Paragenesis of Mineralized Fractures in the Wolfcamp Shale

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ABSTRACT

Mineralized fractures are common in organic-rich shales and are of particular interest because they can be conduits or barriers to flow, and their mineralogy and distribution can influence mechanical properties. We are examining mineralized fractures in the Permian Wolfcamp Shale from the nanoscale and up to core scales to characterize them in terms of mineralogy, crystal habit, as well as the presence of porosity and permeability zones. The fractures in the Wolfcamp contain localized vertical/subvertical and horizontal mineralized fractures that vary in width from thin(- 0.04 mm to thick(> I mm). X-Ray Computed Tomography (XCRT) data indicate there can be a very complex fracture network with multiple generations in some samples. Most fractures occur in siliceous mudstones or in the debris flow deposits as relatively straight, discrete fractures. However, in some lithologies (e.g., phosphate nodules) they split into multiple smaller fractures that bifurcate with an anastomosing pattern. Many fractures are composed of equant minerals but 'cone-in-cone' and 'beef filled fractures are also present. Many ofthe fractures have a complex mineralogy and paragenesis. Common minerals include calcite, dolomite, ferroan carbonates, silica, barite, celestine, pyrite, and sphalerite. Hydrocarbons are also found in some fractures. Authigenic phases that occur in the matrix include albite, barite, sphalerite, chlorite, pyrite, silica, and dolomite. Some fractures contain barite that extends into the matrix and displays a displacive morphology. These samples are associated with anomalous magnetic fabrics, consistent with displacive fracturing. Barite in the matrix near a barite-filled fracture has chlorite-filled fractures which contains organic matter between the clay sheets. Sphalerite most commonly occurs as horizontal laminae. Compositional variability in some fractures indicate that fluids were evolving during precipitation. These include solid solution variations of Ba and Sr in barite and Fe content in calcite and dolomite. Preliminary fluid inclusion data from fracture calcite and barite indicate homogenization temperatures less than I 00°C which is consistent with other data on burial temperatures. Barite which fills some fractures was replaced by pyrite and calcite/dolomite. Calcite also occurs in fractures in barite and along grain boundaries. These observations suggest that fluids moved into the fractures along permeability pathways and either replaced previously formed phases or precipitated minerals in porosity after the initial mineralization. One of our objectives is to determine the nature of these pathways in the mineralized fractures. We also note that some fractures contain pores at the contacts between different phases. Organic material in the Wolfcamp Shale contains nano-scale porosity and we are investigating how that porosity may be connected to permeable zones (e.g. along fractures). The results of this study suggest the mineralized fractures can form in different ways and that a number of different fluids moved through the fractures. We are currently evaluating whether internal and/or external fluids moved through the fractures and if the shale was an open or closed system.