The Effects of Deformation Bands on Uranium-Bearing Fluid Migration in Sedimentary Sequences, Flinders Ranges, South Australia

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ABSTRACT

Deformation in porous sedimentary rocks (>10% porosity by volume) is often accommodated in discrete zones of localised strain, known as deformation bands. These bands form as a result of compaction or dilation due to sediment loading, or high horizontal or vertical stress. While deformation bands can act as conduits for fluid flow during their early growth stages, they can also reduce permeability in their later stages of development, baffling fluid flow and leading to reservoir compartmentalisation. Thus, the petrophysical properties of deformation bands are an important factor when investigating the flow properties of petroleum reservoirs. Until now, deformation bands have not been considered important features to sediment-hosted mineral systems of the brittle upper crust. Similarly, fluid migration pathways related to sedimentary-hosted uranium deposits worldwide are poorly constrained and understood. Deformation bands have recently been recognised within Eocene–Palaeocene sediments of the Frome Basin adjacent to the Four Mile uranium deposit. The Four Mile uranium deposit is located on the eastern flank of the Northern Flinders Ranges, proximal to the NE-SW striking Paralana Fault. The study area (Dead Tree Creek) is situated downslope, intermediately between the Mt Painter domain uranium source and the Four Mile uranium deposit. Dead Tree Creek exposes the uranium deposit host Eyre Formation, which is composed of kaolinized terrestrial sandstone, abundant in thorium- and uranium-rich oxidised palaeo-fluid fronts. We have produced a series of face maps highlighting the spatial relationship of 256 deformation bands. Five sets of shear-enhanced deformation bands were identified, defining a range in σH orientations between NW-SE to NE-SW, and one set of pure compaction bands defining a similar σH orientation. We make the critical observation that the presence of thorium- and uranium-rich roll front deposits associated with intersections between deformation bands indicates that the deformation bands highlighted in this study have influenced the migration of uranium-bearing fluids. Deformation bands are extremely sensitive to discrete changes in the local stress regime, and thus are proven here to be a reliable indicator for constraining the temporal evolution of palaeostress, that is proximal to the Four Mile uranium deposit, critical for modelling and reconstructing the dynamics of fluid pathways related to the Four Mile uranium deposit.