Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.35852

H_2O-poor mineral inclusions coexisting with H_2O-rich diamond-forming fluids in the mantle

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Diamonds are metasomatic minerals that form from COH-bearing fluids in the mantle. They carry pieces of the Earth's mantle to the surface in the form of mineral inclusions which, once trapped, behave as a closed system, and provide important geochemical and petrological information about the inaccessible deep Earth.

Recently, the H content of nominally anhydrous mineral (NAM) inclusions have received much attention due to important implications related to the Earth's deep-water cycle. Many studies show that NAM inclusions have low H_2O contents, possibly indicating a H_2O-poor cratonic lithosphere. However, given the fast diffusion of H in NAMs, the H_2O content measured in diamond-hosted NAM inclusions likely reflects equilibration with the diamond-forming fluids rather than the original concentration of the cratonic lithosphere [1]. As such, the low H_2O content of diamond-hosted NAM inclusions was interpreted as indicative of a low H_2O activity in the diamond-forming fluid. Previous studies however discussed the composition and H_2O content of COH fluids only qualitatively and did not consider the thermodynamics and stability of the phases involved during diamond formation.

We present the results of analyses of the H_2O content of 21 NAM inclusions extracted from Canadian diamonds. The samples have a very low H_2O content, in agreement with previously reported data from other cratonic areas, ruling out the possibility that the low H_2O content is the result of a sample bias. A new thermodynamic model for the speciation of COH-bearing fluids accounting for pressure, temperature and fO_2 in the cratonic lithosphere was developed. The model results show that, contrary to what has been previously suggested, diamonds are unlikely to form from a fluid at the water-maximum. Moreover, H incorporation modelling shows that H_2O-poor NAM inclusions may exist in equilibrium with H_2O-bearing diamond-forming fluids. These data will be discussed in the context of diamond formation accounting for the stability of diamond-forming fluids and the redox reactions through which diamonds may form.

References:

[1] Curtolo A. et al. (2025) EPSL 658:119311

This study was funded by the ERC Starting Grant INHERIT (n. 101041620).