Structural Styles and Estimates of Shortening for the Inverted External British Variscides.

This poster is dedicated to the late Professor Michael Brooks

W.A.J. Rutter[1], M.N. Miliorizos[2], N.S. Melis[3] and N. Reiss[4]

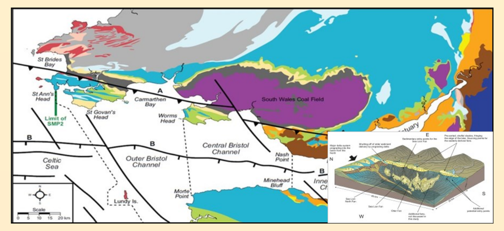
[1]***University of Manchester,*** *Interdisciplinary Centre for Ancient Life, Williamson Building, Oxford Road, Manchester, M13 9PL.*

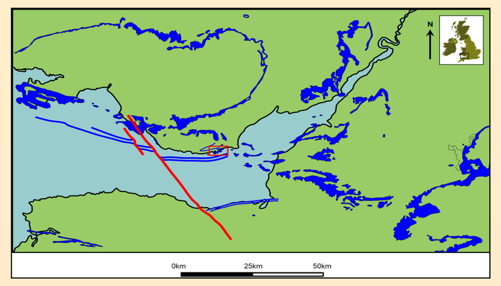
[2]***University of South Wales / Prifysgol De Cymru,*** *Alfred Russel Wallace Building, Glyntaff Campus, Pontypridd, CF37 4BD.*

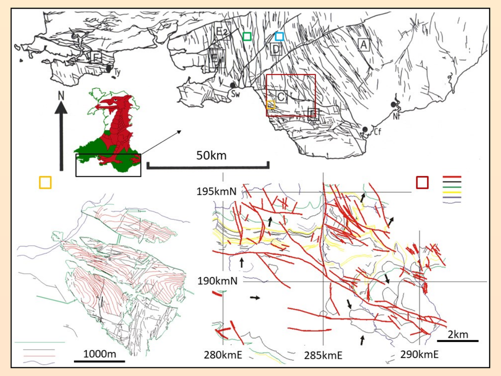
[3]***National Observatory Athens,*** *Lofos Nymfon, 118 10, Attica, Greece.*

[4]***Cornerstone Resources Group,*** *H1, Hill of Rubislaw, Aberdeen, AB15 6BL.*

1. Introduction



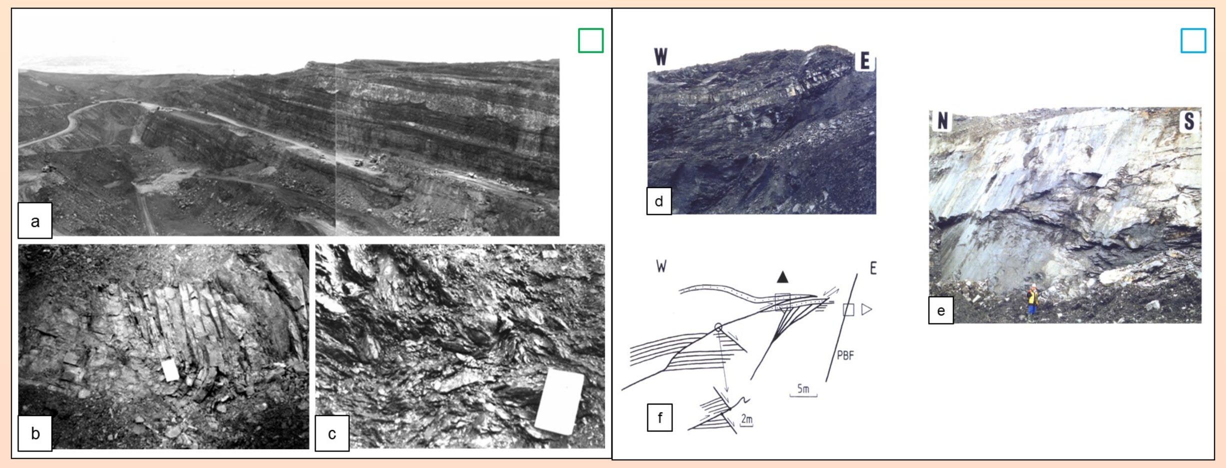




The accepted position and trend of the main Variscan thrust front separating the Culm (model inset) from the Main Coalfield. A task here is to find the major change in Variscan shortening after restoration for the effects of Mesozoic negative inversion.

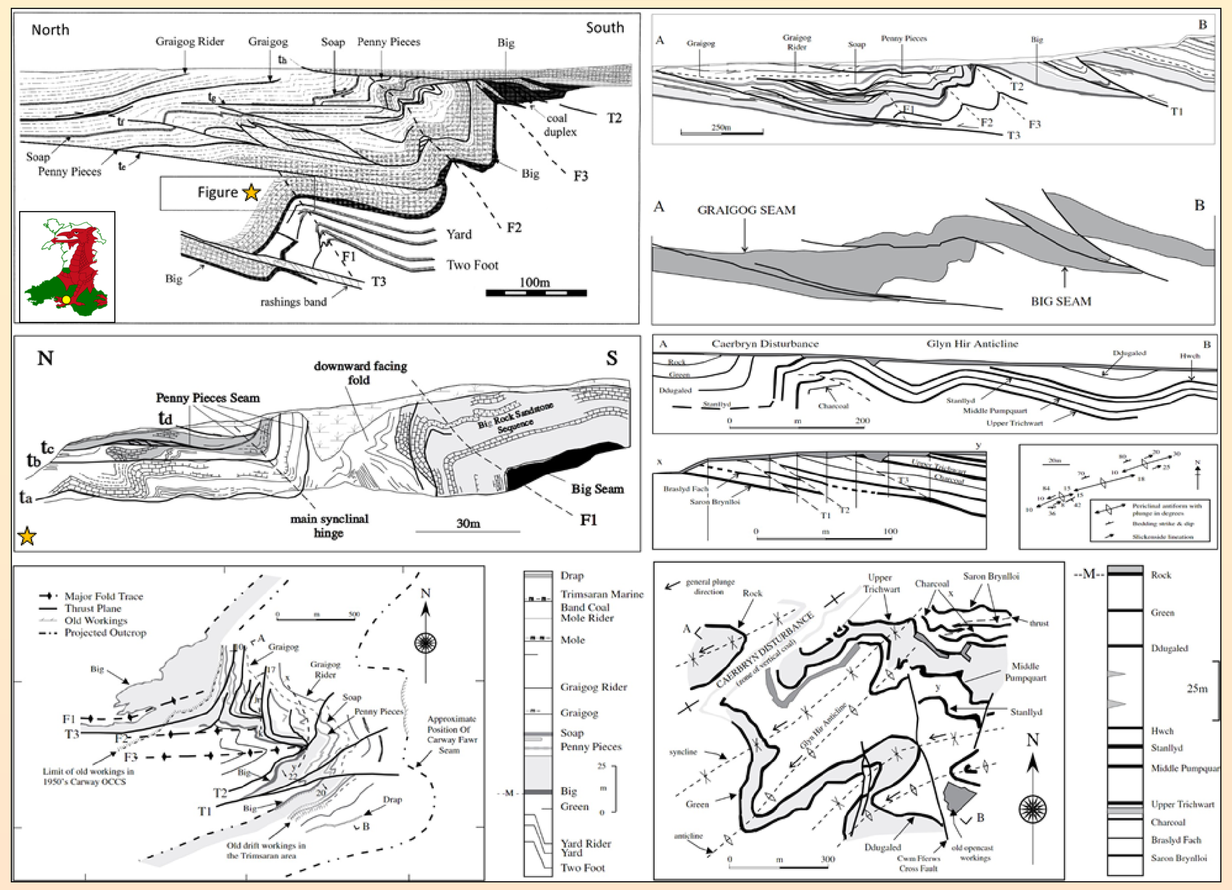
Outcrop of the Carboniferous Limestone, with some subcrop and seismic time structure. The main front has been drawn by others, WNE-ESE along much of the Limestone outcrop, but with little attention to local structures, their trend and history.

The structural style of deformation is one of compression followed by extension – shown in the following: fault line map of the south central Main Coalfield; fault line details around Maesteg; mine plan data from the Dyffryn Graben and open cast crop at Nant Helen and East Pit Extension, South Wales. They all display negative inversion of Variscan thrust faults.

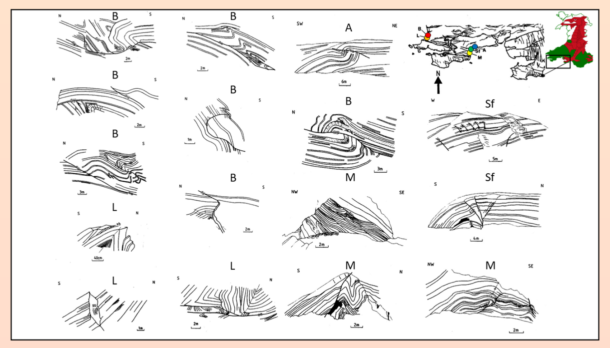


Structural style – Nant Helen open cast displayed thrust faults and folds that deformed sequences containing coal seams as well as deforming the coal seams internally. The eastern wall of the opencast displayed the Pwllau Bach Fault, a N-S striking cross fault with an early strike slip displacement and a late normal dip slip displacement indicative of inversion. Similarly, East Pit Extension opencast displayed a monocline above a major cross fault with a late normal displacement as well as thrust faults and folds at lower levels of the opencast where the effects of early Variscan compression on the Middle Coal Measures were clearly preserved.

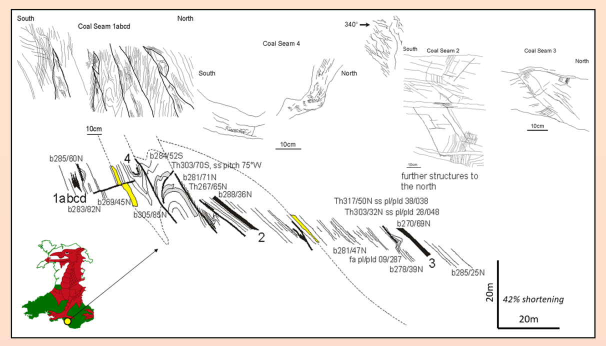
3. Geological Sections



Detailed maps and sections constructed over decades of work by Drs. R.A. Gayer and K. Frodsham of the Coalfield research team, University of Wales, Cardiff, illustrating highly strained, folded and faulted Middle Coal Measures at Ffos Las and Gilfach Iago open cast sites. The structures were formed partly by reactivation of disturbances.

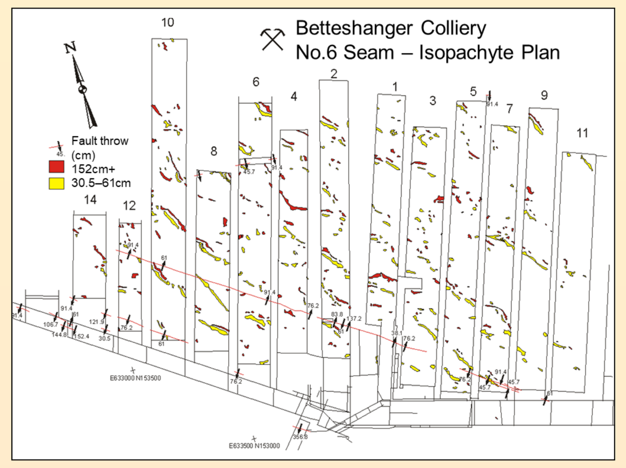


Structural style illustrated in sketches of Variscan folds and thrust faults from the coastal section through the Pembrokeshire Coalfield. Local shortening agrees with estimates based upon restoration of complex sections through the region, drawn by Dr. C. Powell.

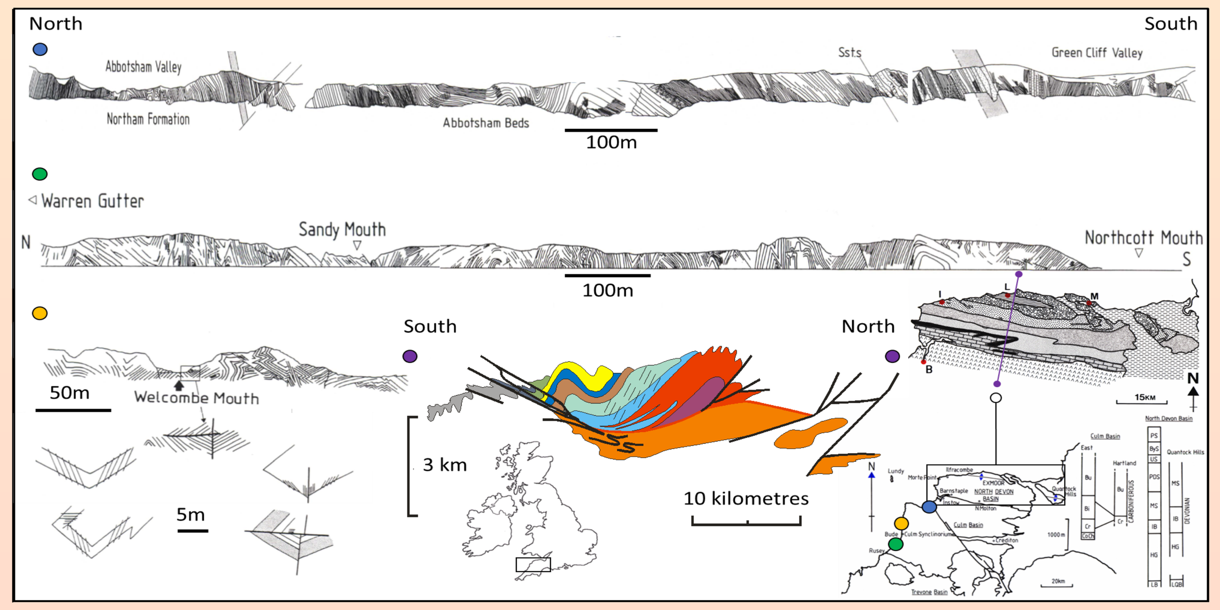


Structural style – an estimate of in-site Variscan shortening. Detailed fracture maps illustrate the composite nature of cleat, rashes, joints and veins due to several early compressional and late extensional events.

4. Comparative Styles and Modelling

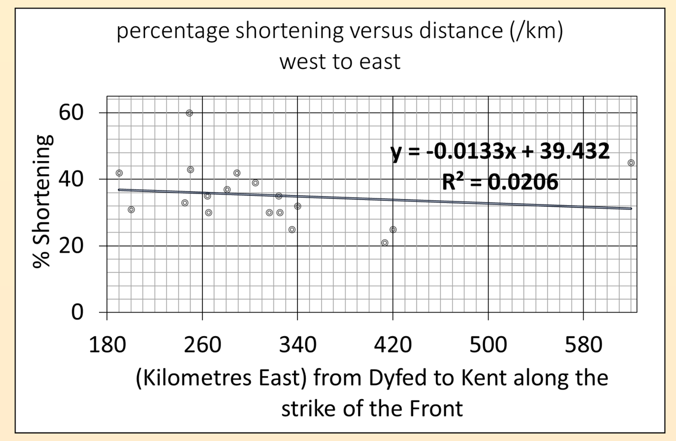


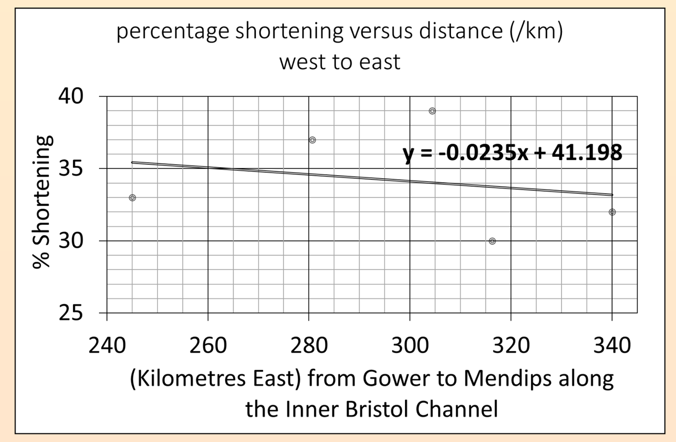
Thrust repetition of coal seams in the Betteshanger colliery described by Drs. J. Rippon and R. Gayer, with local shortening therein agreeing with regional foredeep shortening estimates. Structural styles within the open cast sites of the Main Coalfield: sandstone channels, fault growth and faults with displacement gradients studied by Prof. A. Hartley and Dr. P.A. Gillespie; thrust-fold interaction and friability researched by Drs. Gayer and K. Frodsham; regional thrust faults and folds described by Drs. T. Hathaway and J. Cole; and technical aspects investigated by I. Harris. An open system of partially mineralised fractures due to inversion events, points to fluid facilitated metamorphism of coal additional to structural controls illustrated by Dr. S. White.



The structural style of the SW England Culm basin includes the fold dominated sections in the Crackington, Bideford and Bude Formations with compressional growth faults, slumps, accommodation structures and refolding of chevron and box folds. Here also is a new model illustrating the structural style of the north Devon basin, bound by inverted fore-thrusts to the north and a major back thrust and periclinal folds to the south.

5. Shortening Estimates

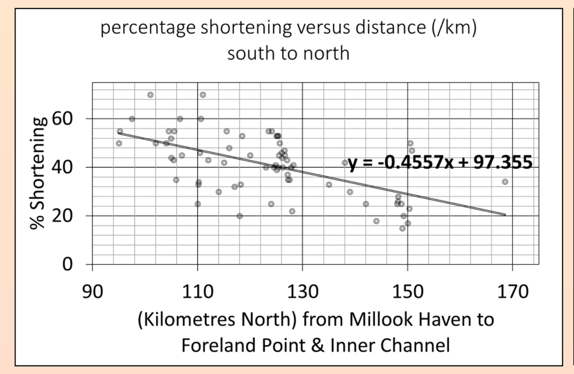


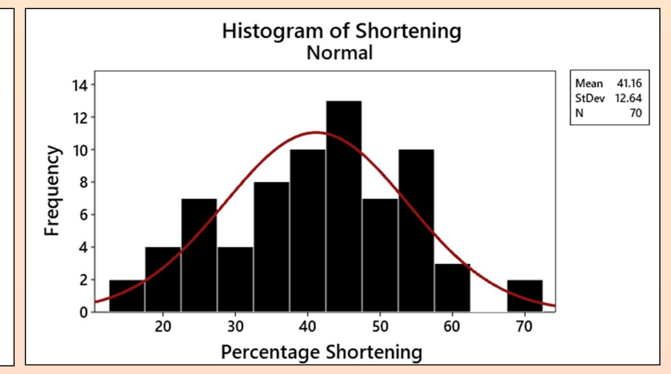


Graphs of percentage shortening for Variscan structure beneath the Inner Bristol Channel; from Cornwall to the south Bristol Channel and from SW Dyfed to Kent – showing a northward decrease across the British Variscides and the maintenance of a moderate shortening within and along the foredeep.

The shortening estimates have been adjusted for 5% extension due to negative inversion and a 1% Tertiary positive inversion.

The section SW Dyfed to Kent ranges from approximately 38% shortening to approximately 36% shortening, and the section Gower to Mendips ranges from approximately 35.5% to 33%.



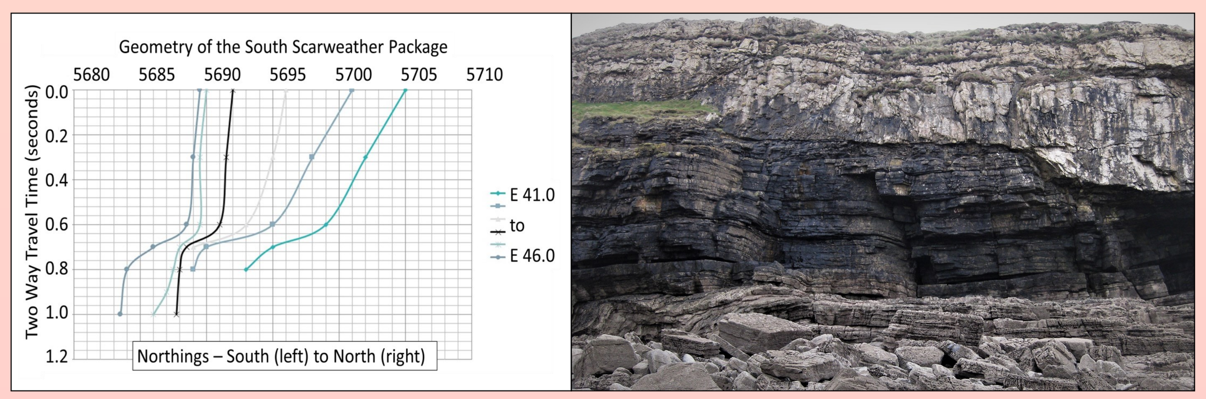


Analysis:

(i) a best fit line on the scatter plot has a negative gradient indicative of a northward decrease in regional shortening, approaching the foreland, likely influenced by negative inversion upon the major central Bristol Channel fault zone, north of the Culm and north Devon basins.

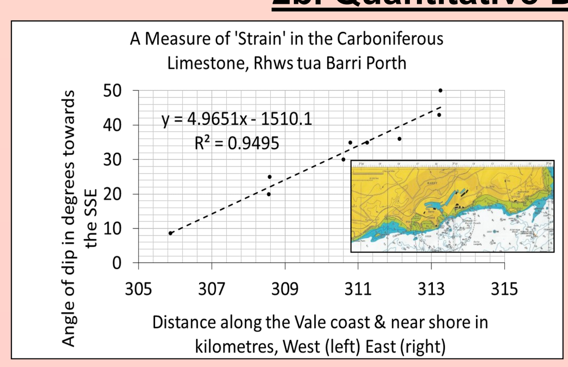
(ii) a normal distribution for the percentage shortening measured in the Culm basin of Cornwall and north Devon basin. The mean shortening is 41.16%.

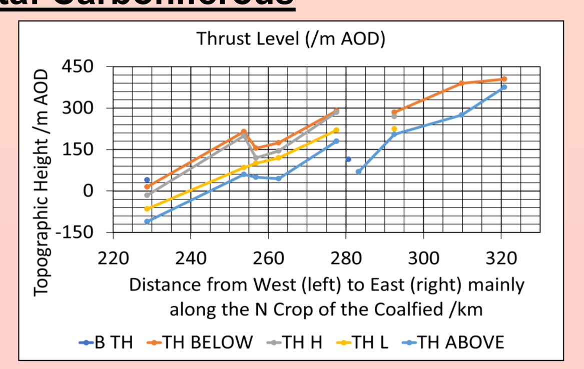
2a. Quantitative Data: South Scarweather Package



Time structure of the South Scarweather Package on its approach to the Regional Unconformity (Southerndown on the right) and the Bristol Channel Thrust Zone; the folds are indicative of high strain, induced by early thrusting and late negative inversion. The photograph was taken looking directly south at the Trwyn-yr-Wrach unconformity. The length of section shown is ~15m, with east to the left.

2b. Quantitative Data: Carboniferous

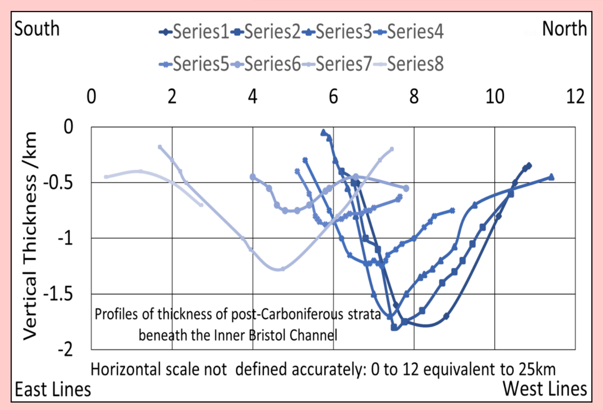




Increase of Carboniferous Limestone dip angle ENE along the Vale shore (admiralty chart inset); indicative of increase in strain approaching the Vale coast fault line with its composite kinematic history of inversion. The inset chart shows coastal detail of the central red rectangle on the second map in Box 1.

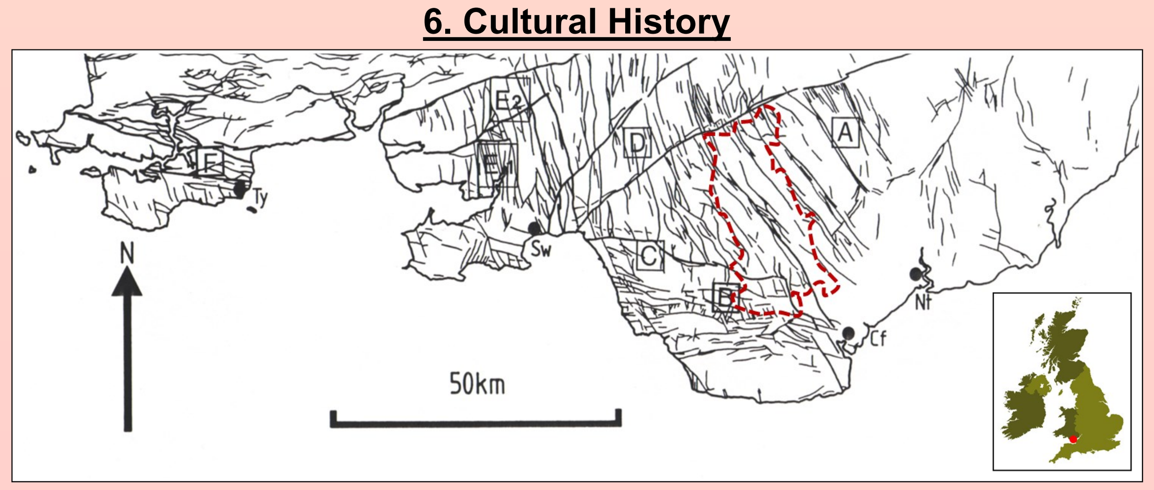
Continuation of Variscan deformation into the Foredeep and traced mainly along the north crop. The level of deformation concentrated within the middle part of the Middle Coal Measures dips westwards due to Late Variscan uplift of about 500m but also climbs northwards and westwards within the MCM by several degrees.

2c. Quantitative Data: Post-Carboniferous



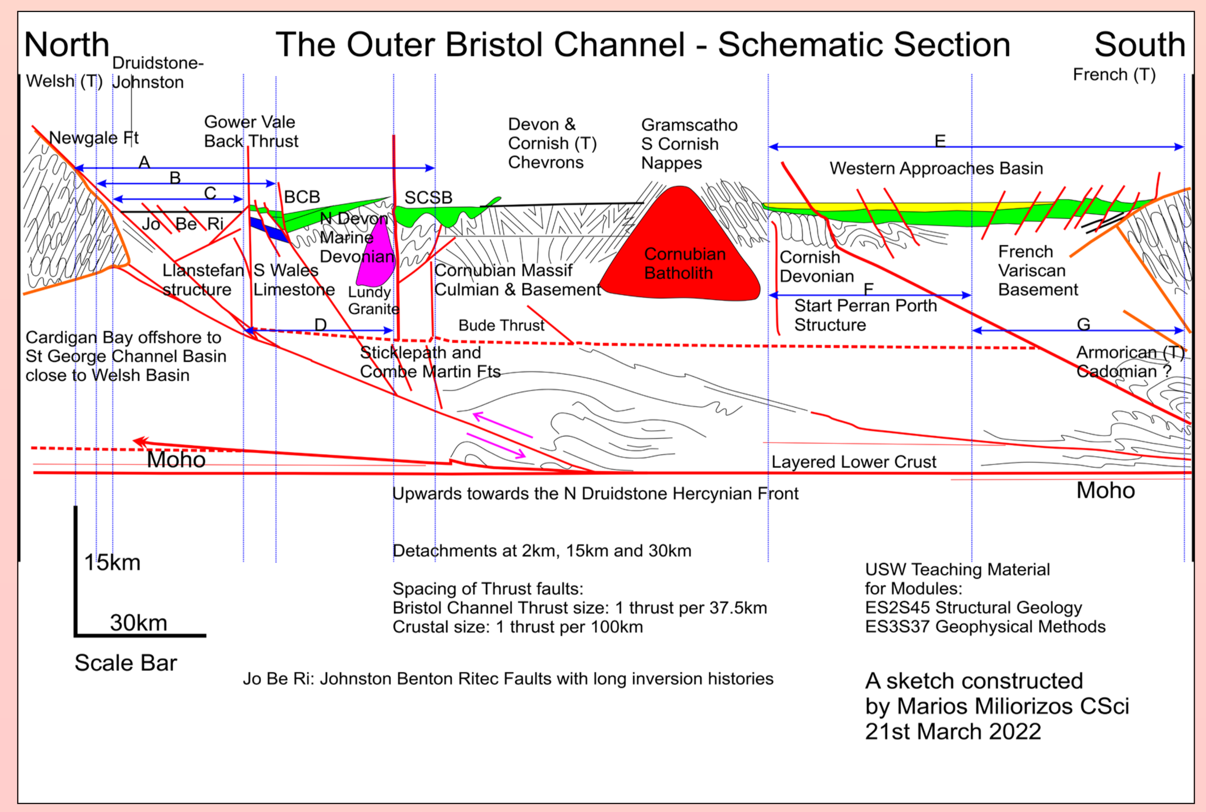
Inversion: time structural sections drawn looking along the strike of the Bristol Channel illustrating the dextral strike slip offset of the long-lived Watchet Cothelstone Hatch fault, with Late Carboniferous, Trias, Late Jurassic and Oligocene time components of slip. The Series 1 to 8 represent time-structure profiles along the channel from W-E.

6. Cultural History



The Rhondda Cynon Taff County (outlined in red dashes) is the subject of social historical studies of mining and post industrial Wales. RCT Council and USW staff have great interest in recording the transition from a fossil fuel-driven economy to the development of a green and vibrant post-industrial valley community; this is to be addressed in further research, including the potential of carbon capture sites and prediction of new fracking sites, and mapping out the transition amongst others.

7. Schematic Section: Scales of Displacement



In conclusion, there is room for three major thrust faults with hundred-kilometre scale displacements, that may have juxtaposed the Rhenohercynian zone and sub-Variscan foredeep by dextral transpression indicated by the magnitude and directions of shortening.

Key References

Brooks, M., Miliorizos, M., Hillier, B.V., 1994. Deep structure of the Vale of Glamorgan, South Wales, UK. Journal of the Geological Society 151, 909–917. https://doi.org/10.1144/gsjgs.151.6.0909.

Burgess, P.M., Gayer, R.A., 2000. Late Carboniferous tectonic subsidence in South Wales: implications for Variscan basin evolution and tectonic history in SW Britain. Journal of the Geological Society 157, 93–104. https://doi.org/10.1144/jgs.157.1.93.

Cole, J.E., Miliorizos, M., Frodsham, K., Gayer, R.A., Gillespie, P.A., Hartley, A.J., White, S.C., n.d. Variscan structures in the opencast coal sites of the South Wales Coalfield 5.

Frodsham, K., Gayer, R.A., 1999. The impact of tectonic deformation upon coal seams in the South Wales coalfield, UK. International Journal of Coal Geology 38, 297–332. https://doi.org/10.1016/S0166-5162(98)00028-7.

Frodsham, K., Gayer, R.A., 1997. Variscan compressional structures within the main productive coal-bearing strata of South Wales. Journal of the Geological Society 154, 195–208. https://doi.org/10.1144/gsjgs.154.2.0195.

Gayer, R.A., Cole, J., Frodsham, K., Hartley, A.J., Hillier, B., Miliorizos, M. and White, S.C. 1991. The role of fluids in the evolution of the South Wales Coalfield foreland basin. Proceedings of the Ussher Society, 7, 380-384.

Hathaway, T.M., Gayer, R.A., 1994. Variations in the Style of Thrust Faulting in the South Wales Coalfield and Mechanisms of Thrust Development. Proceedings of the Ussher Society, 8, 279-284.

Hinde, G.J., Fox, H., 1895. On a well-marked Horizon of Radiolarian Rocks in the Lower Culm Measures of Devon, Cornwall, and West Somerset. Quarterly Journal of the Geological Society 51, 609-NP. https://doi.org/10.1144/GSL.JGS.1895.051.01-04.45

Le Roy, P., Gracia-Garay, C., Guennoc, P., Bourillet, J.-F., Reynaud, J.-Y., Thinon, I., Kervevan, P., Paquet, F., Menier, D., Bulois, C., 2011. Cenozoic tectonics of the Western Approaches Channel basins and its control of local drainage systems. Bulletin de la Société Géologique de France 182, 451–463.

Miliorizos, M.N, Reiss, N., Melis, N.S., 2020. A demonstration of the tectonic evolution of the inner Bristol Channel UK: application of structural geological analogues to interpretation of legacy and new seismic data. EGU General Assembly 2020, EGU2020-3178.

Miliorizos, M.N, Reiss, N., Melis, N.S., Rutter, W.A.J., 2021. Structure of the Inner Bristol Channel and Severn Estuary: regional mapping and seismic interpretation yield a refined model for mountain front deformation and inversion. EGU General Assembly 2021, EGU21-3225.

Miliorizos, M., Ruffell, A., Brooks, M., 2004. Variscan structure of the inner Bristol Channel, UK. Journal of the Geological Society 161, 31–44. https://doi.org/10.1144/0016-764903-035.

Peace, G.R., Besly, B.M., 1997. End-Carboniferous fold-thrust structures, Oxfordshire, UK: implications for the structural evolution of the late Variscan foreland of south-central England. Journal of the Geological Society 154, 225–237. https://doi.org/10.1144/gsjgs.154.2.0225.

Pullan, C.P., Donato, J.A., 2022. The Eastern Extension of Southwest England under the Mesozoic Southern England Basin and its Variscan Dextral Translation. Ukogl/Oxford University, Beneath Britain Website.

Rippon, J.H., Gayer, R.A., Miliorizos, M., 1997. Variscan structures in the Kent Coalfield, southeast England, and their regional significance. Geological Magazine 134, 855–867. https://doi.org/10.1017/S001675689700722X.

Rutter, W.A.J., Miliorizos, M.N., 2021. A review of geological and geophysical evidence for major inverted faults at shallow depth beneath the Vale of Glamorgan coast, South Wales, UK. TSG@50, Online: 5-8 January 2021.

Tappin, D.R., Chadwick, R.A., Jackson, A.A., Wingfield, R.T.R., Smith, N.J.P., 1994. United Kingdom offshore regional report: the geology of Cardigan Bay and the Bristol Channel. London: HMSO.

Waters, R.A., Lawrence, D.J.D., 1987. Geology of the South Wales Coalfield, Part III, the country around Cardiff; Memoir for the 1:50,000 geological sheet 263 Third Edition. London: HMSO.

Williams, G.D., Chapman, T.J., 1986. The Bristol-Mendip foreland thrust belt. Journal of the Geological Society 143, 63–73. https://doi.org/10.1144/gsjgs.143.1.0063.

Wilson, D., Davies, J.R., Fletcher, C.J.N., Smith, M., 1990. Geology of the South Wales Coalfield, Part VI, the country around Bridgend. Memoir of the British Geological Survey, Sheet 261 and 262 (England and Wales). London: HMSO.

Woodcock, N.H., Soper, N.J., Strachan, R.A., 2007. A Rheic cause for the Acadian deformation in Europe. Journal of the Geological Society 164, 1023–1036. https://doi.org/10.1144/0016-76492006-129.

We would like to thank the following scientists: R.A. Gayer, K. Frodsham, C. Powell, A. Hartley, P. Gillespie, J. Cole, T. Hathaway, S. White, P. Burgess, I. Harris, J. Rippon, G. Williams, B. Hillier, and M. Nemčok, for their work on the South Wales coalfield and for paving the way for this study.