Metamorphic fluids associated with Archaean and Palaeozoic orogenic gold deposits: Geodynamic implications

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■ Common links between orogenic gold deposits in both the Archaean and the Palaeozoic are processes that involve the generation of metamorphic fluids

■ Fluids associated with the world's major orogenic gold deposits share similar characteristics, they are rich in CO_2 and low salinity. However, fluids associated with Palaeozoic orogenic gold deposits appear to less rich in $X(CO_2)$ than their Archaean counterparts.

■ Two Gold deposits, the Archaean Eastern goldfields, Yilgarn, Australia and the Palaeozoic Victorian goldfields, Australia are studied to investigate the processes responsible for differences in $X(CO_2)$ content of the fluid associated with the deposits

■ An assessment of the controls behind the composition of fluids linked to metamorphic devolatilisation provides geodynamic constraints on terrains associated with world class gold deposits. This is relevant even for gold models that link magmatism to gold, as any thermal event that resulted in magmatism and melting of crustal rocks will also generate large volumes of metamorphic fluids.

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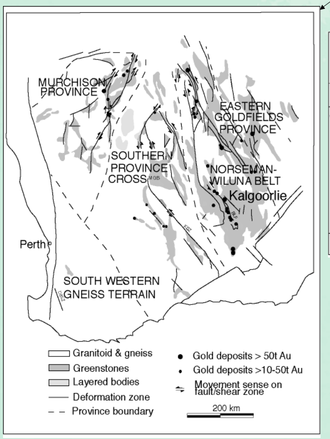
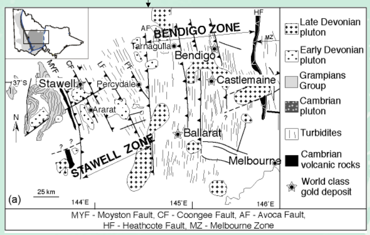
Geological setting of orogenic gold systems



Eastern goldfields, Yilgarn, Australia

- The fluid composition for the Archaean Golden Mile deposit in Kalgoorlie is $X(CO_2)$ = 0.15-0.3 (Ho *et al*., 1992 and White *et al*. 2003, calculations based on 1.5 kbar)
- The majority of gold in the Eastern goldfields was deposited late to post D2 (Groves *et al*., 1998) with a major change in granite geochemistry (high-Ca to low-Ca) linked to an increase in geothermal gradient and melting of crustal rocks (Champion and Cassidy, 2002).

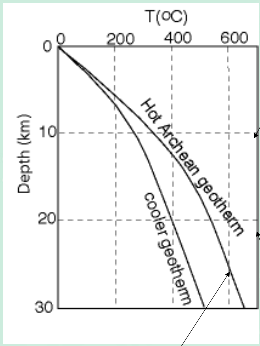


Western Victorian goldfields, Australia

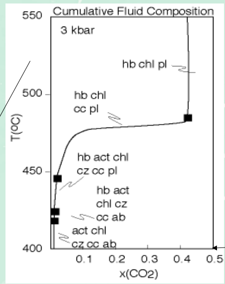
- The fluid composition for the Palaeozoic Stawell deposit in the Victorian goldfields is $X(CO_2)$ < 1 (Elmer *et al*., submitted calculations based on 3 kbar).
- At Bendigo and Stawell major gold deposition occurred at 440 Ma (Foster *et al*., 1998). This represents the only phase of orogenesis at Bendigo, but at Stawell reflects late hydrothermal thermal pulse within an older fold belt (Miller *et al*., 2005). Studies suggest a moderately low geothermal gradient of 26°C/km (Offer *et al*., 1998).

Controls on the $X(CO_2)$ of fluids associated with orogenic gold deposits

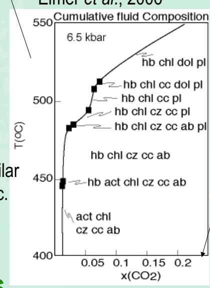
- The amount and composition of the fluid produced vary depending on *P-T* conditions, the proportion of carbonate minerals and the $X(CO_2)$ of the rocks prior to prograde metamorphism (Elmer *et al*. 2006).
- The volume of the metabasic pile from the Eastern goldfields and the Western Victorian goldfields will also play a role in the volumes and compositions of fluid that can be produced.



- Geotherm calculated by Bodorkos & Sandiford, (2005).



- Results obtained from Elmer *et al*., 2006



	Palaeozoic compositions*		Archaean compositions#	
	Dookie	Heathcote	TH1	TH2
SiO_2	48	46.9	50.2	49.5
TiO_2	1.1	1.1	0.94	1.49
Al_2O_3	14.4	13.7	15.5	15.2
Fe_2O_3	2	3.3	1.63	2.8
FeO	8.9	9.1	9.26	9.17
MnO	0.2	0.2	0.22	0.18
MgO	8.1	7.8	7.53	6.82
CaO	10.8	11	11.6	8.79
Na_2O	3.1	2.4	2.15	2.7
K_2O	0.23	0.17	0.22	0.69
P_2O_5	0.14	0.1	0.1	0.17

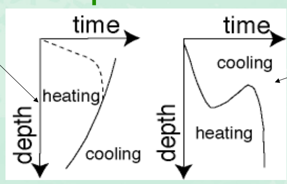
* compositions from Crawford and Keays (1978)
\# Composition from Condie (1981)

- Metabasic compositions are similar in the Archaean and the Palaeozoic.

- Processes of devolatilisation at depth, infiltration of fluid at higher levels and further evolution occurs with rising geotherms. Buffering during devolatilisation and infiltration in mafic rocks, that have previously been carbonated by earlier interaction with seawater will drive fluid rock systems to higher $X(CO_2)$ towards shallower levels.
- Mafic rocks undergoing a greenschist to amphibolite facies transition at lower pressure will have higher $X(CO_2)$ fluids (Elmer *et al*., 2006). This may explain the higher $X(CO_2)$ for Archaean fluids linked to a higher geothermal gradient. A lower geothermal gradient in the Palaeozoic would prevent the greenschist-amphibolite transition moving to shallow levels compared to an identical Archaean system causing cessation of processes such as devolatilisation, buffering and fluid infiltration at deeper levels.

Geodynamic implications

- Metamorphic fluid produced during prograde metamorphism at depth may infiltrate rocks at shallower levels that are on their retrograde path (Powell *et al*., 1991 and Stüwe, 1998).



- The effects of erosion

- A key control for a model involving a single orogenic event is that no major erosion occurred during the later stages of the orogeny as this "unroofs" the system and prevents a P-T-t path occurring where a package of rocks can experience a thermal peak linked to devolatilisation of carbonated mafic rocks post their peak pressure (England and Thompson, 1977).

- The best geodynamic process to produce the observed fluid with respect to $X(CO_2)$ is to raise the geotherm through a package of mafic rocks that have previously been carbonated (metasomatised) via infiltration of fluid produced by devolatilisation beneath. This earlier phase of metasomatisation and the later increase in geotherm could be part of the same orogenic event (inferred model for Yilgarn and Bendigo Zone of Victoria) or have occurred during an earlier orogenic event with a much later thermal event linked to Au (inferred model for Stawell Zone of Victoria).

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