

Read at the Annual Conference of the Ussher Society, January 1989

## The Variscan foreland in South Wales

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Intense Variscan deformation is developed in a WNW-ESE fold and thrust belt across the southern margin of Wales. Shortening estimates vary from 40% in SW Dyfed (Smallwood 1985) to 20-30% in S Glamorgan (Jones and Gayer, in prep.). In the south this belt involves both the Old Red Sandstone and the Dinantian Limestones, elevating them > 2km above their regional level in the South Wales coalfield. In SW Dyfed Lower Palaeozoic and Precambrian rocks are also involved in thrusts (e.g. the Johnston Thrust) which can be shown to have inverted Devonian and Dinantian extensional growth faults (e.g. the Benton and Ritec Faults, Fig. 1) (Powell 1987, 1989). Thus the South Wales area underwent a period of extensional tectonics during the Devonian and Early Carboniferous before suffering inversion during post-Westphalian Variscan contraction.

The continuity between the Variscan deformation in South Wales and that in North Devon is interrupted by the Inner Bristol Channel Basin, formed by Mesozoic extension, and deformed during later Mesozoic and Cenozoic inversion (Kamerling 1979). It has been suggested by Tunbridge (1986) that the principal extensional fault of this Mesozoic basin - the

Bristol Channel fault zone (Brooks and James 1975) - represents a reactivated Late Palaeozoic strike-slip fault that controlled Mid-Devonian sedimentation. However, analysis of recently acquired seismic reflection data shows that this Late Palaeozoic fault is a major south-dipping Variscan thrust (Brooks *et al.* 1988), thus providing a thin-skinned link between the South Wales foreland deformation and areas towards the orogenic hinterland in south-west England. It is not possible to determine from the seismic reflection data whether or not an earlier, pre-thrust fault existed along the line of the Bristol Channel fault zone to control Devonian sedimentation. However, by analogy with the Ritec and Benton Faults, such a fault might well have been an extensional fault, with major footwall uplift to provide a source area for the Mid-Devonian sediments (Fig. 2A). Inversion of an extensional fault to produce the observed thrust would be mechanically easier than inverting a vertical strike-slip fault.

The Variscan fold and thrust belt extends northwards into the South Wales Coalfield. Stratigraphic and sedimentological analysis of the E-W elongate coalfield basin demonstrates a

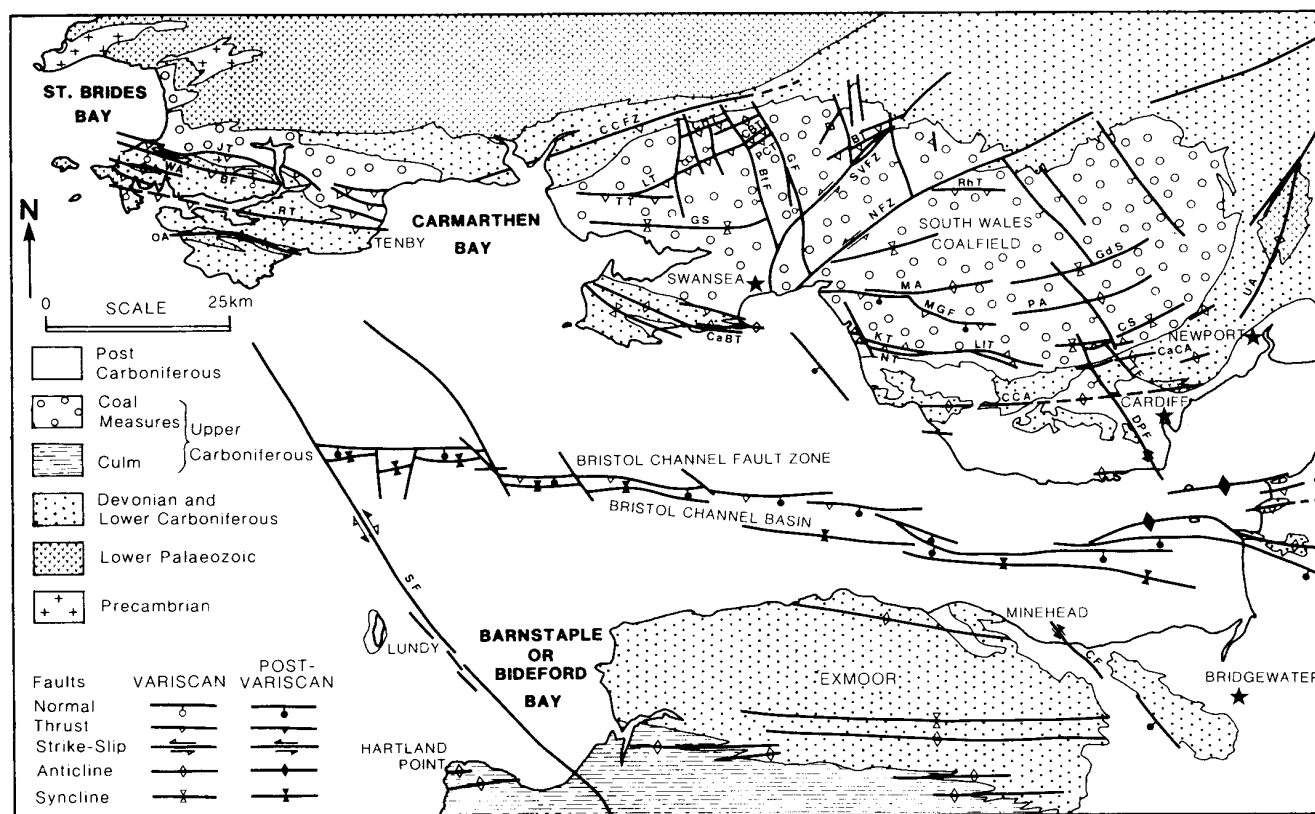


Figure 1: Map showing Variscan and post-Variscan structures of the Variscan Foreland of South Wales and the Bristol Channel. Variscan structures that have been reactivated during post-Variscan deformation are shown with symbols for both structural events. Named structures are: BF, Benton Fault; BT, Blaina Thrust; BtF, Bettws Fault; CaBT, Caswell Bay Thrust; CaCA, Castell Coch Anticline; CBT, Caer Bryn Thrust; CCA, Cardiff-Cowbridge Anticline; CF, Cothelstone Fault; CCFZ, Carreg Cennen Fault Zone; CHT, Cross Hands Thrust; CS, Caerphilly Syncline; DPF, Dinas Powys Fault; GdS, Gelligaer Syncline; GF, Gardeners Fault; GS, Gorseion Syncline; JT, Johnston Thrust; KT, Kenfig Thrust; LT, Llannon Thrust; LIT, Llanharan Thrust; MA, Margam Anticline; MGF, Moel Gilau Fault; NFZ, Neath Fault Zone; NT, Newlands Thrust; OA, Orielton Anticline; PA, Pontypridd Anticline; PCT, Pont-y-Clerc Thrust; RhT, Rhigos Thrust; RT, Ritec Thrust; SF, Sticklepath Fault; SVFZ, Swansea Valley Fault Zone; TF, Tongwynlais Fault; TT, Trimsaran Thrust; UA, Usk Anticline; WA, Winsle Anticline.

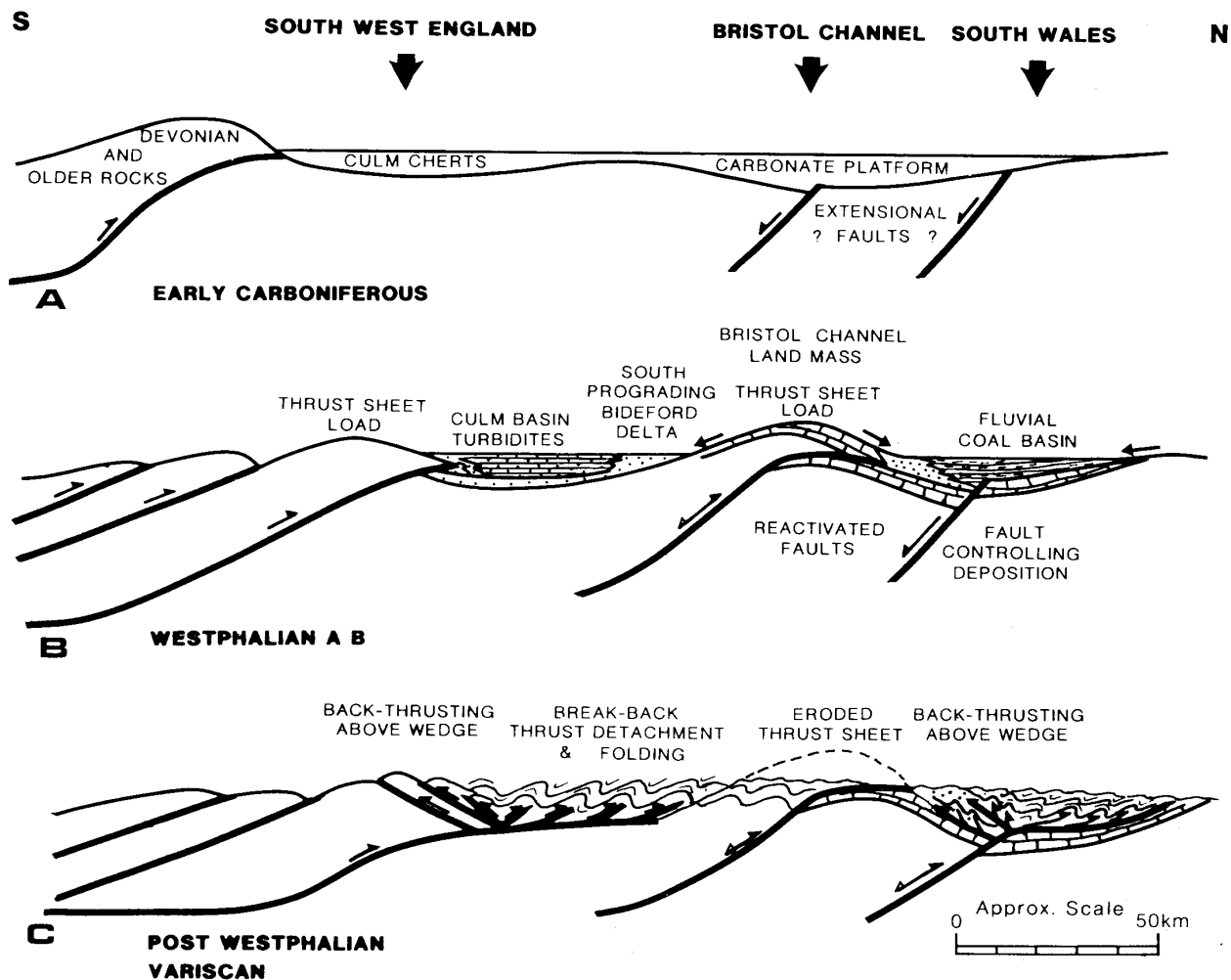


Figure 2: Diagrammatic cross-sections across the northern Variscan margin in southwest Britain to show stages in the development of the South Wales coalfield foreland basin and related structures to the south.

A. Early Carboniferous (Dinantian): initiation of the Culm basin as a response to thrust sheet loading in the south. South dipping extensional faults, active during the Devonian, may have continued activity in the Bristol Channel and South Wales areas (Powell 1988; Jones 1989).

B. Late Carboniferous (Westphalian A and B): Thrusting continued in the south, downflexing the Culm turbiditic foreland basin of north Cornwall and Devon, with the development of a north dipping active palaeoslope in the south (Enfield *et al.* 1985). The northern margin of the basin was occupied by the south prograding delta of the Bideford Formation (Elliott 1976), sourced from a Bristol Channel landmass to the north. It is suggested that this landmass originated as a thrust sheet uplift, possibly inverting an earlier extensional fault along the Bristol Channel. The thrust sheet, identified on seismic reflection profiles (Brooks *et al.* 1988), was also responsible for the South Wales coalfield foreland basin, and sourced the immature sediments of the Pennant Measures in that basin.

C. Variscan orogenic deformation (post-Westphalian) developed in two zones: firstly by forelandward propagation of thrusting into the South Wales coalfield reactivating earlier extensional faults, such as the Moel Gilau Fault; and secondly by continued movement, in an out of sequence manner, of thrusts to the south of the Culm Basin, with northward propagation of a detachment beneath the Culm basin sediments. Backthrusting occurred above the upthrust wedge associated with both zones. Note that there is no necessity for the foreland upthrusts to be linked in a thinskin system with the thrusts in the south.

sudden pre-Namurian breakdown of the Dinantian carbonate platform, and a northward migration of the depocentre through Namurian and Westphalian time (Kelling 1988; Jones 1989a, b).

This development is most likely related to foreland basin dynamics in response to a northward propagating thrust sheet load. Namurian and Early Westphalian clastic input has a mature source from St George's land to the north (Bluck and Kelling 1963; Kelling 1964), possibly resulting from erosion of a foreland basin peripheral bulge (Beaumont *et al.* 1982). Later, during Westphalian C and D, large volumes of immature lithic sands of the Pennant Measures were derived from tectonic sourcelands to the south, possibly representing an uplifted Variscan thrust sheet beneath the Bristol Channel (Fig. 2B).

Subsidence and basin-fill architecture were influenced by reactivation of pre-existing deep-seated structures (Jones 1989a, b). These structures are oriented in three main sets: 1. EW (Variscanoid); 2. ENE-WSW (Caledonoid); and 3. N-S (Malvernoid). During the subsequent northward propagation of Variscan deformation, a major linked thrust system developed in the incompetent Lower and Middle Coal Measures. Extensive thrust flats tend to lie within the roof or floor of coal seams and short ramps cause repetitions of individual seams. Northward verging structures extend to the northern margin of the coalfield and were buttressed against the ENE-WSW Caledonoid basement structures, producing prominent zones of disturbance (Trotter 1947, 1948), where early thrusts have been progressively refolded by later tip folds. In the south of the coalfield, to the south of the E-W trending

Moel Gilau Fault (Woodland and Evans 1964) a major southward verging thrust system developed as a passive roof duplex (Banks and Warburton 1986; Jones 1989b) beneath the Upper Coal Measures (Pennant Sandstone), (Fig. 2C). Such a thrust geometry is typical of many orogenic forelands (Vann *et al.* 1986), probably representing a period of sticking of the foreland directed thrusting.

It is suggested that the ancestral Bristol Channel fault zone was a major Variscan thrust forming the floor thrust of an extensive thrust sheet. The emplacement of this thrust sheet during Early Namurian to Westphalian times downflexed the lithosphere and produced the South Wales coalfield foreland basin, filled with Namurian and Westphalian clastic sediments. The Culm basin of north Cornwall and Devon must thus lie in the hangingwall to this thrust and represent a thrust sheet top basin (e.g. Howard and Kuznir 1988). The northerly derived sediments of the Namurian and Early Westphalian Bideford Formation (de Raaf *et al.* 1965; Elliott 1976) in the northern part of the Culm basin would be sourced from the uplifted thrust tip in the Bristol Channel (Fig. 2).

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