Source of ore-bearing fluid for orogenic gold deposits in the Western Alps

Carole Lachavanne*, Larryn Diamond*, Alannah Brett*

* Institute of Geological Sciences, University of Bern, Switzerland

UNIVERSITÄT BERN

INTRODUCTION

Orogenic gold deposits are currently the second largest source of mined gold worldwide. Over the past decade, the transport and precipitation mechanisms of gold have been well studied but the source of the fluid transporting the gold is still under debate. Two models are considered to produce fluid: 1) model for fluid of metamorphic origin; 2) model for fluid of magmatic origin (Ridley and Diamond, 2000).

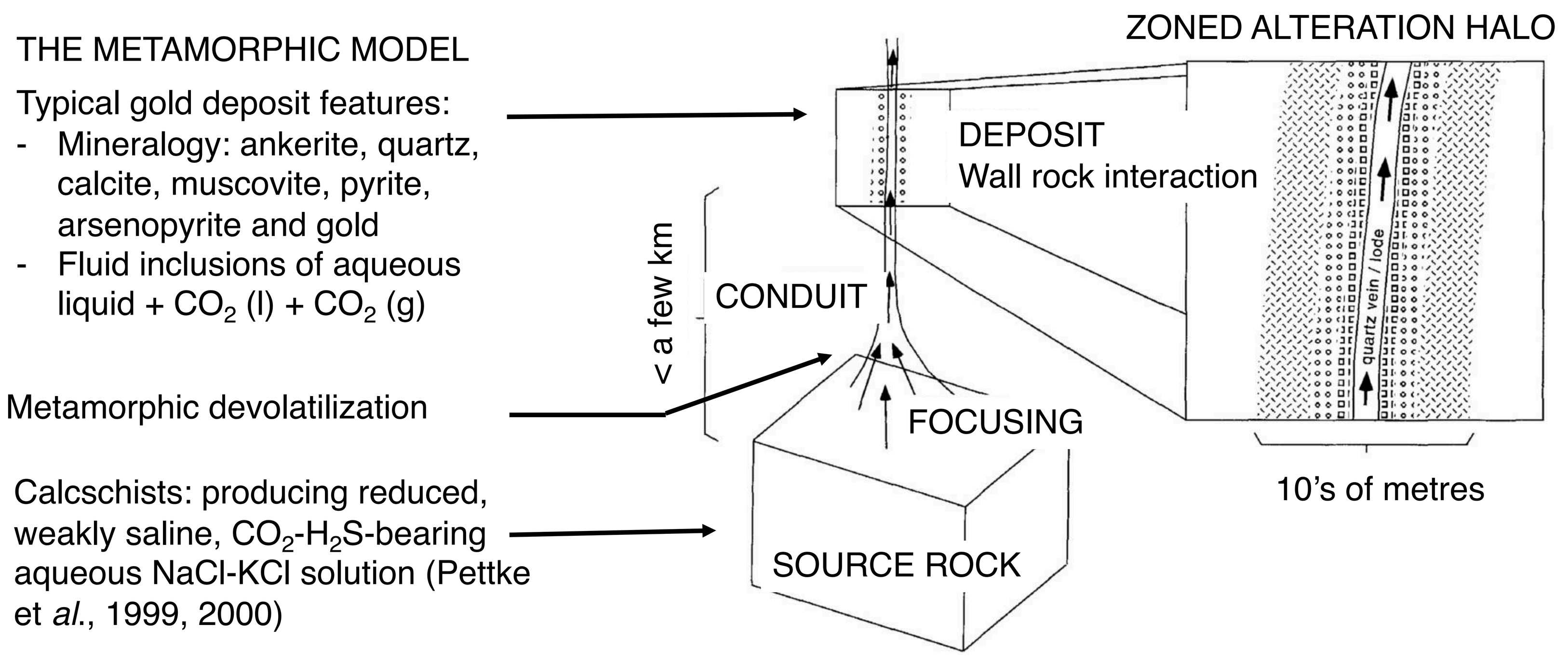


Fig. 1: Model of the essential parts needed to form an ore deposit according to the previously proposed metamorphic model (Ridley and Diamond, 2000).

The **aim** of this work is to search for evidence within the calcschists that they are the source of fluid for orogenic gold deposits in the Western Alps.

APPROACH

This work investigates a potential link between gold deposits previously mapped in the region by (Pettke *et al.*,1999, 2000) and calcschists that devolatilised during Lepontine-phase Alpine metamorphism. The calcschist outcrops (Fig. 2) contain hydrothermal veins, and so are propitious to determine whether the following features fit with the orogenic deposit geochemistry:

1. Lithologic composition
2. Mineralogy of metamorphic veins in calcschists
3. Fluid inclusion compositions

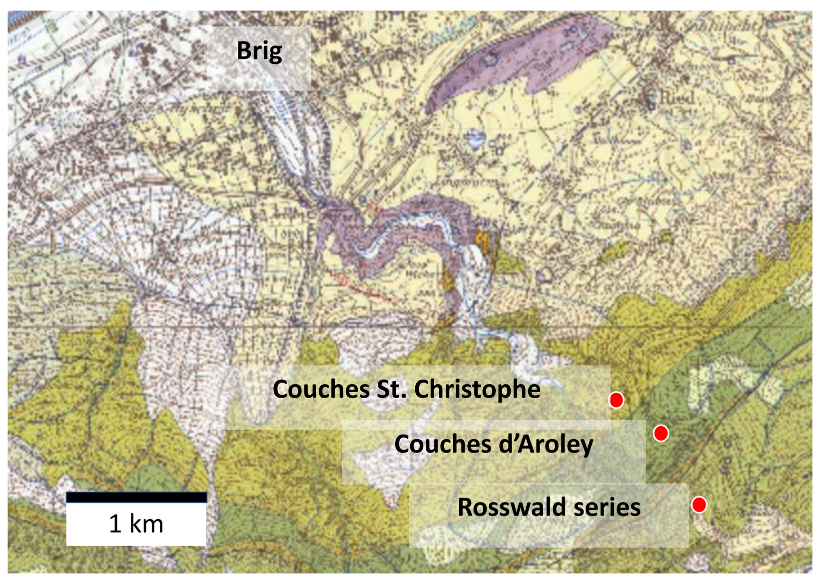


Fig. 2: Geological map (Swisstopo geology GA25) of Simplon area, W. Switzerland. Red dots are mapped calcschist outcrops in the Sion Courmayeur and Monte Leone nappes.

Main methods: field work (transect mapping, geological structures, sampling), image analysis (ImageJ), microscopy, Raman, XRF (loss of ignition), Carbon Nitrogen Sulphur (CNS), microthermometry.

RESULTS

Wall Rock Lithologies

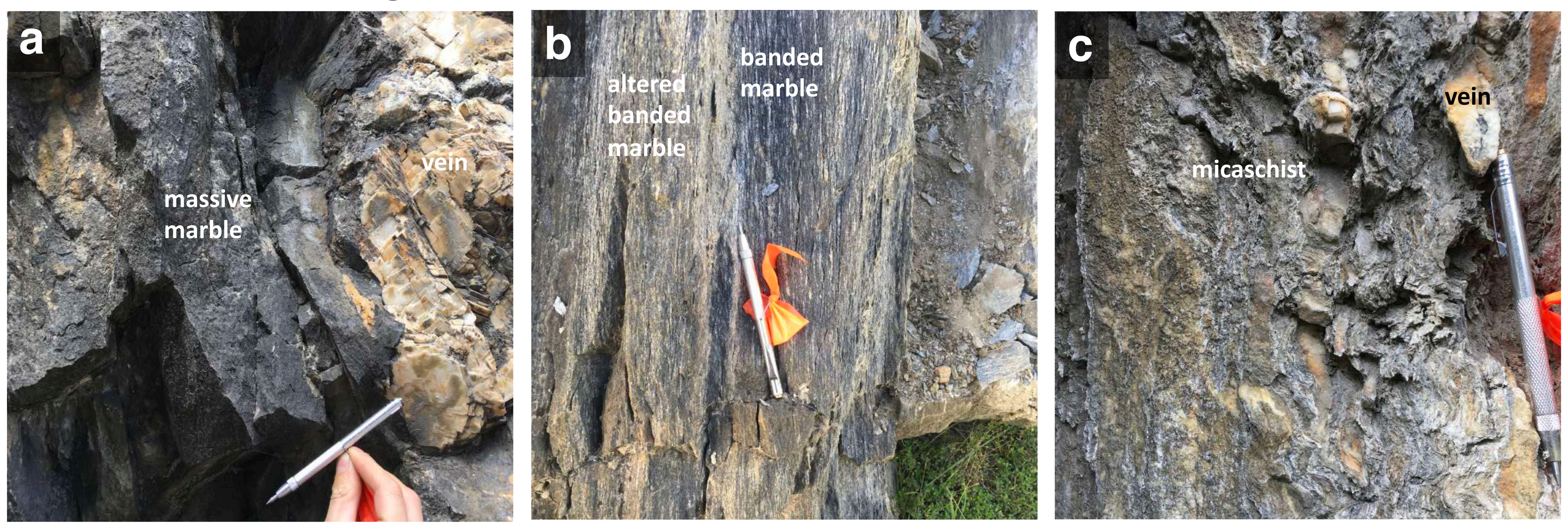
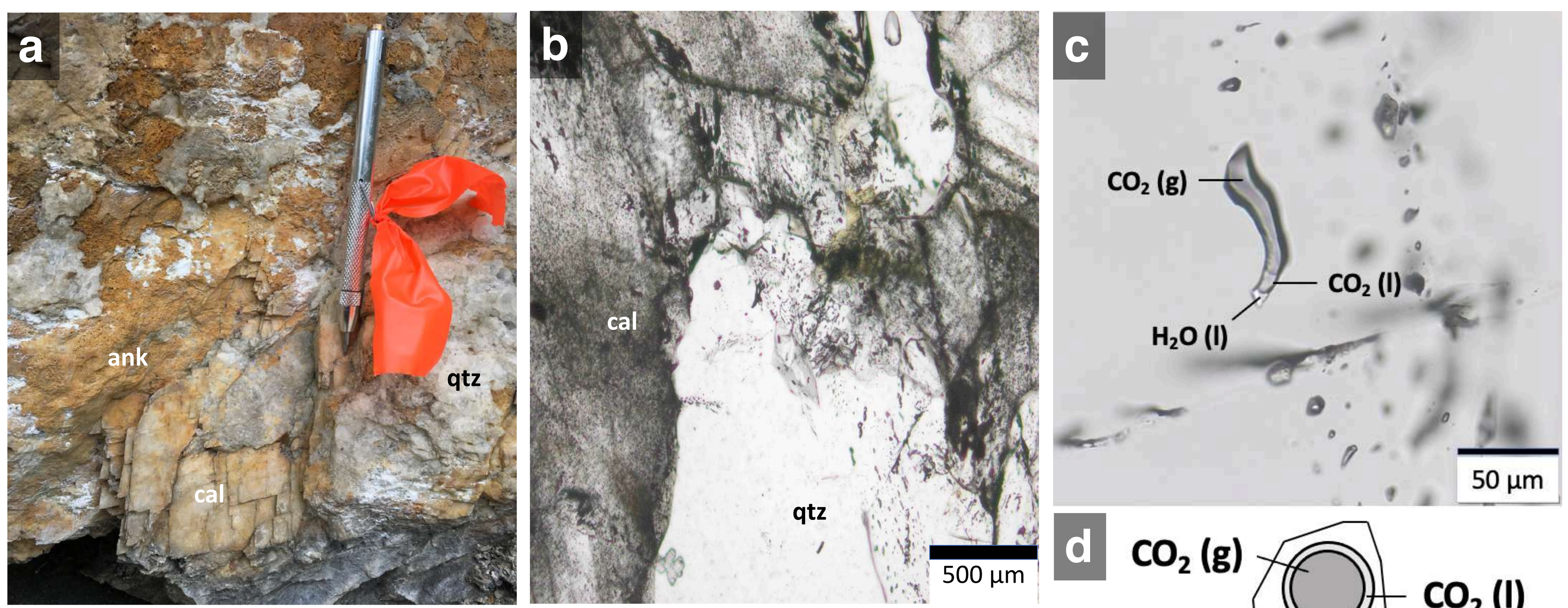


Fig. 3 Wall Rock Lithology: a) massive marble and calcite vein; b) banded marble and some alteration on its surface; c) closely folded micaschist with some small veins.

Vein Mineralogy and Fluid Inclusions

No alteration haloes were observed in the field. Secondary fluid inclusions having the same composition as those typical of orogenic gold deposits occur in some veins (Fig.4). No primary fluid inclusions were found. Thus, the inclusions are younger than the vein minerals.



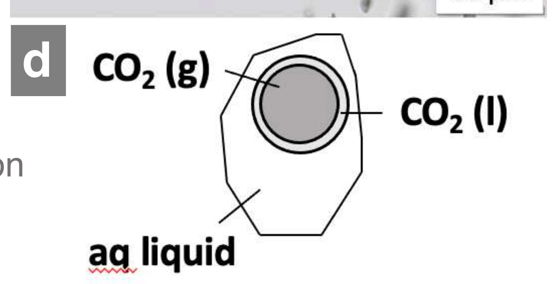


Fig.4: a) Quartz-carbonate vein. b) Thin section of vein. c) Fluid inclusion in vein quartz. d) Typical fluid inclusion in orogenic gold deposit.

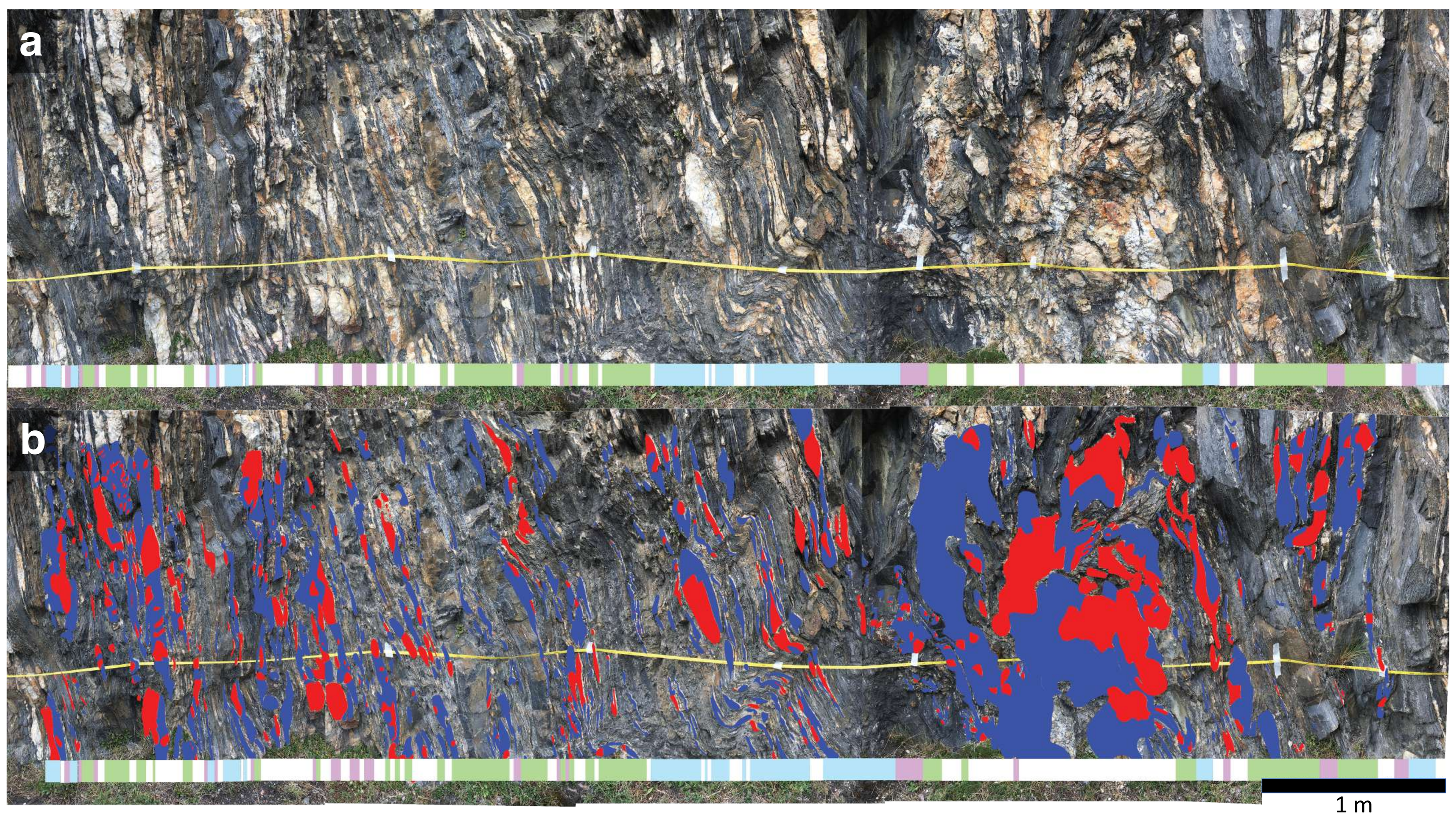


Fig. 5: Field maps from the St. Christophe outcrop. a) Outcrop image with lithology line transect mapped in the field. b) Wall rock and vein zonation recorded using a field tablet to draw over field images. Legend: white: vein; purple: micaschist; green: massive marble; light blue: banded marble; dark blue: calcite; red: quartz.

Table 1: Amount of wall rock and vein in [%] from the study area, calculated with the software imageJ. Rock composition given as length fraction of banded marble (band), massive marble (mass) and micaschist (mica) calculated from the line transect map.

Outcrops	Wall rock [area % of outcrop]	Wall rock composition [length fraction %]	Vein [area % of outcrop]	Calcite [area % of vein]	Quartz [area % of vein]
St. Christophe (1)	73.6	mica 14.3, band 64.3, mass 21.4	26.4	61	39
Aroley (2)	94.5	mica 7.9, mass 92.1	5.5	98.1	1.9
Rosswald (3)	91.7	mica 11.1, band 67.7, mass 21.2	8.3	37.3	62.7

Field Mapping and Image Analysis

Two types of maps were created at each outcrop: (1) lithology transect maps and (2) zonation maps distinguishing wall rock, calcite veins and quartz veins (Fig.5). Type (2) maps were converted to binary images to calculate the area fractions of wall rocks and veins using ImageJ software. This reveals correlations between the vein abundance and wall rock lithology and between vein mineralogy and wall rock lithology (Table 1, Fig. 6).

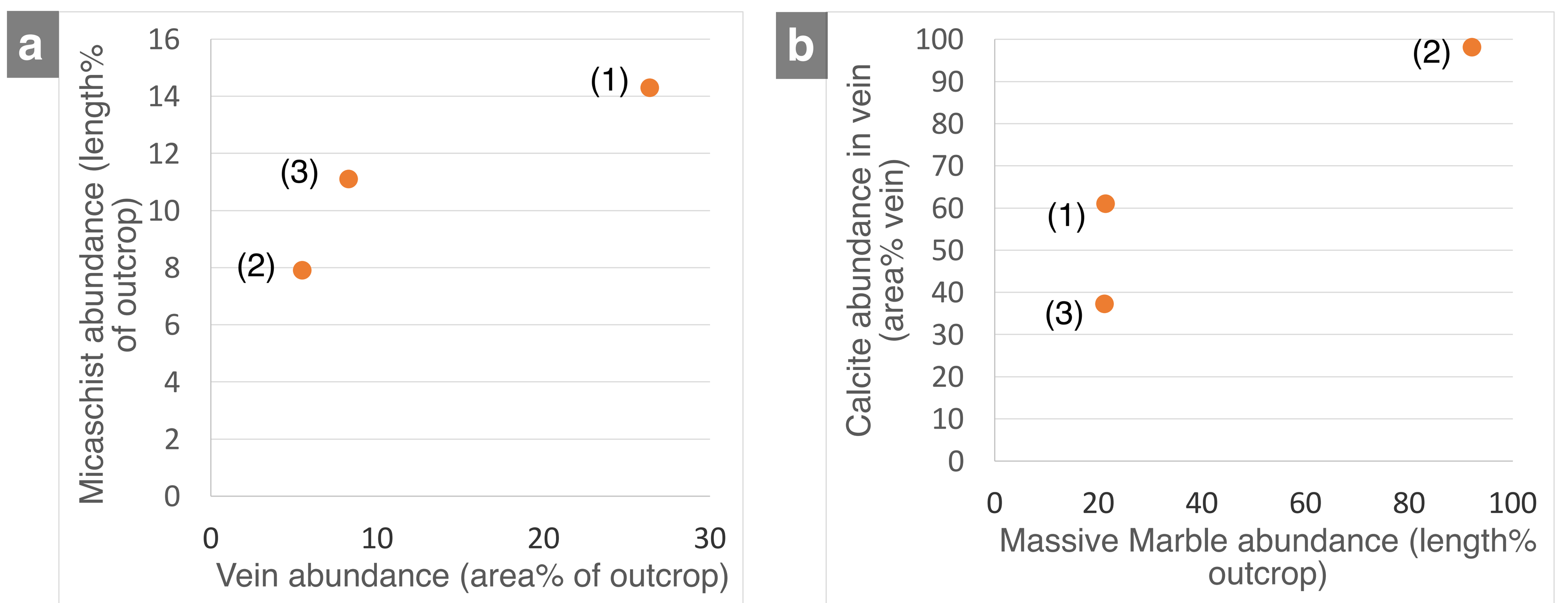


Fig. 6: Correlation plots for a) vein and micaschist abundance and b) massive marble and calcite abundance.

INTERPRETATION AND PRELIMINARY CONCLUSIONS

- Do the veins observed represent locally derived fluid devolatising from the calcschists or are they externally derived from a different rock type? The following evidence indicates a locally derived fluid: 1) vein abundance correlates with wall rock lithology (Fig 6a), 2) vein mineralogy correlates with wall rock lithology (Fig. 6b), 3) no alteration halos around veins (i.e. veins and wall rock were in chemical equilibrium).

- The mineralogy of the veins formed from metamorphic devolatisation of calchists (ank, qtz, ms, cal, py, asp) and some fluid inclusions within them match the mineralogy and fluid inclusions in orogenic gold veins. This evidence supports the metamorphic fluid model, whereby fluids devolatilise from calcschists during regional metamorphism to form orogenic gold deposits (Fig. 1).

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carole.lachavanne@outlook.com