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Multiphase quartz cementation in sandstones: Terra group (Tithonian, Cameros basin, NE Spain)

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Fluid inclusion microthermometry and Scanning Electron Microscope-Cathodoluminescence shows multiple episodes of quartz cementation in the studied sandstones, buried to 4800 m from the Tithonian to Late Cretaceous at the El Espino locality.

Quartz overgrowths postdate early kaolinite and nonferrous calcite cements (Tithonian). At least, three different quartz cement generations have been identified:

1. Bright luminescent overgrowth precipitated with relict fibrous texture, which is interpreted as a pseudomorphic replacement of chalcedony or some less stable silica precursor. Primary fluid inclusions have $T_h=114-120^\circ\text{C}$ and salinities 14,3–14,6 wt.% NaCl eq. Assuming a geothermal gradient of $30^\circ\text{C}/\text{km}$, these T_h imply burial of 3100–3300 m, consistent with Late Barremian– Early Aptian age. Composition of high salinity fluids may have played a part in growth of less stable fibrous silica.
2. Non-luminescent overgrowths precipitated from primary fluid inclusions with $T_h=122-128^\circ\text{C}$ and salinities 15,8–16,2 wt.% NaCl eq., imply burial depths of 3400–3600 m, consistent with a Late Aptian–Early Albian age. Secondary fluid inclusions show $T_h=152-153^\circ\text{C}$ and salinities 11,5–11,7 wt.% NaCl eq. High temperatures are probably associated with metamorphism that affected the Cameros Basin during the mid-late Cretaceous.
3. Banded luminescent quartz cement fills microfractures in earlier overgrowths. First stages have $T=127-128^\circ\text{C}$, followed by later fracture fillings with $T=141^\circ\text{C}$ (salinities 11,5–12,1 wt.% NaCl eq.). This sequence indicates progressive heating that could be associated with a second metamorphic event that affected the basin during the Eocene, in association with Alpine contraction.