Faulting and groundwater in the Hawkesbury Sandstone: Examples from the Southern Sydney Coalfields

Timothy McMillan
UNSW Sydney

Titus Murray
Southern Highlands Structural Geology

Wendy A. Timms
Deakin University

Gabriel C Rau
Karlsruhe Institute of Technology

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Timothy C McMillan[1,4], **Titus Murray[2]**, Wendy Timms[3], Martin S Andersen[4,5], Gabriel C Rau[4,6], Paul Hagan[1]

School of Minerals & Energy Resources Engineering, UNSW Sydney, Australia[1]
Southern Highland Structural Geology, Mittagong, NSW, Australia[2]
School of Engineering, Deakin University, Geelong and Melbourne, Australia[3]
Connected Waters Initiative Research Centre, UNSW Sydney, Australia[4]
Water Research Laboratory (WRL), School of Civil and Environmental Engineering, UNSW Sydney, Australia[5]
Institute of Applied Geosciences, Karlsruhe Institute of Technology, Karlsruhe, Germany[6]

Abstract

The hydrogeological and hydromechanical properties of faults zones in the (Mid-Triassic) Hawkesbury Sandstone have a propensity to enhance groundwater flow rates. However, there are scenarios where fault gouge or the increasing stress with depth may close fractures and reduce flow rates. To understand these processes a refined conceptual model of the paleo and present day structural geomechanics of faulting, folding and fracture development is essential to predict the impact on groundwater flow.

Surface outcrops of faults within the Hawkesbury Sandstone are rare compared to the number of structures identified in underlaying underground mining operations. An enhanced structural anomaly tool, a topographic residual filter (TRF), has been developed to assist in identifying and geolocating folds and faults at the surface. This tool was applied to high resolution LiDAR derived digital elevation models from the Southern Sydney Coalfields to enhance the visibility of the anomalies at the surface which do not conform to geomorphological norms. This tool enabled targeted field work ground-truthing results with outcrop assessments. Using these results we are able to develop a new kinematic model of low propagation to slip, trishear folding for the basin (monoclines).

We found that the Hawkesbury Sandstone is highly heterogeneous effecting how fault propagation occurs. These heterogeneities are the result of a depositional environment consisting of a seasonally flooding braided river system which has led to large variations in facies architecture, with massive to strongly bedded sandstones, laminated sandstone, siltstones and mudstones, thick overbank mudstone deposits and infilled abandoned channels. The facies types are extremely variable and inconsistent in three-dimensional space and feature a varied rock strength, which allows for a preferential path of elastic energy release during fault formation within the premise of volume conservation. The resulting deformation can be observed as horizontal bedding plain separations / rotations along weak detachment surfaces with high angled sub-vertical to vertical fracturing. This has led to non-conventional fault / shear geometries based around channel boundaries rather than discrete fault surfaces.

Compressional features appear to form fault propagation folds rather than distinct fault scarps. At outcrop, these features are characterised by regularly spaced fracture sets rather than the conventional damage zones and fault cores. In many cases these are masked by heterogeneities within the fluvial sandstone. Nonetheless, fault propagation folds form distinct connected fracture networks that, depending on factors such as stress conditions, could possibly be connected at depth.

The increased presence of shear derived fracturing and lack of discrete unitary fault core suggests that fault / fracture zones within the Hawkesbury Sandstone will act to increase vertical hydraulic transmissivity within the fault/fold zones. A qualitative assessment of these effects on the groundwater flow is still required.