Hydrothermal fluid chemistry in exploration. Acoustic decrepitation as a method of locating potentially auriferous quartz systems formed from CO_2 rich fluids.

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SUMMARY

There is a well documented relationship between Au mineralized quartz and CO_2 rich fluid inclusions within that quartz, indicating the CO_2 rich nature of the parent hydrothermal fluids. This relationship has been suggested to be a function of CO_2 buffering the Ph of the geothermal fluids in a range which enhances gold solubility. It is also known that the acoustic decrepitation method can identify quartz formed from fluids which had high CO_2 contents, as CO_2 rich fluid inclusions decrepitate upon heating at temperatures well below that of aqueous inclusions trapped under the same pressure and temperature conditions. CO_2 contents at least as low as 5 mole % are readily detectable using the acoustic decrepitation method.

The decrepitation method has been applied to a number of gold deposits in Victoria and shows that CO_2 is a common but not ubiquitous constituent of the fluid systems which deposited the quartz and gold. Although the precise relationship between CO_2 and gold is not clear, the method provides a means to 'fingerprint" quartz veins as an exploration guide. Samples from the Meguma terrane in Nova Scotia also show widespread but variable levels of CO_2 rich fluids in the gold deposits.

Knowledge of the CO_2 contents of quartz systems is a valuable exploration tool and the acoustic decrepitation method is the easiest way to acquire this information for exploration purposes as it is an automated and quick instrumental procedure.

Key words: fluid inclusions, gold, carbon dioxide, decrepitation.

INTRODUCTION

The relationship between gold mineralised quartz and formational fluids which were rich in CO_2 is well documented but has not been effectively used in exploration for gold because of the difficulty of measuring CO_2 contents in fluid inclusions using the traditional microthermometric methods. Some authors have also stressed the importance of methane and nitrogen over carbon dioxide and inferred that it is necessary to use expensive laser raman analyses to obtain useful gas analyses from fluid inclusions. However, the acoustic decrepitation method readily determines the total contents of these gases in fluid inclusions without the need for tedious microscope work or complicated sample preparation. High contents of these gases in fluid inclusions gives a distinctly recognizable low temperature decrepitation response between 200 C and 300 C. This decrepitation behavior is due to the CO_2 (and other non-condensing gases) expanding upon heating in approximate accordance with the gas law, $PV=nRT$, whereas aqueous inclusions undergo condensation to a liquid phase and do not generate significant internal pressure upon heating until after the liquid and vapour phases homogenize. Consequently the CO_2 rich inclusions develop high internal pressures sufficient to burst the host mineral grain at much lower temperatures than the aqueous inclusions. (Figure 1) The gas law applies to all species of gases and so the presence of methane or nitrogen does not reduce this effect unless there is some other fundamental difference in the trapping or preservation conditions of the inclusions.

Decrepitation analyses from deposits in the Victorian goldfields show that CO_2 is a common but variable constituent in the auriferous quartz and may thus be used to distinguish between different generations of quartz formed from different hydrothermal fluids of potentially different Au potential (i.e. to "fingerprint" potentially auriferous quartz). Although the levels of CO_2 in fluid inclusions from the Victorian deposits are quite modest (in contrast to the very high CO_2 contents in quartz from the Archaean metamorphogenic deposits in Western Australia), samples with noticeable CO_2 levels often correlate with known mineralization, as at the Central Deborah mine in Bendigo. In other locations, such as at Ballarat, the CO_2 rich quartz does not correlate well with the Au analyses, but this quartz is quite inhomogeneous on a scale of centimetres, indicating considerable variation in the parental fluids during deposition.

Samples from the Meguma terrane in Nova Scotia have been compared with those from Victoria and many but not all of the Nova Scotia deposits are also associated with CO_2 rich fluids.

CONCLUSIONS

Acoustic decrepitation is a sensitive and quick method to obtain fluid CO_2 compositional information from fluid inclusions which represent the original ore forming fluids.

This information is very useful in exploration for Au bearing quartz and is an important step in making use of fluid inclusion data to assist in exploration, rather than merely consigning fluid inclusion studies to post-discovery genetic research.

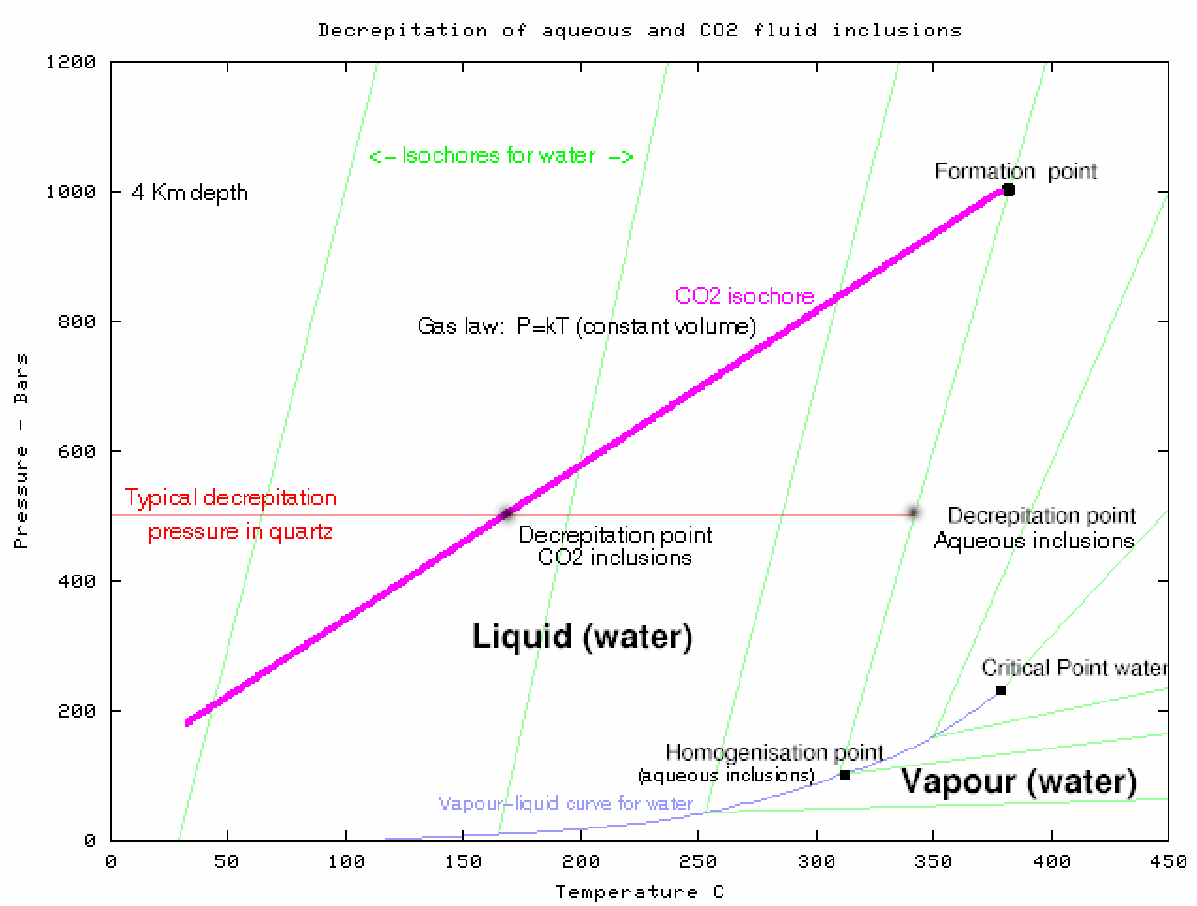

Figure 1

When heated, pure gas inclusions will follow a path close to the CO_2 isochore (magenta) line and quickly develop enough internal pressure to decrepitate at low temperature. However aqueous inclusions will follow a path along the vapour-liquid curve for water (blue) until they homogenise at the homogenisation point, and then along the water isochore (green) and will not develop a high internal pressure until above the homogenisation temperature. Inclusions containing mixed water and gases will follow paths between these two extremes.