Geology

Death of an ancient ocean

from Peter Gambles

THE Caledonide Orogen is the name given to the mountain belt, now torn apart by the modern Atlantic ocean, that was formed by the collision of the continental plates of North America, Africa and Baltica between about 550 and 350 million years ago. Stretching from Spitzbergen and Greenland in the north, to the Mauritanides and the Gulf of Mexico, it is one of the longest such belts in the world. The broad outline of the plate tectonic movements that formed the mountains has been known for some time, but their reconstruction still resembles a child's drawing with straight-edged continents closing over a smooth ocean floor. A glance at any globe will show that this is not the real world. Oceans are dotted with mid-ocean ridges, volcanic arcs and islands of both oceanic and continental crust; moreover, continental margins are far from straight. The exciting challenge now was made clear at the symposium on 'Evolution of the Caledonide-Appalachian Orogen', University of Glasgow,

3-8 September 1984. It is to integrate the wealth of data from traditionally distinct disciplines within earth sciences into a more realistic model of this major episode in the Earth's history.

The fashionable concept of suspect or allochthonous terranes is part of the new approach to plate tectonics. In essence, such a terrane is a sizeable chunk of continental crust, the geology of which is incompatible with that of adjacent areas. The Western Cordillera in the United States and Canada is now thought to comprise a multitude of such microcontinents. Many of these have moved hundreds of kilometres, largely parallel to the continental margin. By contrast, some of the terranes in the Appalachians have been transported from one continent to another across the oceans.

To establish the links between the Appalachian terranes and those now on the opposite side of the Atlantic, geologists must rely on the traditional methods of

comparative stratigraphy, using as a standard the Newfoundland portion of the orogen — the Humber, Dunnage, Gander and Avalon zones. Of these, the Avalon is probably the most significant in terms of the evolution of the mountain belt, and has proved useful, for example, in examining the very earliest development of the Caledonide Orogen. During the latest Precambrian (700–580 Myr), the eastern margin of North America underwent a large degree of crustal extension (D.W. Rankin, USGS, Reston). This is indicated in the geological record by the presence of basaltic dykes, forming up to 50 per cent of the exposed rocks, and by the extrusion of continental tholeiitic and alkali basalts. However, contemporaneous volcanism in Avalon was calc-alkaline, and so not related to rifting, suggesting that Avalon was not part of North America. Moreover, the distribution of fauna, especially trilobites (L.R.M. Cocks, British Museum and W.S. McKerrow, University of Oxford), favours closer links of Avalon with Gondwana (a supercontinent comprising today's southern continents including Africa) than with America during the early Cambrian (570 Myr). To the north of the continental fragment lay a number of ridges and basins such as the Irish Sea

THE evolution of the mountainous Caledonides of Scandinavia and Britain, the Appalachians of North America and Canada and the Mauritanides of North Africa has been the subject of a 10-year programme of geological research entitled 'The Caledonide Orogen'. Organized jointly by Unesco and the International Union of Geological Sciences, it has been led by a group of Norwegian geoscientists. Together over 200 specialists from countries bordering the present north Atlantic have carried out nationally financed research projects and exchanged results at a series of symposia held in conjunction with field studies.

The final symposium of the project was one with a difference in that the entire orogen was studied in terms of four time slices rather than in the more conventional divisions into subject specializations. Some of the coordinators of these sessions had clearly done their homework, while others, for one reason or another, were forced to rely on lecturers who had only a vague knowledge of what the Caledonide Orogen was and even less knowledge of its present day geography.

The scene was set by the geophysicists, whose models of the earth, based partly on data beyond the reach of the field geologist, must be tested against the field evidence. The two approaches sometimes conflict. For example, fossils and sediments may indicate a warm climate, while the geomagnetic palaeopole position suggests the contrary. In my view the evidence for an equatorially placed American plate during the Ordovician

period and for a high latitude position for Baltoscandia (~60°S) during at least the first half of the period, is overwhelming. The majority of geologists are prepared to accept this. What is not certain, however, is the relative positions of both plates and that of the African. Did they meet along a so-called triple junction, and were Africa and Baltoscandia separated by the so-called Tornquist Sea?

Meanwhile the palaeontologists continue to provide dates (with an accuracy of one million years in some instances) and information which both startles and irritates. Yet they cannot be disregarded, even when they happen not to fit some of the many, and often conflicting, dates produced at vast expense by radiometric methods. I was amazed at how uncritically some of the radiometric dates were used to fit the geological models. A fossil cannot be reset nor can it be destroyed (unless lost). It can be wrongly interpreted but it is a firm piece of tangible evidence. The Caledonide Orogen project has done more than any other to encourage palaeontologists to provide answers to questions posed by field geologists rather than other palaeontologists. Their diligent collecting has provided a wealth of material from the most unlikely rocks; shelly fossils have even been found in volcanic ashes derived from oceanic islands along the length of the belt.

Perhaps the most successful part of the whole project, and certainly the most exciting session of the symposium, concerned geological maps. From the inception of the project, specialist study groups were set up with the specific goal of

producing a series of 1:1 million scale geological maps of the Caledonide-Appalachian Orogen. In addition to the more usual maps of geological structures, the distribution of volcanic and plutonic rocks, and the relationships between sedimentary rock types and faunas, there were a number of more adventurous projects. These covered the timing of deformation and age of metamorphism in various parts of the orogen, and the relationship between basement rocks and their cover, topics almost designed to be controversial. From the start, a standard time scale was agreed on, as were symbols and colours. The end result is that British and Irish geologists cooperated to provide three handsome new maps, on sale at the symposium, and Norwegian and Swedish geologists jointly produced a map with boundaries that actually coincide where they cross the state border. Regrettably, a number of the thematic maps are still provisional and there is doubt as to whether funds to publish them will be forthcoming.

When the final speech of the symposium declared the end of the project, those of us who thought it an enjoyable and worthwhile experience have the prospect of another to look forward to. 'Suspect terranes', as it may be called, will be considered by the board of the International Union of Geological Societies in 1985. □

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