Conceptual models of risks to shallow waters associated with underground mining through geological fault structures

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Water risks associated with mining through geological faults have received little attention compared to geomechanical and safety risks. Longwall coal mines in the Sydney Basin, Australia, work to avoid consequences of impacting water supply dams, creeks, peat swamps and shallow aquifers. Various models for geological faults in the near-field and far-field of mining operations were considered to inform the design of strategic monitoring and adaptive management.

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Background

Water risks associated with mining through geological faults have received little attention compared to geomechanical and safety risks. Longwall coal mines in the Sydney Basin, Australia, work to avoid consequences of impacting water supply dams, creeks, peat swamps and shallow aquifers. Various models for geological faults in the near-field and far-field of mining operations were considered to inform the design of strategic monitoring and adaptive management.

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Ground movement – Tower longwall mine

Monitoring longwall mine ground movements (that could open conduits to flow) are improving including:
- eg. GPS stations – total movement from start of one longwall to 3 months after an adjacent longwall
- Movement of monitoring stations was
  - up to 65 mm at 680 m from goaf edge, AOD 45°
  - up to 70 mm at 450 m from goaf edge, AOD 45°
- Possible mechanisms: horizontal stress effects, activation of sub-horizontal structures, valley notch effect, massive strata cantilevering

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Models and likelihood of fault impacts for shallow waters

Fault scenarios are being explored using RS2 v9, 2D FEM (Roccscience Inc.), a geomechanical model for simulating stresses from extraction, and also groundwater conditions.

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Lessons for adaptive management and monitoring

Options for adaptive management and mine design to reduce surface subsidence, particularly related to geological structures, include the following:
- 1. Mining geometry – panel width, mining height, cover depth eg. sub-critical design
- 2. Changing distribution & length of panels
- 3. Orientation of panels to principle stresses
- 4. Splitting panels to avoid sensitive features
- 5. Changing distribution & length of panels
- 6. Backfill – emplacement of coal rejects into mine voids
- 7. Barrier pillars – coal left in place, reduced resource extraction (80% → 50% → 35%)

Avoiding long term consequences for shallow aquifers, creeks and peat swamps depends on on-going monitoring and site investigation of fault zone hydrogeology. eg. Bense et al. (2013)

Basic to advanced strategic monitoring, depending on risk level:
- High frequency pore pressure monitoring, isotopic tracer s
- Moisture monitoring within thin peat swamps

Ground movement in near-field and far-field can occur under some conditions along strike of geological faults, outside the angle of draw and >500 m from goaf

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A risk based approach for adaptive management can be advanced based on monitoring and modeling of potential impacts of faults on shallow waters. Under favorable conditions, faults that are restricted to mine levels are a low risk to shallow waters. However, in high risk situations, mitigating negative environmental consequences is particularly important.

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References
