Introduction

It is well known that faults affect fluid movement within the subsurface and this can have a host of implications for the measurement, monitoring, and verification of subsurface technologies (e.g., carbon capture and storage (CCS), energy storage, geothermal energy, and radioactive waste disposal). Faults are an important control on the escape of fluids from depth (e.g., Dockrill and Shipton, 2010). It is therefore important to consider the potential effect of faults in the shallow overburden to any future CCS sites. However, there is very little data on fault architecture in shallow sediments, and consequently their effect on fluid flow is far less well understood than flow through faults at hydrocarbon reservoir depths.

In early 2024, a novel field trial injection will be conducted at the CO2CRC Otway International Test Centre (OITC), located in southern Victoria, Australia (Figure 1). The injection will involve a small volume of CO_2 (~10 t) being injected into the Brumbys Fault, which will be monitored using various surface and downhole monitoring techniques (Tenthorey et al., 2022), to provide data on the transport of CO2 through shallow faults.

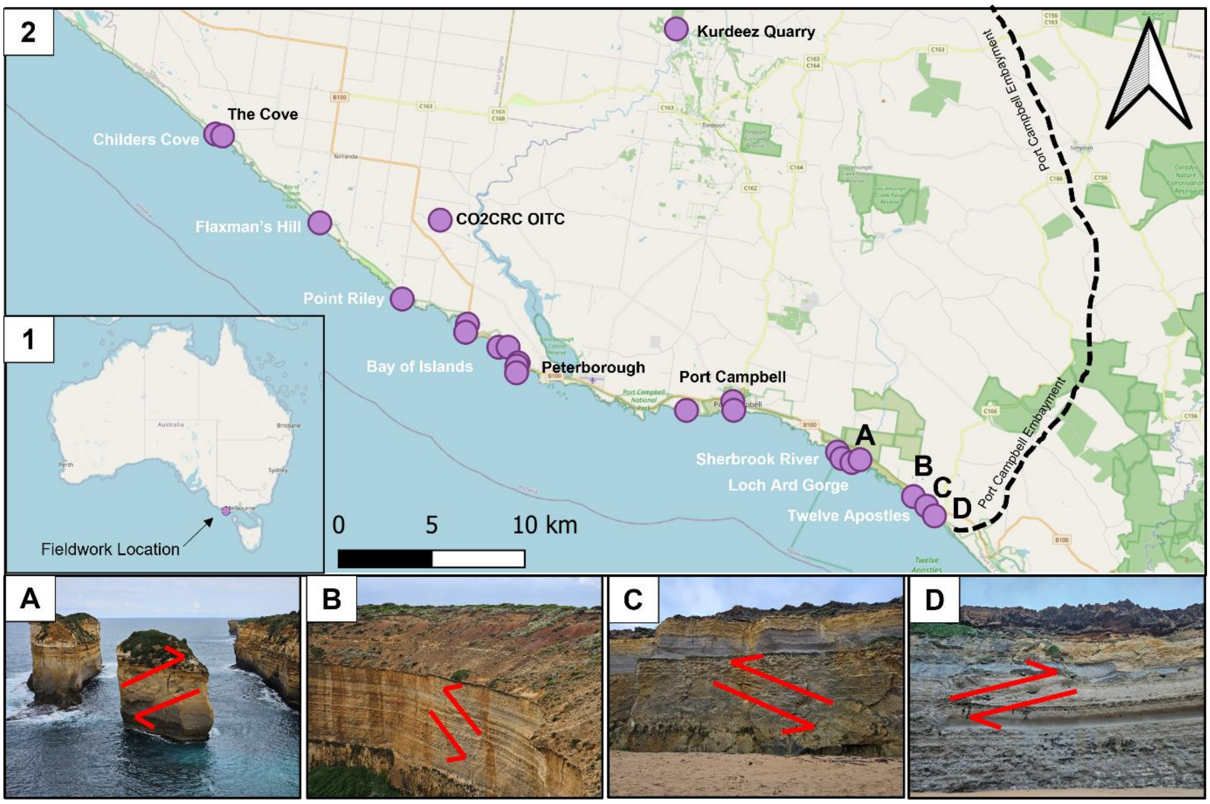

Figure 1 – Map of the field area within the Port Campbell Embayment in Victoria, SE Australia. Purple dots show locations visited. (1) Shows the fieldwork location in Australia (purple dot). (2) Map of the Port Campbell Embayment showing observation locations in purple. Images A-D (labelled on map) show reverse faults at Loch Ard Gorge (A), the Twelve Apostles lookout (B), west Gibson Beach (C) and east Gibson Beach (D).

The 1.2km long Brumbys Fault is hosted in the Miocene Port Campbell Limestone (PCL) carbonate sequence that outcrops across southern Victoria, with varying thickness from ~30m to 270m (Radke *et al.,* 2022). Brumbys Fault has been interpreted as a strike-slip fault, due to its near-vertical dip (~80°), small throw (2-4m), and favorable orientation to the present-day stress (~30° from the maximum horizontal stress) (Feitz *et al.,* 2018). However, there are no convincing surface markers indicating horizontal displacement. To reduce the uncertainty regarding the fault kinematics, we attempt to

McMahon, C. J., Roberts, J., Shipton, Z., Johnson, G., Feitz, A., Tenthorey, E., & Gallagher, S. (2023).
Could faults provide conduits for fluid escape? New field data in the vicinity of the Otway International Test Centre.
Abstract from 2nd EAGE Workshop on Fluid Flow in Faults and Fractures, Canberra, Australian Capital Territory, Australia.

reconcile the styles of faulting observed in nearby field exposures with the observations made at the OITC boreholes.

Method

The Port Campbell Limestone is exposed in coastal cliffs, from Childers Cove in the west (38.489101, 142.672736) to Gibson Beach in the east (-38.674070, 143.117769) and inland in Kurdeez quarry (Figure 1). Access to the cliff faces is limited due to the lack of access points and tides, precluding the collection of detailed field data therefore most field observations were made from adjacent cliffs and tourist lookout spots where available.

Results

Reverse faulting (1-2m throw) was observed along coastal outcrops (Figure 2) in the eastern portion of field area: outcrops examined west of Port Campbell did not exhibit any faulting. Reverse features had a strike ~50-60°, which is consistent with the maximum horizontal stress direction (~142°). There is some evidence of large vertical fractures (10s m vertical extent) that could be associated with strike slip movement, but horizontal offset could not be seen in cliff and quarry outcrops due to limitations is 3D accessibility of features. These features had a strike of either ~105-110° or ~170-175°. Smaller, more localized vertical and sub-vertical fractures striking ~175° are confined to individual layers within the PCL, highlighting the variation in mechanical properties within different sections of the PCL sequence.

At Kurdeez quarry, the PCL is significantly less consolidated compared to the coastal outcrops, which is similar to the rock core retrieved from the Brumbys-1, 2 and 3 wells. Spatial variations in diagenetic or depositional history have influenced the mechanical properties of the PCL and may in turn have influenced the fault formation.

Conclusions

There is a spatial variation in the location and type of faulting in the study area: eastern coastal areas host reverse faulting, whereas western coastal areas and inland areas lack evidence of reverse faulting and are unconsolidated. The PCL is much thicker to the west and north (where it reaches its maximum thickness of ~270m thick), which may explain this spatial variation in deformation style. Further work on the interpretation and characterisation of Brumbys Fault will be necessary before any injection experiment to ensure the fault geometry and fluid flow implications are fully understood.

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