1. WHAT IS A DEFORMATION BAND?

Strain in highly porous rocks and sediments is not initially accommodated by fracture, instead by formation of discrete deformation structures (Fossen et al. 2007). A deformation band is a tabular zone of localized compressional strain that forms as a result of compaction due to sediment loading or high horizontal or vertical stress (Fossen et al. 2007). Deformation bands were first recognized in porous sandstones of the Colorado Plateau in the 1970s; however, they were largely ignored and incorrectly interpreted, as they resemble quartz veins and silicified shear bands. The first documented case study was published by Attila Aydin (1978) (Fig. 1).

2. DEFORMATION BAND MECHANICS

Deformation bands form as a result of localized scale faulting, folding, bumping, and growth and collapse of salt and shale diapirs (Fossen et al. 2007). They are classified based on their formation mechanisms, resulting from either pure or simple-shear kinematics that can form dilatant or compaction features. Disaggregation bands form as a result of grain boundary sliding, grain rolling, and breaking of grain-bonding cements (Fig. 2a).

Phyllosilicate bands form as a result of plastic slip-surface, further developing fluid conduits. Deformation bands act as structural petroleum traps due to their highly permeable surfaces (Fig. 2b).

Cataclastic bands involve grain crushing to facilitate pore space collapse (Fig. 2c).

Solution/cement bands form as a result of pressure solution and subsequent cementation, in addition to preferential cementation of cataclastic bands due to their highly permeable surfaces (Fig. 2d).

3. PETROPHYSICAL PROPERTIES

Deformation bands form as either compaction or dilation features; therefore, they can act as fluid baffles or fluid conduits (relatively). Moreover, compaction band failure results in fluid loss and slip-surface, further developing fluid conduits. Deformation bands form the main element to fault zones (Fossen et al. 2007), and may result in permeability anisotropy (Fig. 3) (Fossen et al. 2014), or compartmentalization of fluids dependent on the arrangement of deformation bands (Fig. 4; Fig. 5) (Manzocchi et al. 1998). Fossen & Bale (2007) concluded that deformation bands are unlikely to maintain any significant pressure difference within a reservoir due to their inability to connect permeable zones of different permeability (Fig. 6). The petrophysical properties of deformation bands are known to cause large reductions in both permeability and porosity (reductions of up to 6 orders of magnitude) (Fossen et al. 2007). Porosity is the prominent characteristic controlling fluid flow patterns in the vadose or shadow zones, if they have a preferred orientation (Siga et al. 1999).

4. PETROLEUM GEOSCIENCE

The petrophysical properties of deformation bands are known to cause large reductions in both permeability and porosity (reductions of up to 6 orders of magnitude) (Fossen et al. 2007). Porosity is the prominent characteristic controlling fluid flow patterns in the vadose or shadow zones, if they have a preferred orientation (Siga et al. 1999).

5. APPLICATION TO MINERAL SYSTEMS

The role deformation bands play in the mineral industry is poorly constrained, specifically their effects on uranium-bearing fluid migration between source and deposits. This project focuses on understanding the structural evolution of four basins in South Australia and Saskatchewan. Our overall goal is to develop a model to delineate the impact of deformation bands in sedimentary-hosted mineralization focusing on the impacts of fluid flow as it relates to structural permeability (Fig. 8; Fig. 9). The data collected will help select a new set of tools for both petroleum geoscientists modeling basin structure and evolution, and mineral exploration geo-geostats targeting uranium fluid pathways and deposits.

6. SUMMARY

- Deformation bands alter the way fluids move through the subsurface.
- Deformation bands are useful indicators of discrete changes in the local stress regime.
- There is a research gap relating deformation band studies to sedimentary-hosted metal deposits.
- Shallow depth deformation bands have a greater effect on fluid flow than deeply buried deformation bands.
- Deformation bands analysis may provide insight into uranium-fluid pathways.