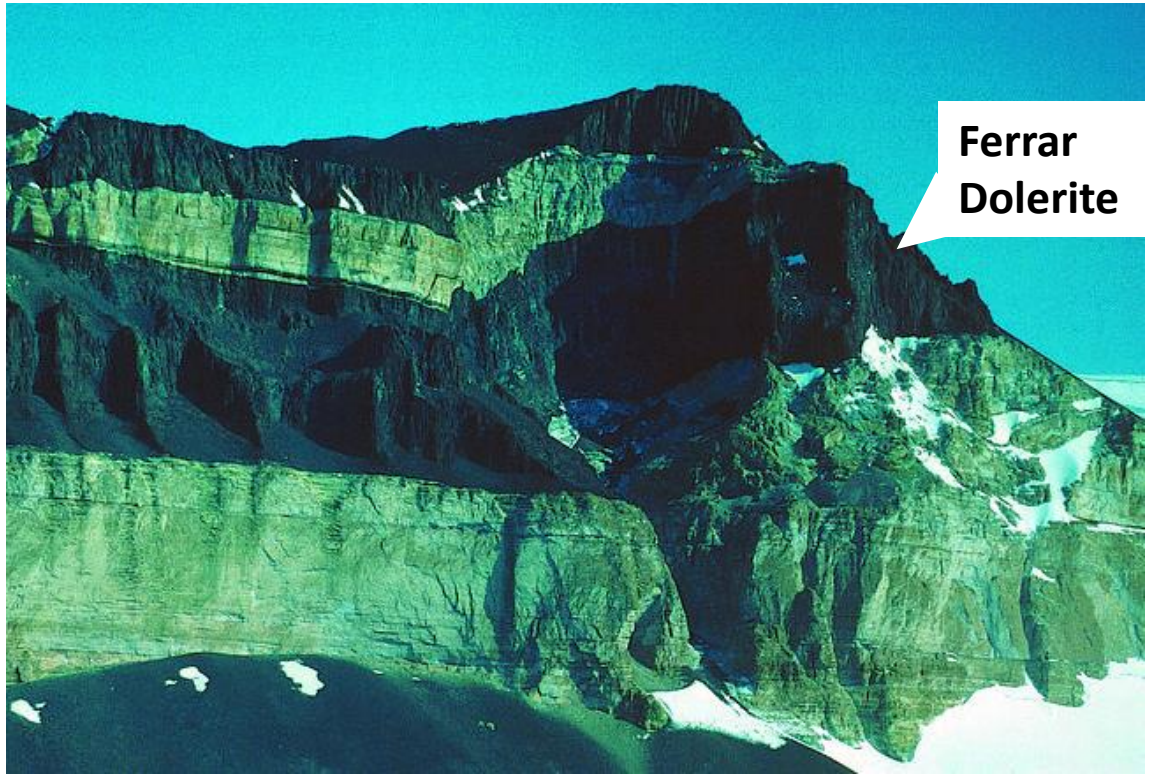
b)



Saucer-shaped sills: a) Golden Valley Sill, South Africa (Galerne et al 2011), b) North Sea (Hald and Tegner 2000)



Schematic cross section of a layered mafic sill highlighting the distribution of lithofacies at irregular margins



Ferrar Dolerite, Antarctica; Photo by Kim Westerskov © Kim Westerskov

Conclusions & Exploration Implications

1. The Kalgoorlie Terrane can be divided into two by the Bardoc Fault System, which is a basin margin structure
2. The northward and southward continuation of this structure should be of interest for mineral explorers
3. There is a strong association between quartz-bearing mafic rocks and gold, which occur in the top half of mafic sills
4. One should target mafic sills with the thickest quartz-bearing lithologies (that occur near deep-tapping structures); such lithologies may be tracked using geophysical techniques (magnetic surveys)


Thanks!