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High pressure abiotic methanogenesis and strain localization in metamorphosed carbonate rocks

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It has been recently discovered that abiotic hydrocarbon-rich fluids can form via carbonate reduction at high pressure condition in subduction zones Vitale Brovarone et al., 2017. The integration of such a process in our picture of deep metamorphic processes at convergent margins opens to new scientific questions, among which is the interplay between hydrocarbon genesis and migration and deformation.
In this study we investigate how fluid-rock interactions leading to carbonate reduction and abiotic methanogenesis affect strain localization in carbonate-rich rocks. Our study integrates data from the field to the microscale, including petrographic, microstructural and electron backscattered diffraction analysis. Methanogenesis evolves from discrete domains unaffected by ductile deformation into localized shear zones marked by grain size reduction by subgrain rotation recrystallization, and diffusion creep. Creep-cavitation occurred at the mineral grain boundaries, with nucleation of new phases, promoting phase mixing and pinning the grain size. Creep-cavities evolved into creep-cavitation bands due to protracted deformation. The newly formed shear zones show evidence for enhanced carbonate reduction, suggesting a positive feedback between carbonate reduction and strain localization. Finally, a late fracture system formed, allowing further hydrocarbon-rich fluid migration and suggesting that several fluid pulses occurred during the subduction history.
This study provides the first insights on how deep abiotic hydrocarbons can migrate from their source regions towards shallower reservoirs and suggests that these processes can promote strain localization and fluid channelization at great depths.

Vitale Brovarone, A., Martinez, I., Elmaleh, A., Compagnoni, R., Chaduteau, C., Ferraris, C., Esteve, I., 2017. Massive production of abiotic methane during subduction evidenced in metamorphosed ophicarbonates from the Italian Alps. Nat. Commun. 8, 14134.