Helium-4 dating of groundwater in the Green River Formation, Piceance Basin, northwestern, Colorado, USA

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Renewed oil and gas production/development in Colorado has highlighted a need to evaluate groundwater resources that overlie current and future production reservoirs in order to define the potential impacts of development activities. Our study focuses on the Piceance Basin in northwestern Colorado, where current hydrocarbon production/development could threaten water quality in the Green River Formation. Given the environmental and economic importance of the bedrock aquifers and associated sediments and the complexity of the bedrock hydrogeology, it is important to develop an understanding of basic system characteristics such as dissolved gas composition, groundwater residence time (or age), and sources of recharge. Our approach was to sample pre-existing well clusters in the basin for dissolved gas compositions, chemistry, noble gas isotopes, and tritium to develop conceptual models of groundwater flow in the upper aquifers.

The application of ^{4}He as an indicator of groundwater residence time has been used to interpret groundwater age for time scales of tens of years to hundred of thousands of years, making it a unique tracer that has both strengths and weaknesses over other radiogenic tracers (e.g. ^{3}H, ^{85}Kr, ^{14}C, ^{36}Cl, and ^{81}Kr) currently in use. Considerable debate has arisen over the interpretation of estimated ^{4}He production rates owing to a lack of understanding of the actual *in-situ* helium production and definition of possible flux of ^{4}He from deeper sources. Error can be further exaggerated by the presence of older reservoirs that interact within the younger, active flow-systems at or near flow boundaries, violating assumptions inherent to the dating application. For the Green River Formation, the possibilities of variable recharge altitudes and migration of gas from deeper sources could complicate the simple application of the ^{4}He dating method. Despite these possibilities, most samples show noble gas compositions that reflect normal air saturated water associated with high altitude recharge, allowing for a simple interpretation of excess helium in the samples. Current age calculations combine the measured concentrations of uranium and thorium in the aquifer and confining units to produce an *in-situ* flux model for ^{4}He accumulation in the basin aquifers, showing an age distribution that agrees well with the conceptual model of groundwater flow and indicate increasing biogenic methane concentrations with increasing age.

Non-gem diamonds from the Diavik diamond mine, Canada: Tracers for cratonic mantle metasomatism

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Non-gem diamonds are valuable tracers of mantle metasomatism, trapping micro-inclusions of the melt/fluids which formed them and allowing direct analysis of the changing chemical environment in which they grew. Approximately 600 non-gem diamonds were selected for this research, including: coated diamonds; fibrous cubes, and polycrystalline boart. We aim to establish the changes in physical and chemical conditions accompanying the transition from gem to non-gem diamond growth and how this affects the sub-cratonic lithospheric mantle (SCLM).

Cathodoluminescence (CL) of five sectioned non-gem diamonds revealed fine scale complexities not observed in visible light, likely related to differences in nitrogen centres. A subset of diamonds change outward from fibrous cubic {100} to more gem-like octahedral habit. This transition may be linked to decreasing supersaturation in the diamond precipitating melt/fluid (e.g. [1]).

Secondary Ion Mass Spectromotry was used to determine N content and δ^{13}C along transects perpendicular to growth of the diamond sections. The coats are generally higher in N content (average 1700ppm) with more negative δ^{13}C (-8 to -5.5‰) than the associated cores (1300ppm and -4.5 to -5‰). The change from gem to non-gem growth appears visually sharp and may represent precipitation from two distinct fluids. However, a subtle shift in N content and δ^{13}C is already observed prior to the visible core-coat transition in two of the three coated stones. This suggests that a more continuous evolution of the diamond preciptating medium, possibly through mixing processes, may have prompted non-gem growth after a critical point of supersaturation was reached. The mantle-like δ^{13}Cvalues suggest a melt/fluid derived from the asthenosphere. Such an interpretation was also made based on Sr–Nd–Pb isotopes and trace elements of fibrous diamonds [2]. The authors suggested fluid mixing from at least two distinct sources — ancient enriched lithosphere and the underlying convecting mantle.

Detailed research on a 54 carat Diavik boart fragment indicates formation from a different type of fluid/melt. The δ^{13}C is typical of eclogitic diamonds (~23.6‰), however, the intergrown minerals are predominantly G9 garnet and peridotitic clinopyroxene. This suggests interaction of a slab derived melt/fluid with a very negative δ^{13}C with mantle peridotite.

Non-gem diamonds thus provide vessels to carry both samples of, and evidence for, melts/fluids operating as metasomatic agents in the SCLM.

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