

Variscan Tectonics of the North Atlantic Region

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edited by

D. H. W. Hutton

Department of Geology, Trinity College, Dublin, Ireland

now at:

Department of Geological Sciences, The University, Durham, U.K.

D. J. Sanderson

Department of Geology, Queen's University, Belfast, U.K.

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Preface

The Variscan orogen is a broad zone of deformation which lies between central Europe, the southern British Isles, and fringes the east coast of North America and the north-west coast of North Africa. Deformation occurred in this area in a broad time span encompassing the Middle Devonian to the early Permian. We have used the term 'Variscan' since it seems to be the generally preferred usage throughout Europe. 'Hercynian' has come to be used as a synonym for 'Variscan' especially in the mainland European context whilst 'Alleghenian' describes the late Carboniferous to early Permian events of North America and 'Mauritanian' refers to the African part of the orogen.

When compared with other orogens the exact nature of the Variscan and the processes which produced it remain particularly unclear. This arises from a number of major problems some of which we can restate.

Although described as a fold belt the orogen is very wide (in excess of 2,000 km) and is not particularly belt-like. There are considerable problems in tracing tectonic-stratigraphic units along the strike of the orogen for any substantial distance. This is exacerbated by the fact that post-Variscan cover in mainland Europe is extensive and much of the Variscan occurs in separated massifs. Nor is along strike comparison helped by the fact that Variscan research has been published in a variety of languages by scientists who have approached the geology with the methodology appropriate to their own differing traditions.

There are clear differences between one end of the belt and the other. Thus in central Europe there are large volumes of granitoids and regionally developed low-pressure high-temperature metamorphics: evidence for high heat flow and thinned crust. Yet in North America the Variscides form a longer, more cylindrical belt of Barrovian metamorphics sitting on large-scale west directed thrusts and containing significantly lower volumes of granitic rocks.

When these differences and difficulties are combined with a comparative lack of ophiolitic and blueschist remnants in the orogen we find that a plate tectonic interpretation of the Variscides is less easily sustained than in other orogens. A tradition has tended to develop of Mid-Atlantic 'mobilism' versus central European 'fixism' in debates about the ultimate meaning of the Variscides.

It was against this background that we decided to organise a meeting in September 1982, under the umbrella of the Tectonic Studies Group of the Geological Society of London and held at Trinity College Dublin, Ireland. However much a discussion of the tectonics and structures of the whole orogen would have been desirable we decided to concentrate on the northern marginal zone around the North Atlantic. This book, although somewhat broader in outlook than the original theme of the Dublin meeting, examines the geology of the marginal zone between central Europe and Alabama. Why should we look at this area?

Firstly, it is easier to define orogenic strike on the margins of the orogen than in the interior, thus allowing along strike correlations and comparisons to be attempted.

Secondly, the margins of an orogenic belt are the results of a set of boundary conditions in which the observed structures arise from the interference of two things: (a) the pre-convergence geometry (e.g. foreland configuration) and (b) the gross convergence vector. With luck it might be possible to separate these two important parameters.

Thirdly, much recent work and new methodology has been devoted to deformation in

the marginal parts of orogens. The resurgence of interest in thrust tectonics has generated many new models and ideas from Variscan areas and it seemed appropriate to give this an outlet.

Fourthly, geophysical studies and particularly crustal scale seismic reflection experiments are being increasingly undertaken at orogenic margins. Hitherto unsuspected major low angle reflectors (thrusts?) are now appearing in reflection studies with great regularity.

Finally there has been a long-standing discussion about the existence and nature of the Variscan front: the putative northern edge of the orogen. A discussion of this problem, in view of the developments noted above, is long overdue.

The general structure of the book is simple and, we hope, effective. We have attempted to present information on the marginal zone in separate but adjacent (and overlapping) geographic sectors. We begin in the east, in central Europe and finish in the west, in southern U.S.A. Each sector is introduced by a substantial review article followed by one or more regional, geophysically based papers and then a number of more detailed contributions. Some sections are completed by general and 'ideas' papers. We have broken this basic structure in (a) including the Massif Central, which although not part of the northern margins, is of some importance in tracing the German structure westwards, and (b) by including papers in Britain and Ireland which deal with the style of deformation in the orogenic foreland.

The facts, ideas and conclusions reached by the authors are difficult to summarize properly here. However, as editors, with a feeling for the 'middle ground', and a little editorial licence, we would like to point to a few limited, but interesting, general conclusions about the northern margins that were not perhaps too apparent until recently.

- (a) South and south-east dipping thrusts occur throughout the northern marginal zone of the Variscides: although the intensity and, we suspect, the translation on these thrusts varies from place to place.
- (b) Although brittle dextral transcurrent deformation is well known as a late stage event in the Variscides, we feel there is evidence of earlier dextral movements. These are ductile in nature and occurred broadly synchronously with the overthrusting, especially in the central part of the belt between Newfoundland and western Europe.

This all appears to us to be consistent with the view of a roughly NW-SE directed collision. Thus in the central sector the oblique collision produces variable amounts of overthrusting and strike-slip movement, whereas in North America closure was more normal to the NE-SW trend of the margin and large-scale thrusting predominated. A post-collision continuation of these movements may then have imposed the better known brittle dextral shear system.

The nature of the Variscan front, as described and discussed by many authors herein, ultimately reflects all of this. Thus it appears relatively sharp in thrust dominated regimes yet more diffuse and difficult to pin-point in areas where transcurrent shear is important. Intensity of thrusting can also be controlled by foreland configuration: intense around promontories, weak in embayments and strike-slip segments. Along strike variations in the position of the front can also depend on gross erosion level within the orogen. On a local scale this may be controlled by whether a thrust tip line is exposed or not. On a more regional level erosion may intersect the upper flat or ramps of crustal scale duplexes, the former giving variable sinuous outcrop of the thrust front, the latter much straighter outcrop closer to the centre of the orogen. Finally the edge of the deformation

will tend to be drawn towards the foreland in an irregular manner by small basin developments in the marginal zone.

Our final task, and pleasure, as editors is to thank the contributors to this volume and in particular to acknowledge their tolerance over the slow processing of some of the papers. We would also like especially to thank Bob Campbell and Nick Parsons of Blackwells with whom it was a pleasure for us to work.

Our final note of gratitude is also one of great sadness. Crosbie Matthews, whose paper appears herein, died in the spring of last year in Uppsala, Sweden. In the early stages of planning the conference and this volume, Crosbie gave freely of his time and advice on Variscan matters particularly in respect of mainland Europe with which he was so familiar. At a later stage he willingly undertook the arduous job of rendering in English the papers of a number of our German and French contributors. We are extremely grateful to him for all this.

Crosbie devoted much of his research life to the problems of the enigmatic Variscides. His linguistic ability and personal knowledge of European Variscan geology, geological literature, people and attitudes placed him in a formidable, unique and not always properly appreciated position within our affairs. The paper that appears here is a final and somewhat personalized statement of his views of this rather unique fold belt.

D. H. W. HUTTON

D. J. SANDERSON