Paleohydrologic evolution of epithermal gold-silver deposits of the Hauraki Goldfield, New Zealand

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Hauraki Goldfield

~50 low-intermediate sulfidation epithermal Au-Ag veins

Produced since 1882–

- *12.7 Moz Au*
- *55.9 Moz Ag*

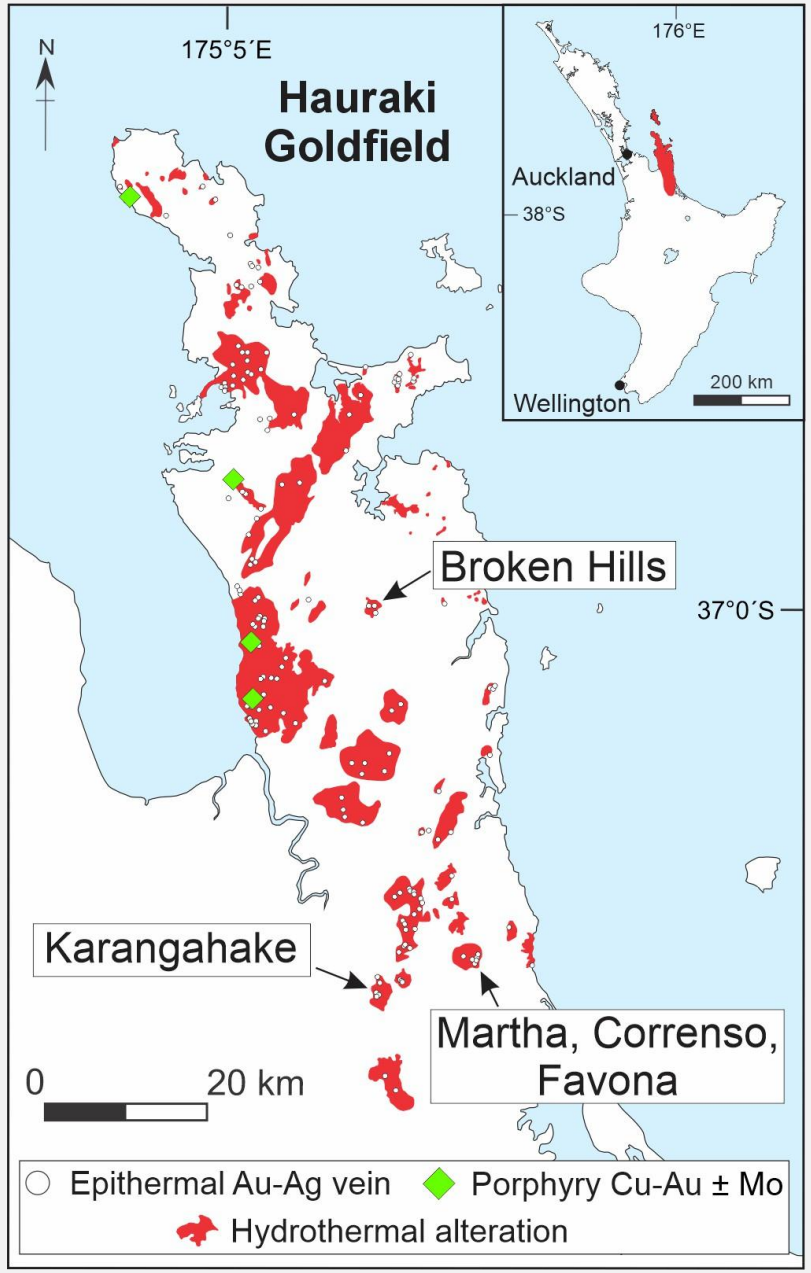
Exposure depths range from surface to ~1 km

Focus on paleohydrology

- *Waihi vein system (Martha, Correnso, Favona)*
- *Broken Hills*
- *Karangahake (including Rahu & Ascot)*



(D. Castendyk)

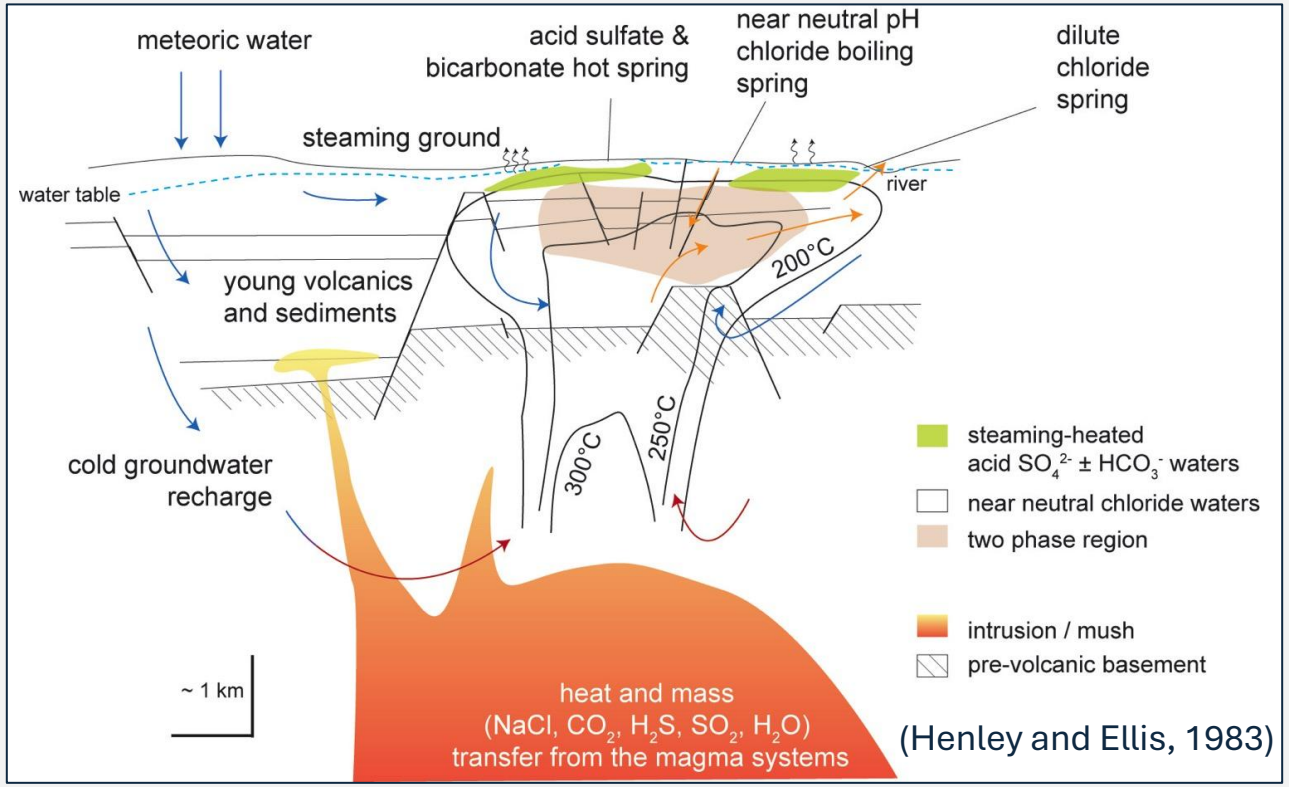


(modified Christie et al., 2007)

Hydrology

- *Sinters (silica)*
- *Hydrothermal eruption breccias*
- *Steam-heated acid sulfate alteration*

Fluid inclusions: *depth estimates from quartz, calcite, amethyst and sphalerite*



(Henley and Ellis, 1983)


Sinter Orakei Korako


Breccia Orakonui


Craters of the moon



Waihi vein system

Comprised of Martha, Correnso & Favona deposits

Favona

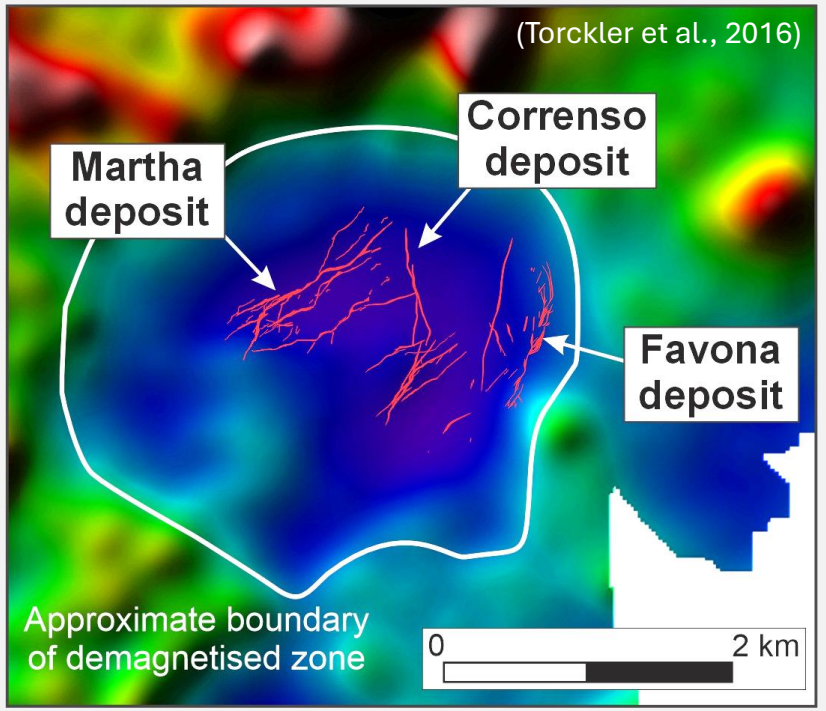
- *Silica sinter = paleosurface*
- *Hydrothermal breccia = at or near paleosurface*

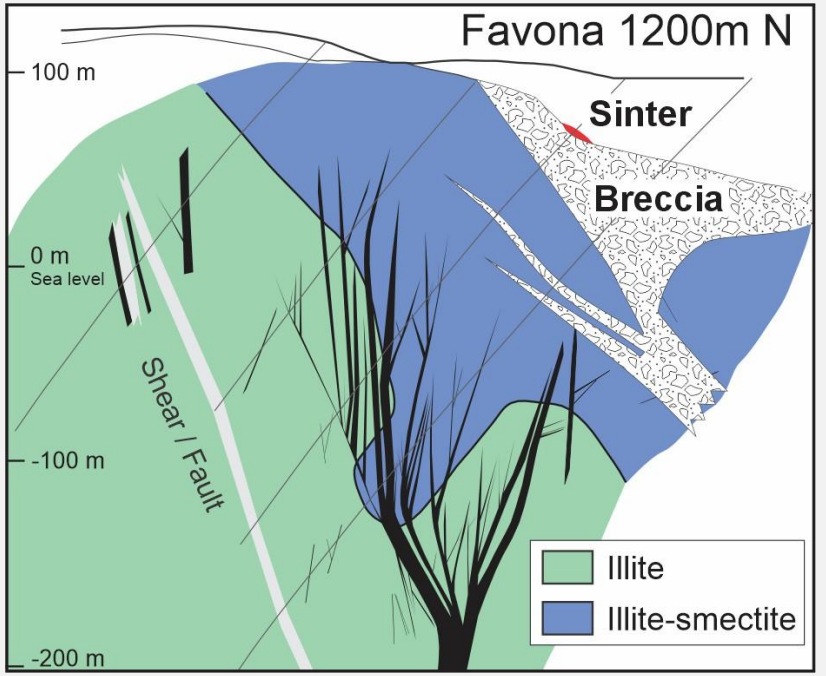


Sinter with cinnabar

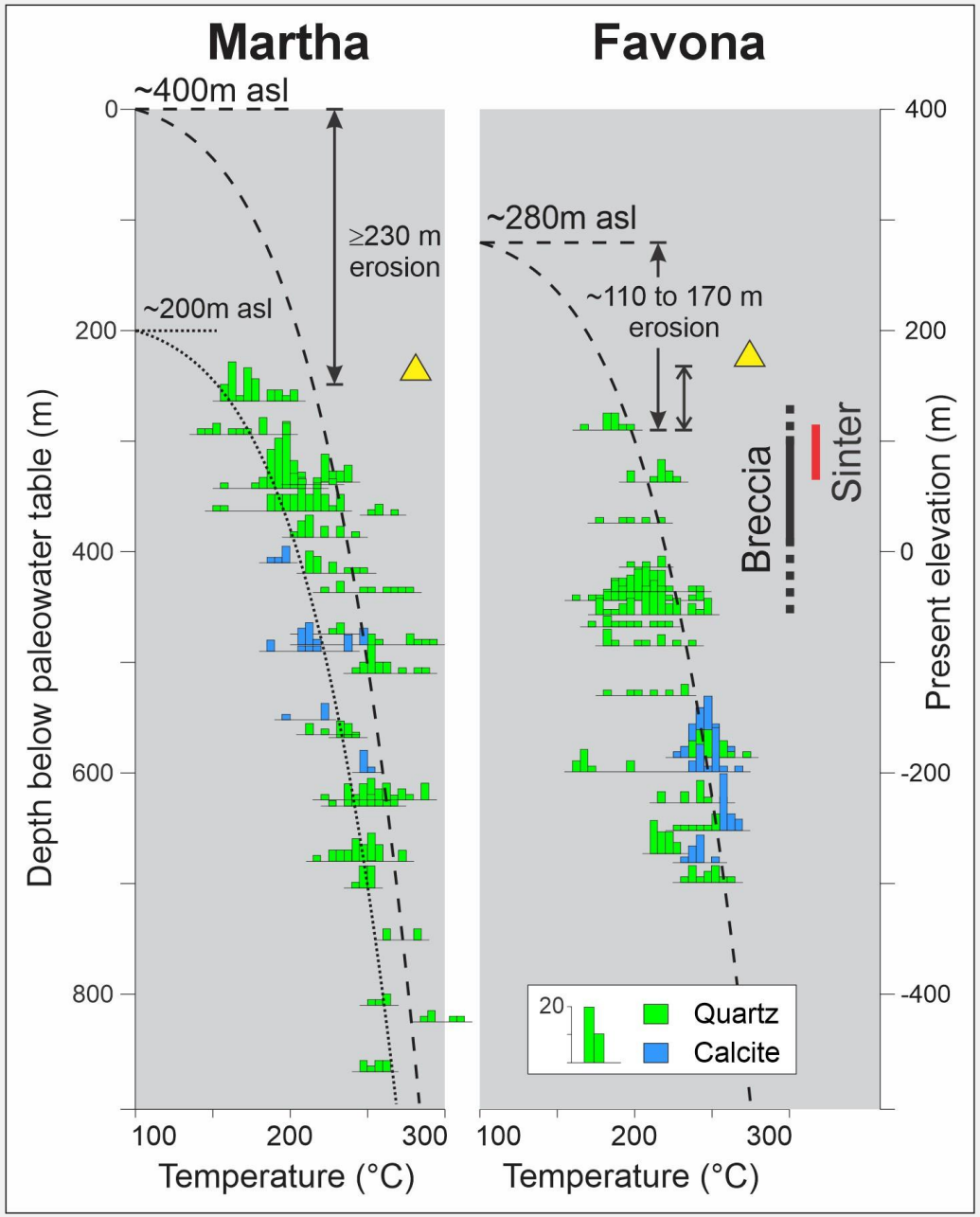


Hydrothermal eruption breccia with quartz vein clasts





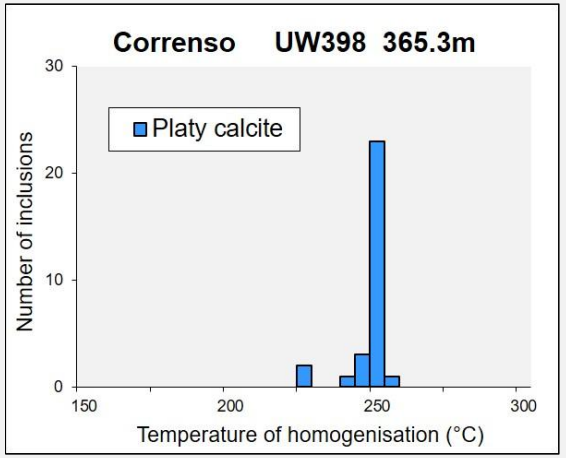
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Fluid inclusion depth estimates

(paleowater table)

Martha	Favona
~400 m	~280 m



Illite (≥220°C) approximated depths

Martha	Amaranth	Favona
*~370 m**	*~365 m**	~330 m

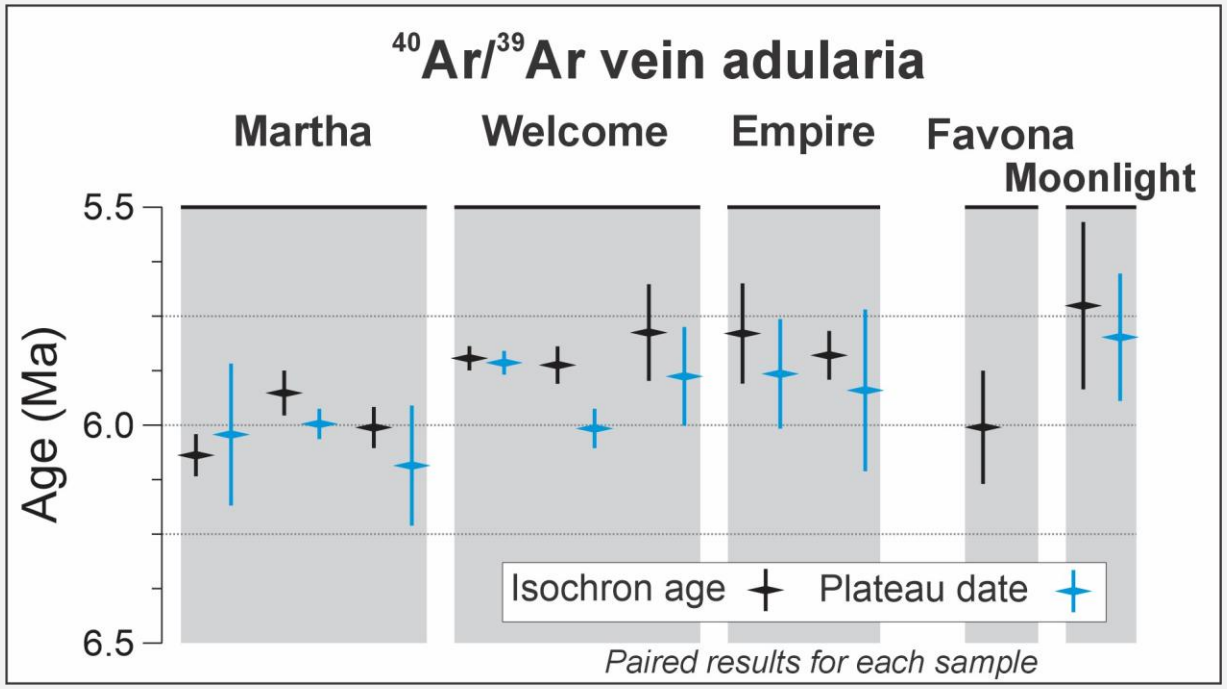
** shallowest occurrence of illite not constrained*

Silica sinter = *paleosurface*

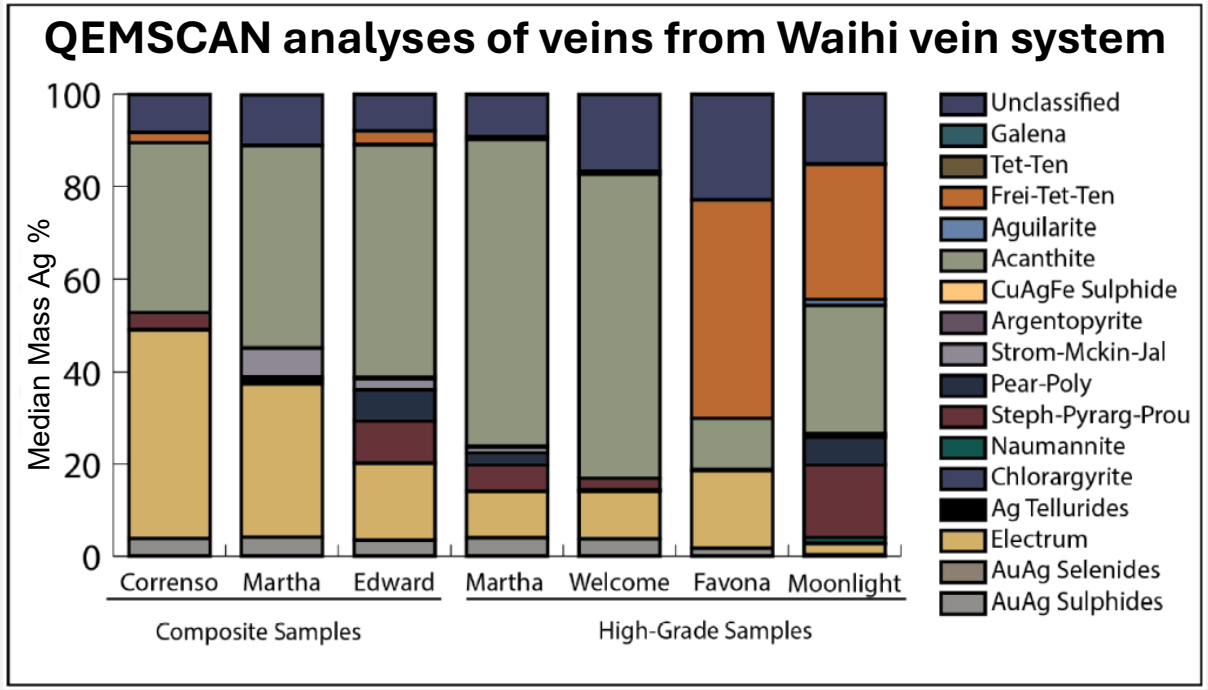
65 to 115 m (Favona)

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Simpson & Mauk (2007) – data Jennings (1991), Brathwaite & Faure (2002), Hollinger (2002)



(Skinner, 2014)



(Fyfe, 2014)

- Ar-Ar vein adularia indicate overlap & differences in time when veins formed
- Some veins have different ore mineral associations – hint at different parent fluids

*Favona & Moonlight**] *Ag-selenides & tetrahedrite (Ag-Sb sulfosalts*)*

Sb-Se fluid

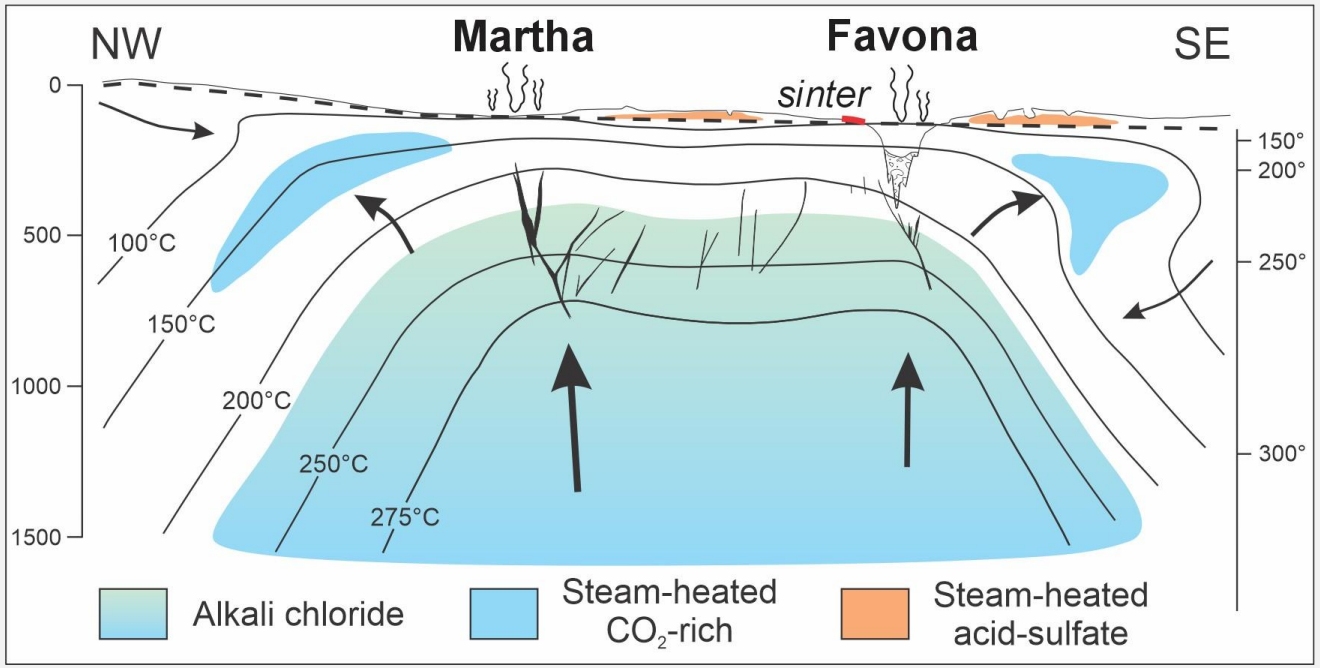


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Complex paleohydrology – elements of reconstruction

- *Overlapping & multi-stage vein formation events*
- *Different parent fluids?*

  Favona *1) veins + sinter*
  2) hydrothermal eruptions
  3) veins + sinter

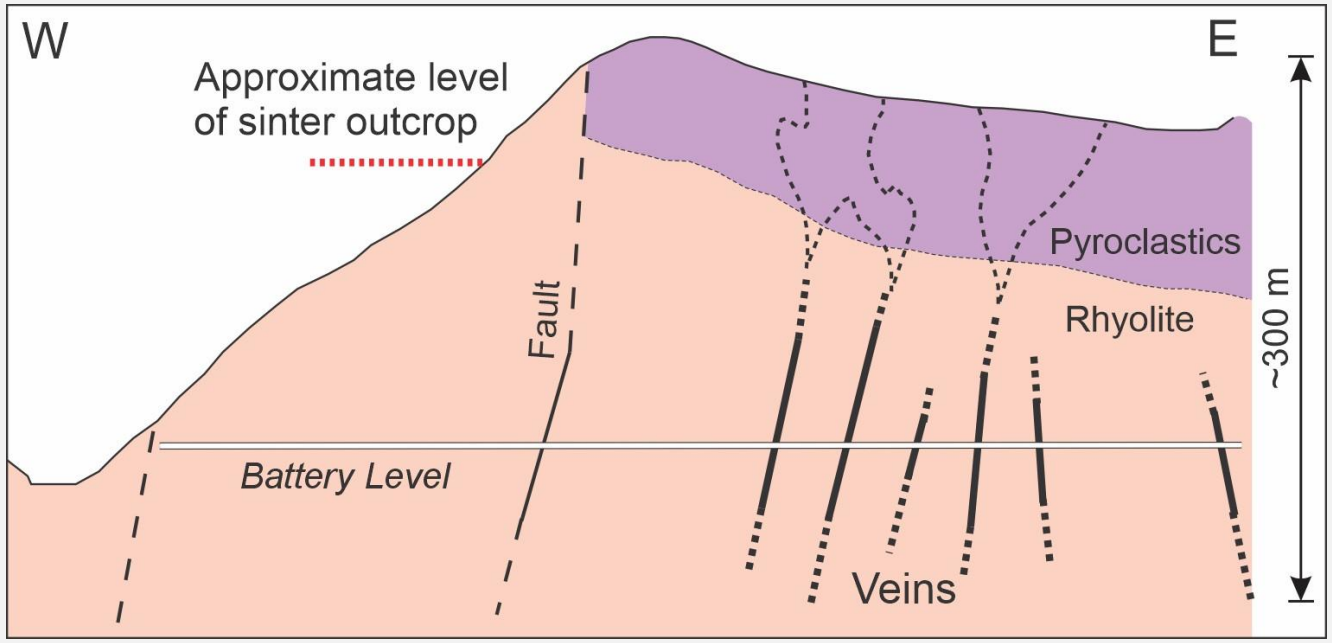


Favona: sinter paleosurface (~100 m) ≠ FI paleowater table depth estimate (~280 m)
burial or erosion during hydrothermal activity

- *Post-mineral volcanism, south-eastward tilting, and erosion*

Broken Hills

- *Breccia pipes extend above veins = hydrothermal eruptions vents*
- *Silica sinter adjacent veins (at ~150 m asl) = paleosurface*
- *Other sinters at Puketui (~1 km) and Skyfarm (~0.8 km)*

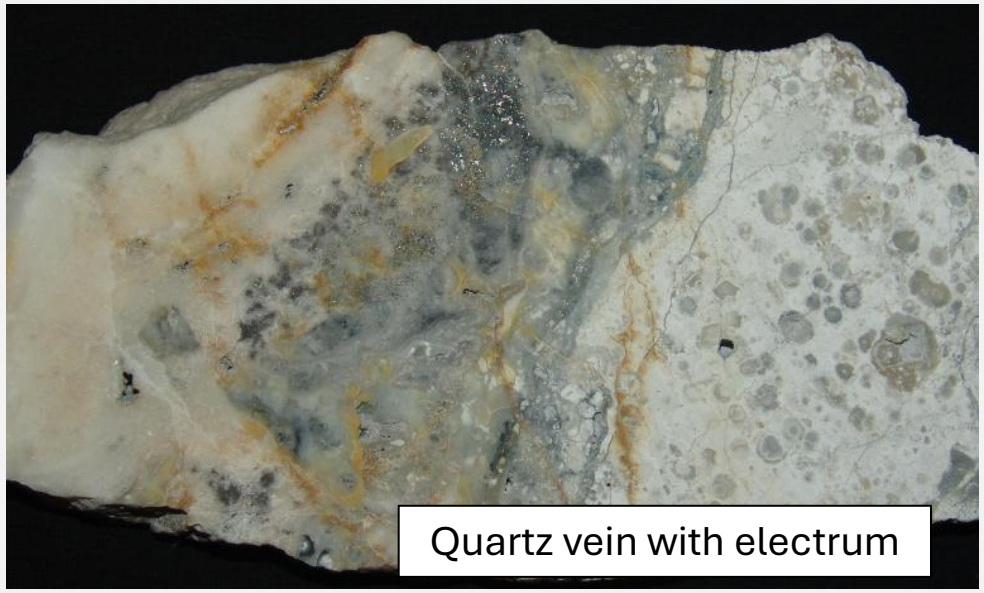


(Cocker, 2009)



Silica sinter - Skyfarm

(L. Carson)



Quartz vein with electrum

Fluid inclusion estimate

Paleowater table ~300 m asl
(T_H median 222°C)

Illite minimum depth ~270 m asl

Sinter

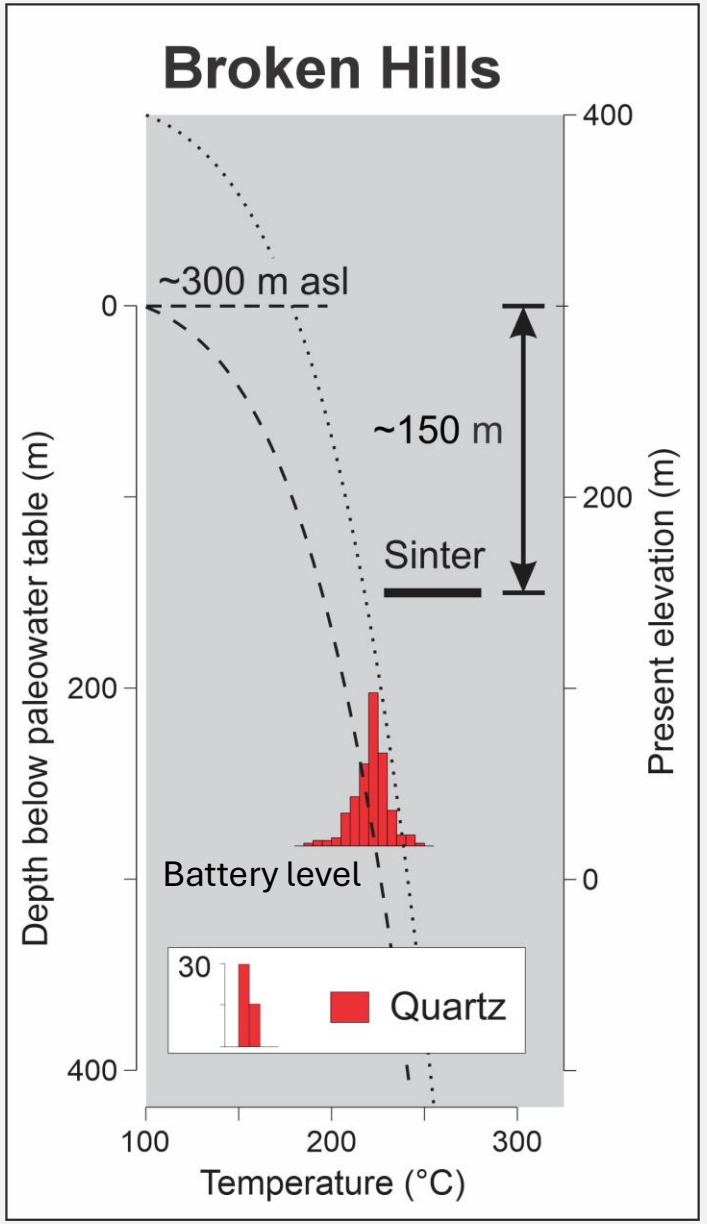
~150 m asl

Sinter ≠ FI depth estimate

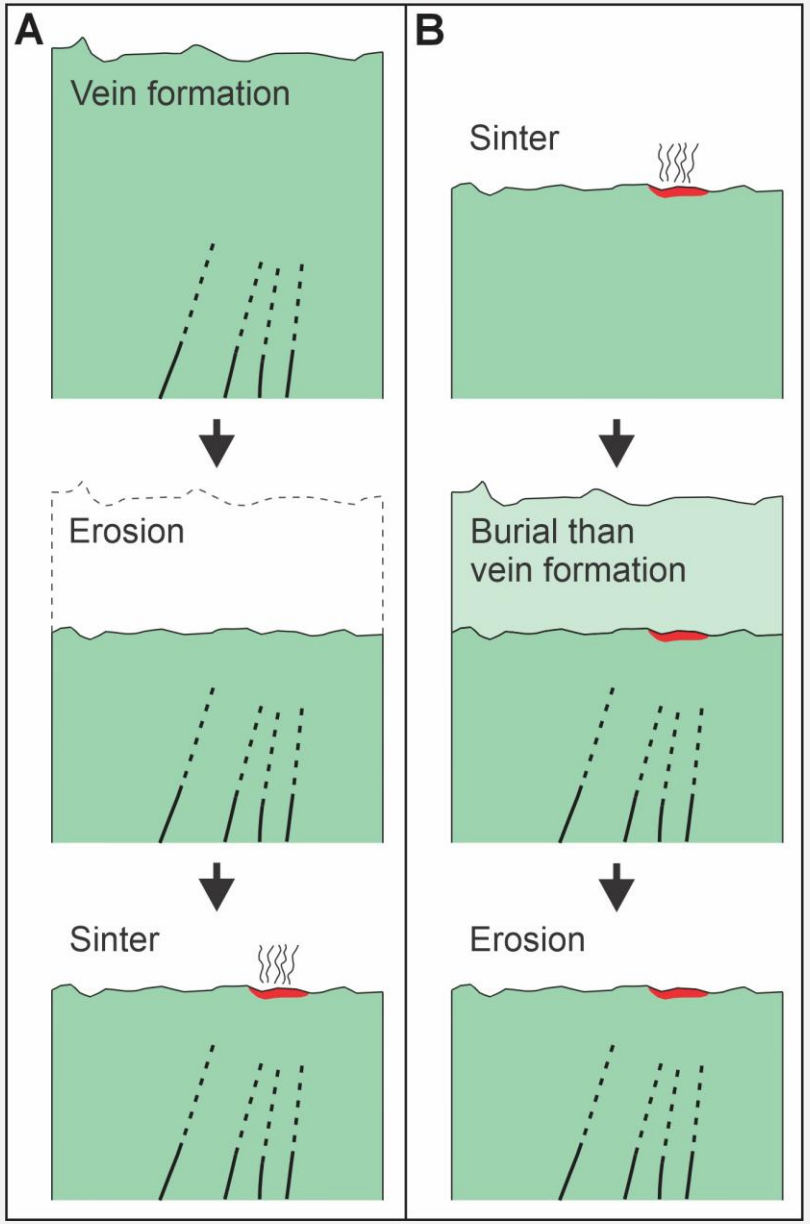
Possible reconstructions

A) *Veins → erosion → sinter*

B) *Sinter → burial → veins*



(data Cocker)



(Cocker, 2009)

Karangahake *(Rahu & Ascot)*

Karangahake: *>700 m vertical mineralisation*

Ascot: *silica sinter = paleosurface*

Rahu: *rare chalcedony (≤180°C) overprinted by quartz*

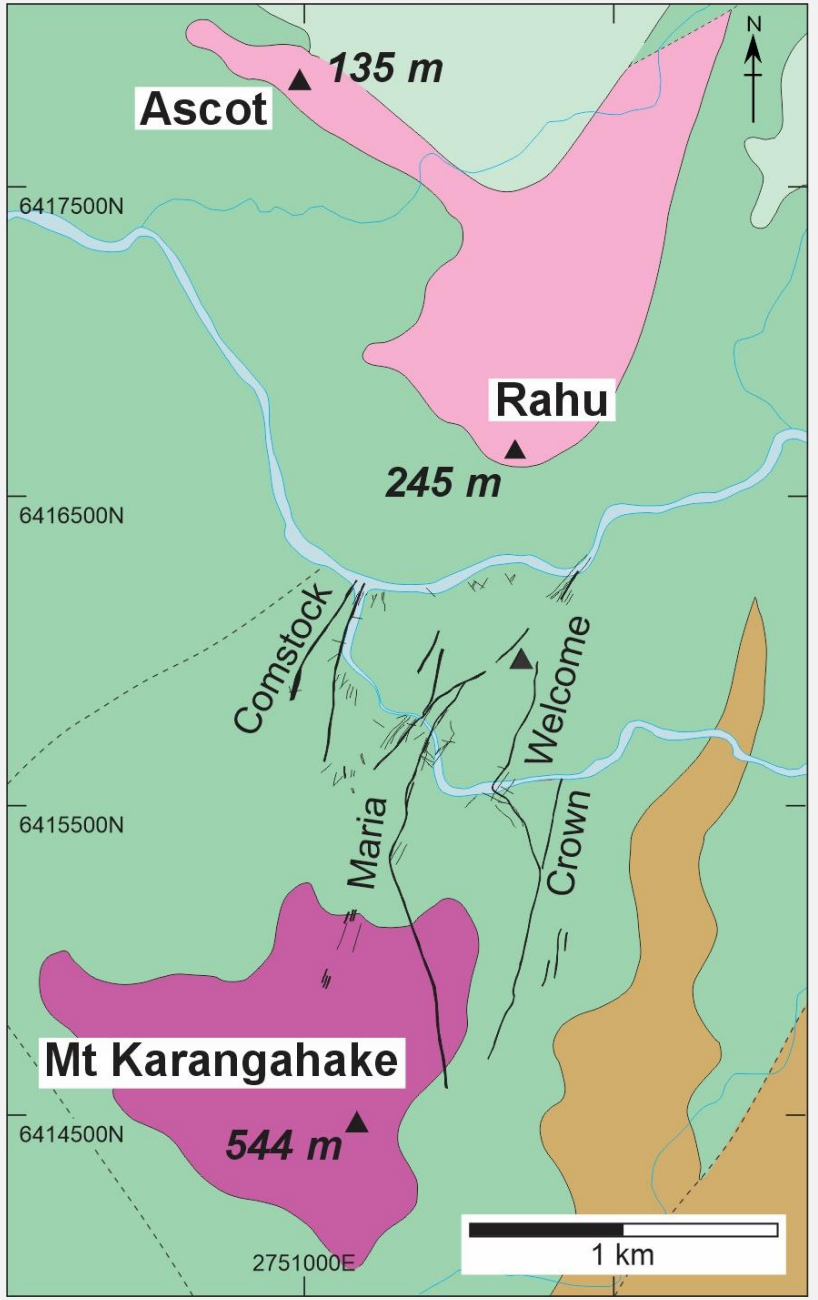




Sinter, Ascot



Chalcedony & quartz, Rahu



(Brathwaite and Christie, 1996; Stevens and Boswell, 2006)

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Fluid inclusion depth estimates

Karangahake	Rahu	Ascot
~600 m ~900 m	~440 m	~430 m

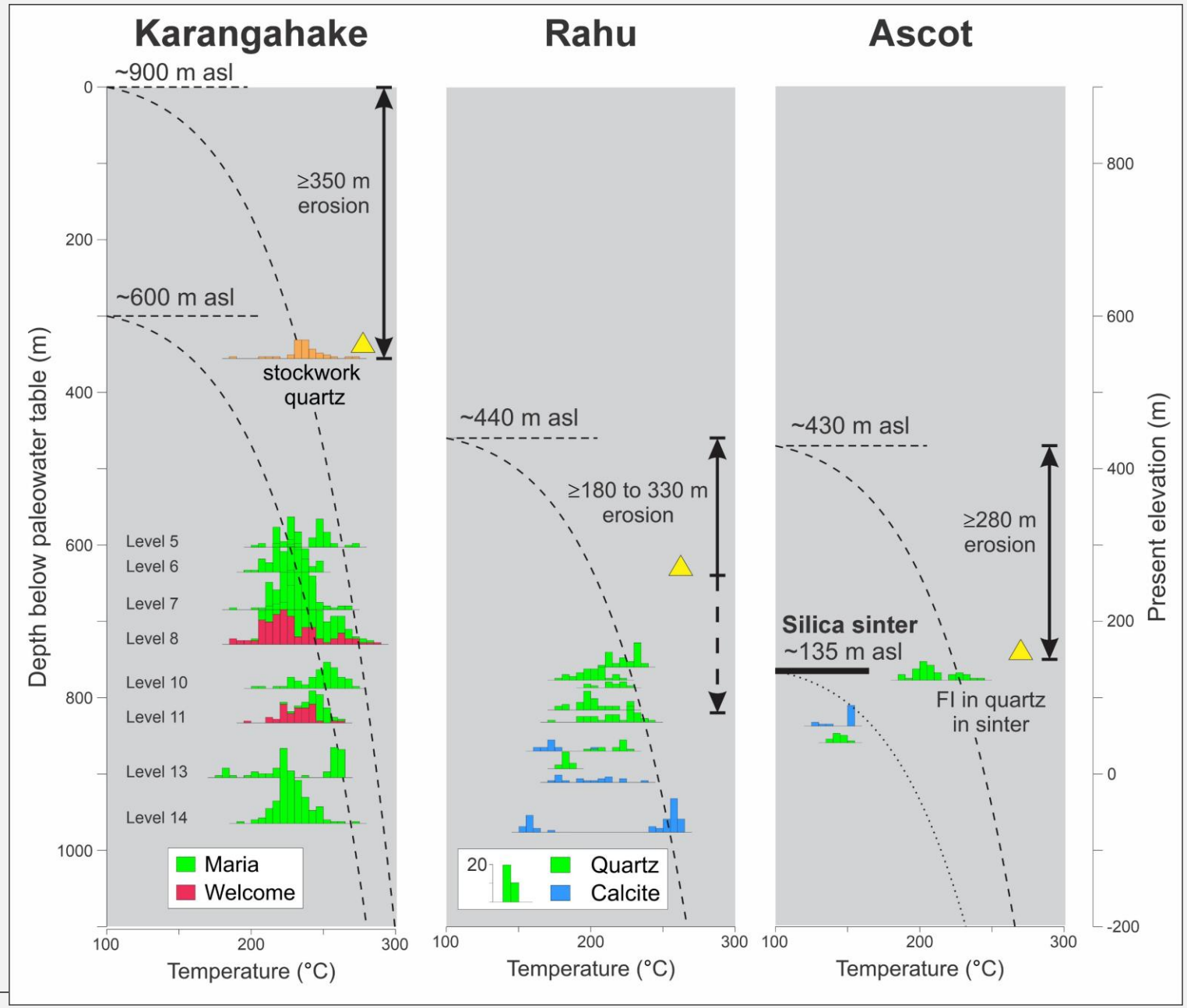
Illite approximated depth

Karangahake	Rahu	Ascot
~610 m	~370 m*	~350 m

Silica sinter *~135 m at Ascot*

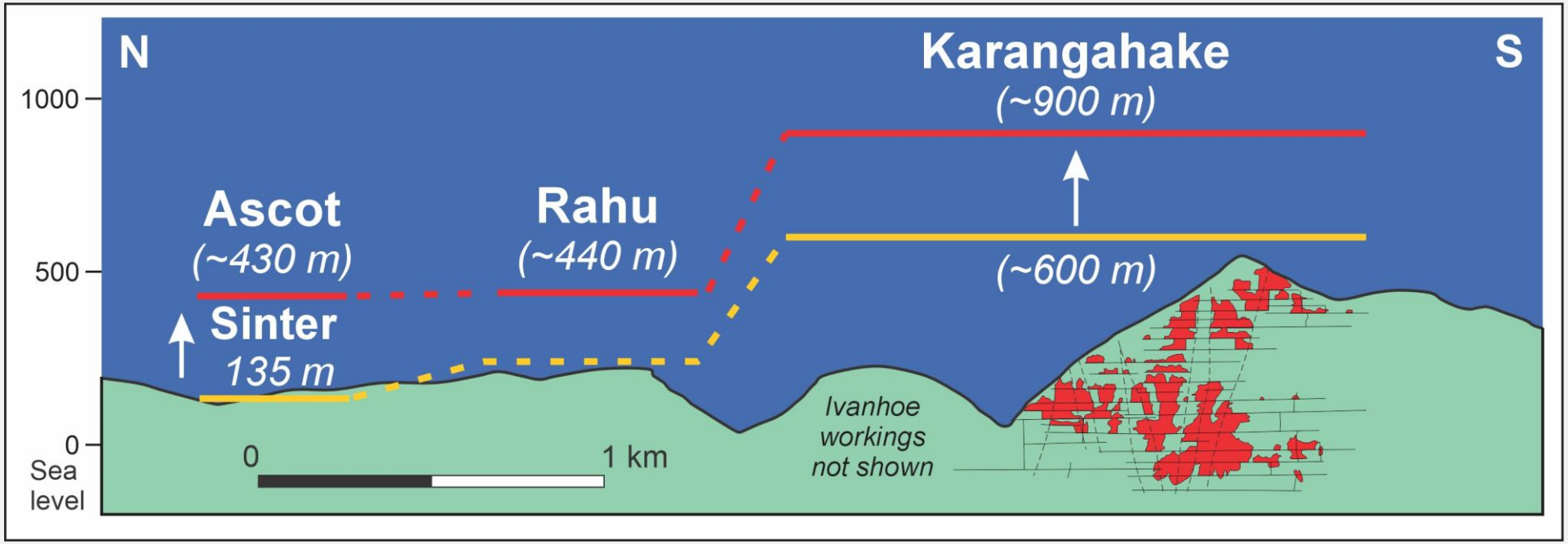


Cavity in sinter lined by quartz



(modified Simpson et al., 2016; Simpson, 2017)

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(Simpson et al., 2016)

A possible reconstruction

1) *Early hydrothermal activity: veins at Karangahake & sinter at Ascot*

2) *Burial by ~300 m (rock / water) with continued hydrothermal activity*

3) *Later hydrothermal activity: Karangahake stockwork & veins at Rahu*

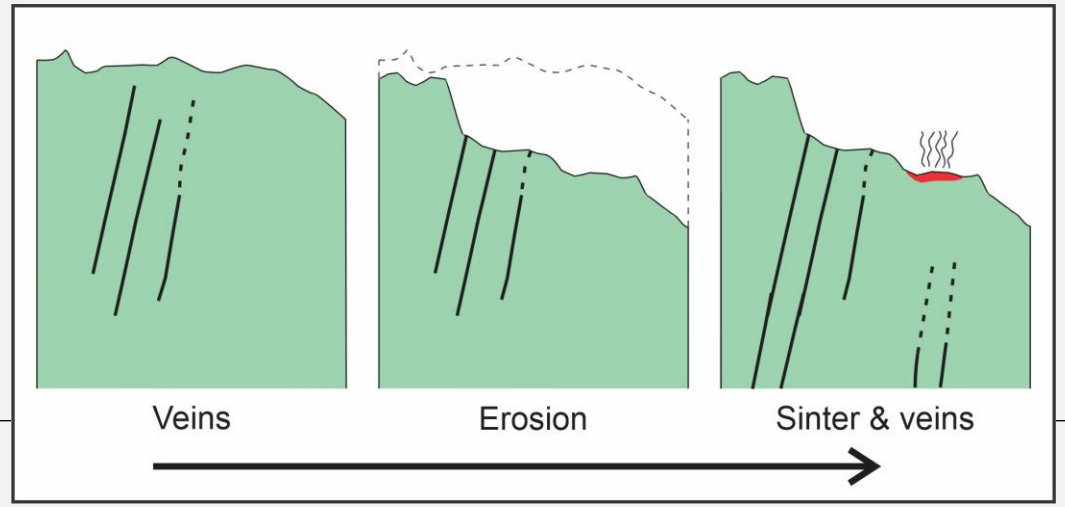


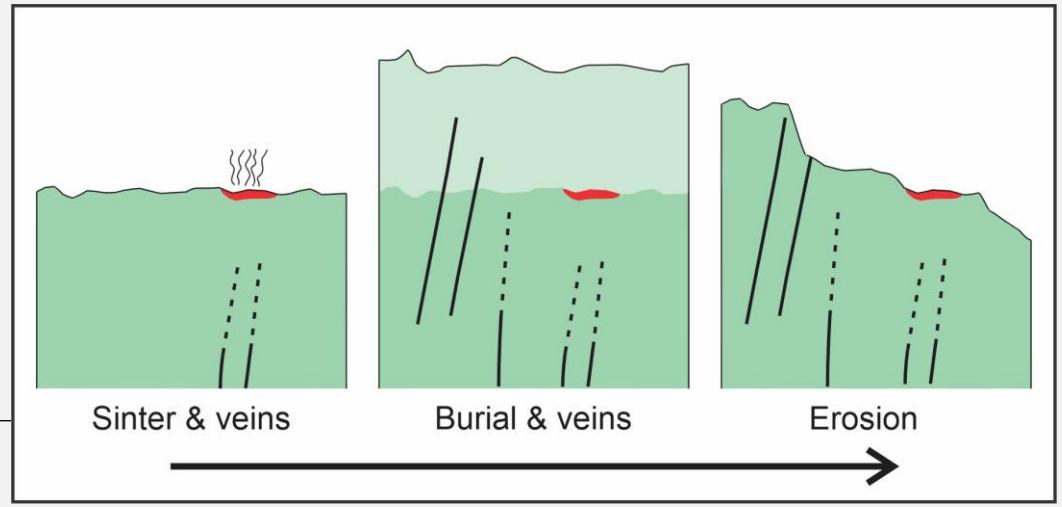
Summary

- The epithermal deposits are the products of past dynamic hydrology that changed during hydrothermal activity

- For the examples presented: the paleosurface from sinters ≠ paleowater table elevation estimated from fluid inclusions (or illite inferred)

Differences suggest changes in the paleowater elevation during hydrothermal activity and has implications for mineralisation extent (extended or telescoped)



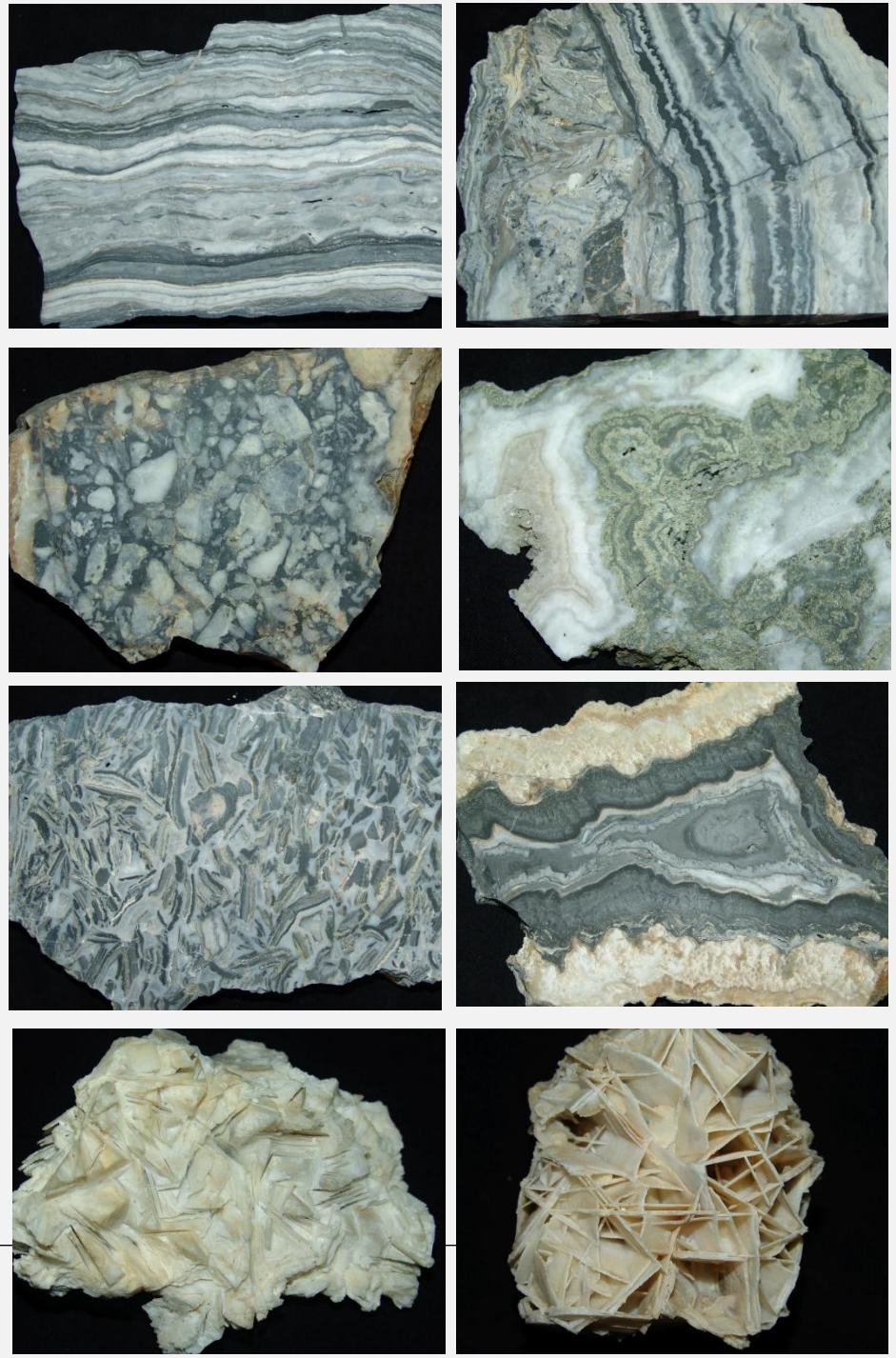


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