Geophysical Research Abstracts
Vol. 20, EGU2018-11551, 2018
EGU General Assembly 2018

The effects of deformation bands on uranium-bearing fluid migration in sedimentary sequences, Flinders Ranges, South Australia

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Fault-induced deformation in porous sedimentary rocks (>10% porosity by volume) is often accommodated by discrete zones of continuous localized strain, known as deformation bands. Dilatational deformation bands have recently been recognized within the Palaeocene–Eocene sediments of the Frome Basin, adjacent to the Four Mile uranium deposit, arguably Australia's most prospective region for sandstone-hosted uranium. Whilst the influence of deformation bands on the fluid flow properties of petroleum reservoirs is well documented, their effects on sedimentary rock-hosted uranium systems are poorly understood. The Deadtree section at Four Mile Creek provides a natural laboratory to study the interplay between the Paralana Fault, subsequent crustal deformation of basin sediments, and palaeofluid roll-fronts. Two-dimensional face-maps of the outcrop at the Deadtree section were produced to study the temporal evolution and spatial distribution of 240 deformation bands forming 6 individual sets within the Eyre Formation, which hosts the Four Mile uranium deposit. Microstructural analysis illustrates a progressive evolution of deformation band dilation, cement precipitation, cement dissolution, and crack propagation, indicating the Deadtree section experienced a dynamic fluid-phase history. These results provide a foundation for modelling the geomechanical evolution of deformation bands as they progress towards discontinuous fractures. Handheld permeameter results indicate that the dilation bands of this study have increased host rock permeability by up to three orders of magnitude. Moreover, Deformation Band Sets 4 and 5 show direct correlation to the palaeofluid roll-fronts, altogether indicating they support the flow of uranium-bearing fluids. We conclude that dilatational deformation bands identified in this study are acting as flow conduits for uranium-bearing fluids from the Mt. Painter Domain uranium source to the Four Mile uranium deposit. Our study highlights the under-recognised role of brittle structural features in providing fluid pathways for sediment-hosted mineral systems in the shallow crust.