

Three-dimensional strain during basin formation – orthorhombic fault patterns and associated MVT mineralization, Lennard shelf, Western Australia

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The northern margin of the Canning basin (Lennard shelf) is defined by northwest-striking normal faults parallel to the basin margin and northeast-striking faults that define accommodation zones at right angles to the basin margin. Northwest-striking faults commonly reactivate 50° to 60° south-dipping Proterozoic shear zones, whereas northeast-striking faults are localized in massive Proterozoic granitic basement. Structural permeability in fault-fracture meshes within Devonian carbonate rocks is the key control on the location of Mississippi Valley-type Zn-Pb mineralization. These deposits developed by infiltration of metalliferous basinal brines related to basin compaction and dewatering during the final stages of Late Devonian to Early Carboniferous extension. Surface and underground mapping of both structural trends, combined with visualisation of 3-D models using gOcad<sup>TM</sup> software, demonstrates that these faults form an orthorhombic geometry (Reches and Dieterich, 1983) and related extension fractures form a rhombic pattern in map view. The relative timing of different vein and fault generations is constrained by paragenesis of mineral fill. Pre-mineralization marine calcite fill in the fault-fracture mesh indicates that the mesh formed early in the deformation history. The orthorhombic fracture and fault geometry is interpreted to have developed initially in response to three-dimensional non-plane strain in which the intermediate finite stretch magnitude was non-zero and thus influenced fault orientation, and ultimately the distribution and geometry of ore shoots in Zn-Pb deposits. Late-stage calcite-galena veins and slickenline data indicate a change to plane strain. Opposite strike separation across northeast-striking graben-bounding faults, and a horizontal intersection of mineralized extension veins with these faults, indicate only a minor component of strike-slip movement. The northeast-striking accommodation zones are inferred to have developed from a component of extension sub-parallel to the basin margin rather than as transform-style transfer zones.