Towards a generic model for localized, highly-enriched orogenic gold deposits.

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Current models which describe the genesis of gold deposits in metamorphic belts have focused on those where mining is established and in the main, these are within cratonic environments such as Western Australia and the Canadian Shield. Even recent literature makes little or no distinction between the genesis of these large deposits of Archaean age, and the more recent, (often smaller) Phanerozoic orogenic gold occurrences. Existing models demand large hydrothermal systems to emplace the requisite amount of gold, however recent research carried out at UBC Vancouver and the University of Leeds has suggested that the spectacularly rich placer goldfields of the Klondike district were derived from at least three localized, but exceedingly rich hydrothermal systems (Chapman et al 2010a,b).

Work undertaken to date (Chapman et al 2010a,b) has identified systematic variation in the mineralogy of gold and other minerals collected from the erosion products of these hydrothermal centres. Consideration of the fundamental controls on mineral deposition has allowed preliminary two dimensional modelling of the hydrothermal systems based on correlation of signature with geographical location. The current hypothesis is that ‘giant’ (>8 million oz) gold mineralization was formed in focused hydrothermal systems which evolved both temporally and spatially to give the observed systematic variation in mineralogical signature.

Gold grains collected in the field (Fig. 1) are mounted, sectioned and analysed by SEM and EMP. The dark grey inclusion centre top in Fig 2 is sphalerite. Systematic changes in the chemistry and mineralogy of placer gold grains from different locations have been used to infer zonation within the original orebody. Alloy heterogeneity within gold grains (as indicated by the grayscale in Fig 3) provides information on the paragenesis of the hydrothermal system. (All images RC)
Gold mineralization may be characterized according to the ‘microchemical signature’ i.e. the alloy composition of the gold (in terms of Au, Ag and Hg) together with the suite of minerals present as inclusions (e.g. Chapman et al 2000). If this hypothesis of a zoned system is correct, the earliest gold to be liberated should conform to the signature of the more distal, weaker mineralizing system.

In the sedimentary environment, gold particles accumulate at the base of the sediment load as a consequence of their extreme density. Thus normally it is not possible to link placer gold particles to liberation from a particular palaeo-surface. However, in the northern Klondike District of the Yukon, excellent sections of sedimentary sequences around 6 million years old are available for study as a consequence of mining activity. In the Bonanza Creek area recent detailed studies of the palaeo-channels have revealed previously unrecognized lacustrine layers and tephra beds in mid sequence. Consequently, strata above these lake and ash layers represent a different period of erosion to those in the lower layer. This project aims to use detailed sedimentological studies to identify time constraints on different sedimentary units using these lacustrine layers, tephras, and the various sequences of palaeo-channels. These data will facilitate recreation of the geomorphological evolution of the area and climatic environments during which gold was eroded. Microchemical signatures of gold collected both from the different sedimentary horizons and different localities (both proximal and distal) will be used to build a three dimensional model for the nature of the eroded orebody within the eroded landform.

Placer mining operations in the Klondike provide unique opportunities to characterize palaeo fluvial sedimentary sequences.

Most studies of placer- lode gold relationships have been carried out by exploration geologists whose aim is simple; to find a source. This project represents a novel and considerable refinement of this approach to recreate a three dimensional model of an eroded orebody. Whilst the intended study is primarily designed to develop a methodology to maximize the information available from placer gold to inform a generic gold ore classification system, ore- placer deposit relationships are important for many minerals, both in the context of discrete placer resources, or in their expression as geochemical vectors which underpin exploration programs. This project has the potential to greatly enhance the amount of information which can be gained from the study of detrital mineral particles at a time when geochemical methods of exploration are routinely employed.

The student would join a vibrant community of allied researchers within the process sedimentology group, working on a wide range of sedimentary and fluid dynamic processes. The project will form part of the newly created ‘Placer Minerals Group’ which augments the existing (and highly successful) industry-facing Fluvial Research Group and Turbidites Research Group. A successful,
The student will be expected to contribute significantly to the highly successful Leeds Chapter of the Society of Economic Geologists. **The project will involve:**

1. Detailed sedimentological studies of modern and palaeo-drainage systems to identify the extent of known marker horizons, and to identify others.
2. Modelling of geomorphological evolution of the catchment area.
3. Collection and mineralogical characterization of samples of placer gold from various horizons in the palaeo and modern gravels.
4. Modelling of the original orebody in terms of gold grade and mineralogical signature and implications for the evolution of the hydrothermal system.
5. Prediction of the extent to which the orebody has been denuded.

**Research training:**

The studentship is the first study to use detailed sedimentological information to study the zonation within ore bodies. The ability to develop a technique which identifies a vector to the most economically important mineralization will make a substantial contribution to global exploration geology at a time when discovering new resources is progressively more difficult. A successful student would have an unparalleled opportunity within the exploration sector as the world expert in this novel approach together with first class field training in detailed, observational sedimentary geology. In addition, the work involves understanding controls on complex hydrothermal gold mineralization. The research will be supported by supervisors and associated research groups with internationally leading expertise in the chemistry and mineralogy of detrital gold and nine years experience in the field area. The student will work with Canadian geologists from industry, academia, (UBC, Vancouver) and Government (Yukon Geological Survey). The results of the work will be disseminated by the student at the annual meeting of the Yukon Geosciences Forum and the Minerals Deposits Study Group of the Geological Society of London both which provide an excellent forum for young researchers.


Chapman RJ, Mortensen JK, Crawford E, LeBarge W (2010a) Microchemical studies of placer and lode gold in Bonanza and Eldorado creeks, Klondike District, Yukon, Canada: evidence for a small, gold-rich, orogenic hydrothermal system. Econ Geol 105: 1393-1410

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