Supplementary 3: Detailed fault descriptions for faults that juxtapose multiple lithologies.

Example 1: Fault meshes in the McDonald Limestone and surrounding lithologies

Faults cutting the McDonald Limestone with less than 3 m stratigraphic separation lead to the development of fault meshes (Figure 6a). Rotation of bedding is accommodated along several fault-strands accompanied by the development of tension gashes. The thickness of individual fault cores is low (<5 cm, Figure 6a,b), and does not increase with displacement. Fault cores are mineralised, with local development of matrix-supported breccias containing angular limestone clasts and clasts of re-worked calcite. These textures, along with the development of Mode 1 fractures that cross cut previous slickenfibers (Figure 6c), demonstrate fault reactivation. Multiple generations of slickenfibers are developed whose dip shallows from the top to the base of the bed (Figure 6c, insert), providing further evidence of block rotation within the fault zone. Folding and bed parallel deformation of the under- and over-lying shale helped accommodate this rotation.

Example 2: Dip-slip faulting of sandstones and seat earths

Although 3D exposures of faults cutting sandstone are rarely observed, a fault with 3 to 5 m stratigraphic seperation outcrops in the center of the void and cuts decimetre thick seat-earth and sandstones of the Limestone Coal Formation (Figure 3). The fault is associated with the phase 2 dextral shear event present at Spireslack. The fault-plane is low-angled (100°/40° S) and displays dip-slip (40° to 55°) lineations. The fault plane is altered to a brick-orange colour (Figure 6). Pyrite is locally preserved within corrugations along the fault plane and consists of <4 cm euhedral crystals (usually <0.5 cm). The alteration and pyrite preservation suggests sulphur-rich fluids migrated along the fault zone, and pods of crystal growth developing elongated to the slip-vector suggesting this was syn-kinematic. Where coal outcrops above the seat-earth (Figure 4e), brecciated coal and thin zones of friable coal are present and cleats are rotated relative to the orientation of the fault plane.

Example 3: ~5 m stratigraphic seperation fault cutting interbedded lithologies from the Lower Limestone Formation and Limestone Coal Formation

A ~5 m stratigraphic seperation, sinistral fault is observed cutting limestones and sandstones of the Lower Limestone Formation and the McDonald Seat-Earth to the west of the void (Figure 3). In the McDonald Seat Earth (Figure 6b) fault dip changes from ~60° near the base of the outcrop to 007°/79° NE near the top and low angle lineations (e.g. 20°/107°) and offset markers indicate a sinistral offset. The main fault plane is cut by several later barren fractures (e.g. 116°/74° N and 292°/71° NE), which occasionally show cm-scale strike-slip stratigraphic offset (18°/019°). Brecciated McDonald coal is found within undulations on the fault plane. In the underlying shale, several iron concretions (<10 cm) have been locally rotated and sheared in response to motion along the fault. An asymetric damage zone is developed, with minimal deformation of the footwall and a 20 to 30 cm wide zone of higher fracture intensity developing in the hanging wall. Bedding in the seat earth away from the the fault displays gentle (2-5m wavelength), low amplitude (~50 cm) folding with wavelength decreasing towards the fault.

In the underlying Lower Limestone Formation, the same fault develops a complex, 2 to 3 m thick, mineralised fault zone (Figure 6c). The fault core is characterised by two mineralised slip surfaces (216°/60° W & 261°/68° NW), each with shallow (10°/080°), moderate (25°/050°) and steeply (68°/083°) dipping sets of slickenfibers developed. It is unclear which order these developed, and all apparently display sinistral offset markers. Along the fault surface (015°/88° E), a ~5 cm thick pod of matrix supported brecciated limestone is present in the hanging wall. Shale appears to have been locally injected into fractures that had already been mineralised with calcite. To the north of the fault, the interbedded sandstones, limestones, and shale dip steeply into the fault zone, reaching dips which match that of the fault plane (60° to 70°). In contrast, bedding to the south displays only low amplitude folding (015°/56° N; 043°/56° N).

Example 4: 80 to 100 m stratigraphic offset fault cutting the full sequence

The internal structure of the 80 to 100 m stratigraphic seperation fault that cuts the west of the main void is only observed at a single location (Figure 6e). The footwall comprises 6' Seat Earth that has been highly fractured, juxtaposed against highly altered coal and folded shale with a steeply dipping cleavage. The fault core is comprised of a thin (<5 cm), clay rich zone of plastic fault gouge containing <2 mm clasts of sandstone and organic fragments. The altered coal has lost its cleat network and is noticeably harder than its unaltered equivalent, creating a spark when struck with a geological hammer. This increase in coal rank is potentially due to shear-heating (c.f. Fowler and Gayer, 1999; Li, 2001). Shear fractures in the surrounding seat earth are often stratabound and increase in intensity towards minor-slip zones and the fault core.

Example 5: Fault strands cutting the high wall

Fault strands cutting the high wall (Figure 7) appear to show a simpler geometry to those observed on the dip slope (Figure 6). It should be noted that because of the predominant strike-slip kinematics, significant out of plane displacement exists, so visible stratigraphic seperation represent an underestimate of true displacement. The majority of throw is taken up by a small number of fault strands, particularly when faults cut channelised sandstones and limestones. Individual fault strands are thin and form an interconnected network of self-juxtaposed faults. Fault core thickness is typically below the width of a pixel on the orthorectified photographs (~5 cm), however, on the major faults the fault-rock thickness can be measured, although the rock type not quantified. The thickness varies considerably down-dip (<1.4 m), and while a continuous strand is observed in Figure 7a, in Figure 7b no fault rock is observed where the thick sandstone bed is self-juxtaposed.

The deformation style in the high wall varies depending on the lithological juxtaposition, with the proportion of sandstone in the faulted section controlling whether fault-core lenses are developed. For example, in both panels of Figure 7 fault-bounded lenses are seen in the lower third of the high wall. Faults are steep (apparent dip ~70° to 80°) with displacement taken up along a single fault strand, and damage zone evolution is low in areas where thick sandstone units are juxtaposed. However, where interbedded units are juxtaposed against each other the fault zone widens to 4 m in Figure 7a and 4.5 to 6 m in Figure 7b. Within these zones, beds of competent lithology are rotated away from the main fault zone and subsidiary antithetic fault strands develop which abut against the main strand. Small stratigraphic offset faults are more abundant in the thick tabular sandstone, interbedded and shale units, with fault stands abutting and branching at lithologically controlled mechanical boundaries.