Field excursion to examine the Jurassic sedimentology and structure of the North Somerset coast, 5th January, 2014

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Members of the Society assembled at the car park at Kilve beach [ST 1445 4425], on a wet and windy January morning. The purpose of the field trip was to determine the timing and nature of structures along the southern margin of the Bristol Channel Basin, examine evidence for the role of elevated fluid pressure in the structural development of the basin (including looking at the early Jurassic mud volcanoes) and further examine stratigraphic and structural evidence for basin inversion. The trip included visits to three principal locations where a range of sedimentary strata and structures are exposed.

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Introduction

The group followed the path to the coast (past the red brick oil retort, built in 1924 as part of the anticipated, but unsuccessful, Somerset oil boom). At this point there are Lower Lias (Sinemurian, Palmer, 1972) limestones and shales exposed spectacularly for more than 3 kilometres in both cliff sections and on the wave-cut platform, generally younging eastwards towards Hinckley Point Power Station (Figures 1, 2a). Here, and elsewhere along this part of the Somerset coast, the exposures of the gently-dipping Jurassic strata provide an insight into the character of the sedimentology, palaeontology and faulting in the region. The faulting includes a series of east-west striking normal faults and veins, many showing reverse

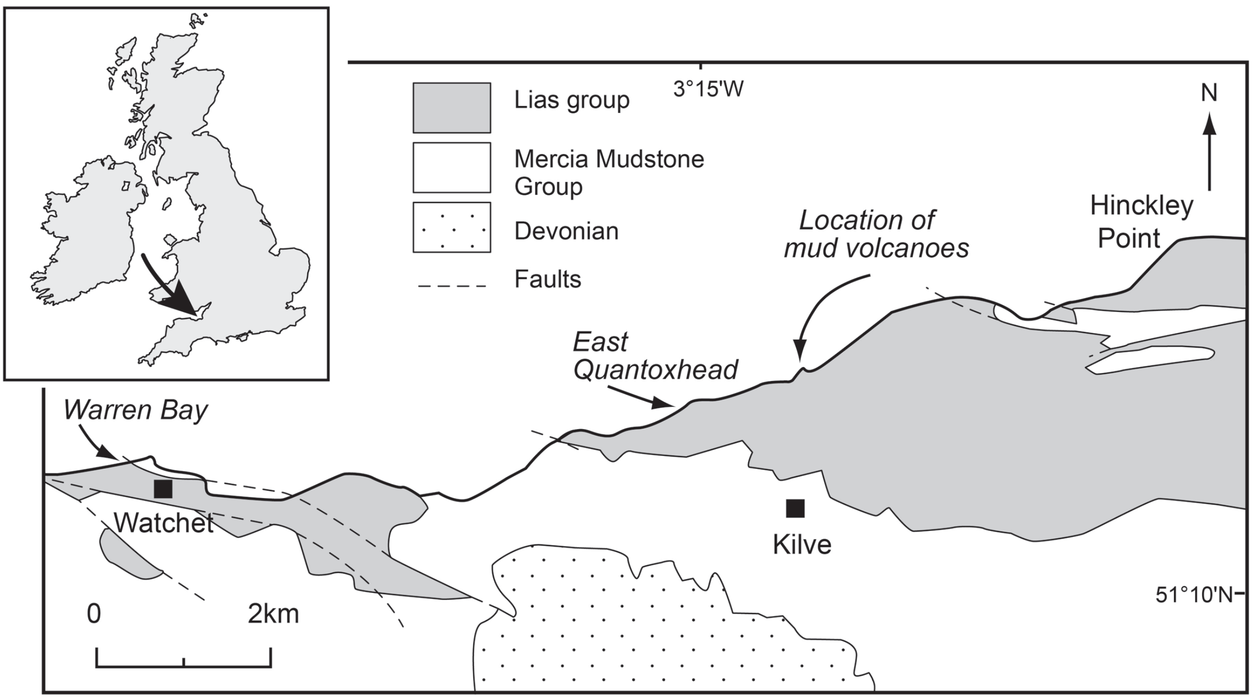

Figure 1. Locations visited and outline geology of the west Somerset coast around St Audrie's Bay (based on British Geological Survey 1:50 000 sheet 279 - Weston-Super-Mare).

Figure 2. *(**a**) Limestones and shales exposed spectacularly in both cliff sections and on the Kilve wave-cut platform, generally younging eastwards (in the direction of viewing) towards Hinckley Point Power Station. (**b**) Mud volcanoes (arrowed) viewed from the cliff top. (**c**) Mud volcano in close up (30 cm hammer for scale). (**d**) Cliff-top discussion on the Jurassic sedimentology and structure of the North Somerset coast. (**e**) The Global Stratotype Section and Point (GSSP) for the base of the Sinemurian at East Quantoxhead. (**f**) The East Quantocks Head Fault, dipping to the south, has a normal fault stratigraphic separation between Liassic rocks in the hanging-wall (younger) and footwall (older). Numerous contractional structures are developed in the hanging-wall and the fault plane is offset by a small thrust which dips gently northwards to beach level in the footwall. (**g**) Mercia Mudstone Group exposed in the cliffs at west beach, Watchet, displaying sub-horizontal and gently dipping gypsiferous veins. Fibrous vein fill indicates sub-vertical opening directions but curved fibres document the evolution of near-field stress conditions associated with changing fluid pressure components. (**h**) A south-dipping reactivated normal fault at Warren Bay with folded and thrust Penarth Group and Lias in the hanging-wall juxtaposed against relatively uniformly dipping rocks of the Mercia Mudstone Group in the footwall.*

reactivation and east-west striking reverse faults (e.g. Peacock, 1991, Bowyer and Kelly 1995).

LOCATION 1: MUD VOLCANOES

The aims at this first locality were to examine the character of mud volcanoes in the Lower Jurassic and to consider the implications for atmospheric methane concentrations and over-pressure in the basin. The series of limestone beds (Figure 2a), with softer shale deposits having been eroded away, expose several dome structures (Figures 2b, c). The mud volcano mounds outcrop *c.* 2 km east of East Quantoxhead [ST 1506 4463] and occur within the *Arietites bucklandi* ammonite zone of the Sinemurian (Blue Lias Formation) (Whittaker and Green, 1983). These sediments are characterized by metre-thick shale beds interbedded with limestones, with the alternations probably resulting from Milankovitch oscillations. At this location the mounds have been interpreted as mud volcanoes (Cornford, 2003; Price *et al.*, 2008) or carbonate mounds (Allison *et al.*, 2008). Carbon isotope data suggest that these mounds were exuding hydrocarbons, probably methane, at the seafloor at the time of their formation (Price *et al.*, 2008). The mounds may have formed benthic islands that elevated the biota (ammonites, crinoids, bivalves and foraminifera) into more oxic conditions or, alternatively, they may have supported a chemotrophic community (Allison *et al.*, 2008). The inclement weather and high tide, however, only permitted a discussion from afar (Figure 2d) of the suggested origin of the mud volcanoes and over-pressuring of the underlying Triassic strata (e.g. Cornford, 2003).

LOCATION 2: KILVE BEACH (WEST)

The weather permitted the group to examine Kilve Beach (west) [ST 1314 4410]. Here the aims and objectives were to examine the character of the East Quantocks Head Fault and determine the kinematic history of the fault and associated minor structures. A quick inspection of the Global Stratotype Section and Point (GSSP) for the base of the Sinemurian at East Quantoxhead was also possible (Figure 2e). This GSSP offers the most complete succession of relatively well-preserved ammonites, meeting the requirements of the International Commission on Stratigraphy for a stratotype section and was ratified by International Union of Geological Sciences in August 2000 (Bloos and Page, 2002).

The East Quantocks Head Fault structure (Figure 2f) has been the focus of much attention in terms of establishing the relative chronology of structures along the southern margin of the Bristol Channel Basin (Kelly *et al.*, 1999; Glen *et al.*, 2005). Normal, strike-slip and thrust faults are all exposed and, together with stratigraphic evidence, can be used to establish the changing stress conditions leading to inversion of the basin in the Tertiary (e.g. Peacock 2009). A pleasant lunch at the very warm and dry Hood Arms, Kilve, was then taken. The group then continued westwards to Watchet.

LOCATION 3: WARREN BAY, WEST BEACH, WATCHET

Arriving at Warren Bay, west beach, Watchet [ST 0608 4333] the weather improved a little and the group was able to examine and assess the nature of fault reactivation along the southern margin of the Bristol Channel Basin as well as again consider the role of fluid over-pressure during basin inversion. The dramatic structures exposed between Watchet and Warren Bay illustrate the partitioning of deformation during basin inversion and the role of fluid over-pressure during fault reactivation. Evidence for protracted periods of elevated fluid pressure within the basin was examined, including sub-horizontal vein systems with sub-vertical calcite and gypsum fibres and sedimentary ('neptunian') dykes, particularly well-developed in the Late Triassic Mercia Mudstone Group. Progressive changes from fibre growth that is orthogonal to vein walls to late-stage oblique fibre growth and the development of reverse sense slickenfibres along many vein walls further suggest a genetic link between elevated fluid pressure and deformation partitioning during basin inversion (Figure 2g). Finally, a major reactivated normal fault was examined at Warren Bay (Figure 2h). The fault remains in net extension according to present day stratigraphic relationships between hanging-wall (Penarth and Lias Groups) and footwall (Mercia Mudstone Group). Intense contractional deformation (tight folds and small-scale thrusts) of hanging-wall rocks in close proximity of the fault are comparatively absent from the footwall and, together with overprinting slickenfibre sets on the fault plane, are indicative of partial reverse reactivation of the fault. Further into the hanging-wall, a second major fault which emplaces Penarth Group back over Lias Group was discussed as a possible hanging-wall short-cut fault, developed as reactivation of the pre-existing normal fault in the footwall became less favourable.

REFERENCES

ALLISON, P.A., HESSELBO, S.P. and BRETT, C.E. 2008. Methane seeps on an Early Jurassic dysoxic seafloor. *Palaeogeography, Palaeoclimatology, Palaeoecology,* **270**, 230-238.

BLOOS, G. and PAGE, K.N. 2002. Global Stratotype Section and Point for base of the Sinemurian Stage (Lower Jurassic). *Episodes,* **25**, 22-28.

BOWYER, M. O'N. and KELLY, P.G. 1995. Strain and scaling relationships of faults and veins at Kilve, Somerset. *Proceedings of the Ussher Society,* **8**, 411-415.

CORNFORD, C. 2003. Triassic palaeo-pressure and Liassic mud volcanoes near Kilve, West Somerset. *Geoscience in south-west England,* **10**, 430-434.

GLEN, R.A., HANCOCK, P.L. and WHITTAKER, A. 2005. Basin inversion by distributed deformation: the southern margin of the Bristol Channel Basin, England. *Journal of Structural Geology,* **27**, 2113-2134.

KELLY, P.G., MCGURK, A., PEACOCK, D.C.R. and SANDERSON, D.J. 1999. Reactivated normal faults in the Mesozoic of the Somerset coast, and the role of fault scale in reactivation. *Journal of Structural Geology,* **21**, 493-509.

PALMER, C.P. 1972. The Lower Lias (Lower Jurassic) between Watchet and Lilstock in North Somerset (United Kingdom). *Newsletters on stratigraphy,* **2**, 1-30.

PEACOCK, D.C.P. 1991. A comparison between the displacement geometries of veins and normal faults at Kilve, Somerset. *Proceedings of the Ussher Society,* **7**, 363-367.

PEACOCK, D.C.P. 2009. A review of Alpine deformation and stresses in southern England. *Bollettino della Societa Geologica Italiana,* **128**, 307-316.

PRICE, G.D, VOWLES–SHERIDAN, N. and ANDERSON, M.W. 2008. Lower Jurassic mud volcanoes and methane, Kilve, Somerset, UK. *Proceedings of the Geologists' Association,* **119**, 193-201.

WHITTAKER, A. and GREEN, G.W. 1983. Geology of the Country around Weston-Super-Mare. Sheet 279 with parts of Sheets 263 and 295. *Geological Survey of Great Britain Memoir.*