Fluid origin and timing of fracture-filling carbonate veins in volcanic rocks from the Chepaizi Uplift (Junggar Basin, NW China)

Xiaobiao He*[1,2], Delphine Bosch†[1], Olivier Bruguier[1], Luo Qun[2], Luo Shujie[2], and Jonathan Outin[1]

[1]Géosciences Montpellier, CNRS, UMR 5243, Université de Montpellier, Université des Antilles, Place Eugène Bataillon, 34095 Montpellier Cedex 05, France – Université de Montpellier I, CNRS – France
[2]Research Institute of Unconventional Petroleum Science and Technology, China University of Petroleum (Beijing), Beijing 102249, China – Chine

Résumé

Calcite veins observed within fractures are the result of coupled tectonic and diagenetic processes, preserving critical evidence of fracture opening and fluid circulation. This study focuses on calcite veins in Carboniferous volcanic rocks from the Chepaizi area (NW Junggar Basin, China), a region with a complex geological history marked by fluid activity and hydrocarbon generation.
A multidisciplinary approach was conducted, including petrographic observations, cathodoluminescence, in situ REE analyses, LA-ICP-MS U–Pb calcite dating, and Sr–C–O isotopic analyses. These methods were applied to fifteen core samples collected from depths ranging between 380 and 1810 meters.

Cathodoluminescence imaging reveals up to four calcite cement types. Geochemical analyses identified three distinct generations of calcite, with one or more types present in individual sample: 1- **first type** – low Sr isotopic values (lower than 0.7047), LREE/HREE enrichment with strong positive Eu anomaly, high Sr and Mn contents ; 2- **second type** – intermediate Sr isotopic values (0.7052–0.706), flat to slightly U-shaped REE profiles, no significant Eu anomaly, and moderate Sr and Mn contents ; 3- **third type** – rare, with high Sr isotopic ratios (upper than0.7068), flat to slightly depleted LREE/HREE profiles, and low Mn content.

These calcite generations reflect different tectonic and diagenetic episodes involving fluids of varying origins. Generations 1 and 2 display Sr isotopic signatures lower than modern or Phanerozoic seawater, suggesting variable to strong interaction of fluids with neighbouring Carboniferous volcanic rocks. In contrast, the third type has Sr values close to similar to Phanerozoic seawater or meteoric water.

To constrain the timing of the formation of the various calcite cements, U–Pb dating was conducted on 15 samples. Only two samples yielded reliable dates. The first, hosting calcite from the first type, provided an absolute age of 313Ma, interpreted as corresponding to

*Intervenant
†Auteur correspondant: delphine.bosch@umontpellier.fr

Late Hercynian tectonic activity within an initially inland basin setting. The second sample, containing both type 1 and 2 calcite, provided an age of 257Ma, attributed to fault activity during post-collisional tectonic events.
This study reveals a multi-phase history of fluid evolution and fracture network development, offering key insights into the dynamic interplay between tectonic and diagenetic processes.

Mots-Clés: U, Pb calcite age, calcite cement, Junggar basin (NW China), fluids origin, C, O, Sr isotopes