

**A fluid phase equilibria model
in the system CO₂-N₂-H₂O-
NaCl-He-Ne-Ar below 200 bar
and 150°C – application to
CO₂/He fractionation in
continental mantle degassing.**

ROUCHON V.^{1*}, COURTIAL X.^{1,2}, DURAND I.¹,
GARCIA B.¹, CREON L.¹, MOUGIN P.¹

¹IFP Energies nouvelles, Rueil-Malmaison, France

(*correspondence : virgile.rouchon@ifpen.fr)

²now at PROSERNAT, Paris La Défense, France

Non-volcanic continental mantle degassing is widespread in many regions of the world characterized by lithospheric stretching, such as the European Cenozoic Rift System. Such degassing is associated with sparkling water springs and CO₂-N₂ mofets channelized by basement faults. The noble gases are often used as conservative tracers of fluid source mixtures in these systems, and the CO₂/³He ratio is commonly used as a CO₂ discriminator between, mantle, carbonate and organic sources [1]. Because of the very constricted behaviors of CO₂ and He in geological environments, physical, chemical and biological fractionation of the CO₂/³He ratio may obliterate its original source signature, and mislead interpretations.

We present here a new model describing the fluid phase equilibria in the system CO₂-N₂-CH₄-O₂-H₂O-NaCl-He-Ne-Ar below 200 bar and 150°C, and salinities up to 5M, relevant to study the partitioning of volatile species in shallow fluid systems. The model, based on the approach from [2], was extended to the noble gases using known solubility data from the literature, and validated on experimental phase equilibria performed in the laboratory. The model is successful in predicting CO₂ and noble gas solubilities in brines at an overall relative precision of ±10%.

The model was used to describe the expected fractionation of the CO₂/³He based on gas analyses from natural spring systems and CO₂-rich aquifers from different European localities. Although having a clear mantle contribution (³He/⁴He > 1Ra), these CO₂-rich gases have CO₂/³He ratios that may vary from 10⁸ to 10¹¹, well different than typical MORB (~10⁹). This range of variation is compatible with single or multiple step equilibrium of water and gas, without invoking any mixing with crustal or sedimentary CO₂ sources. The CO₂/³He ratio may instead record the degassed state of mantle CO₂-rich water systems.

[1] Sano and Marty (1995), *Chemical Geology*, 119, 265-274. [2] Soreide et Whitson (1992), *Fluid Phase Equilibria*, 77, 217-240.