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Caledonides of Britain and Ireland

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Introduction

The term 'Caledonian' is derived from the Latin word for Scotland and has been used widely with reference to the Early to Mid-Palaeozoic orogenic belt that is exposed in the British Isles, eastern Greenland, and Scandinavia (Figure 1). When these areas are restored to their relative positions prior to the Cretaceous–Tertiary opening of the North Atlantic (Figure 1), it can be seen that they were formerly continuous, comprising the northern part of the Mesozoic supercontinent Pangaea. The Caledonian Orogeny is the oldest of three main Palaeozoic collisional events that formed Pangaea, the other two being the Variscan and Uralian orogenies.

The Caledonian orogenic belt has three main arms (Figure 1): the North Atlantic Caledonian Belt and its southern extension, the Appalachian Belt, which were both formed by the closure of the Iapetus Ocean, and the Tornquist Belt, which resulted from the closure of the Tornquist Sea. These belts separate areas of Archaean and Proterozoic crust, which formed the palaeocontinents of Laurentia (North America, Greenland, and the northern British Isles), Baltica (Scandinavia and the Baltic), and Eastern Avalonia (the southern British Isles, Belgium, and the adjacent crust). Eastern Avalonia is the northernmost of a group of continental fragments that were originally derived from Gondwana and include Western Avalonia, Iberia, and Armorica. The collision of these fragments through the Mid- to Late Palaeozoic resulted in the Variscan orogenic belt (*see* **Europe:** Variscan Orogeny), which just impinges on the south of the British Isles.

Palaeogeographical and Tectonic Framework

The Caledonian plate-tectonic cycle began in the Mid- to Late Neoproterozoic with the rifting and break-up of the supercontinent Rodinia and the subsequent dispersion of continental blocks to form the Iapetus Ocean. Palaeomagnetic studies indicate that, in the Late Cambrian to Early Ordovician, Laurentia occupied an equatorial position to the north of Baltica and Avalonia (the latter was still attached to Gondwana at this stage). The distance across the Iapetus Ocean between the locations of present-day Scotland and England was probably about 5000 km, and the width of the Tornquist Sea, which separated Gondwana from Baltica, was probably about 1300 km. Each continent was characterized by a distinctive trilobite fauna. The initial closure of Iapetus was associated with the development of a southwards-dipping intraoceanic subduction zone and volcanic arc off the eastern Laurentian margin. The collision during the Early to Mid-Ordovician between the Laurentian margin and the volcanic arc resulted in the Grampian orogenic event (Figure 2). Subduction polarity then reversed to dip northwards beneath the Laurentian margin.

Eastern Avalonia rifted from Gondwana in the Arenig and drifted rapidly northwards between 480 Ma and 460 Ma to reach a similar latitude to Baltica during the Caradoc. A southwards-dipping subduction zone was located along the northern Iapetan margin of Eastern Avalonia. As on the Laurentian margin, a suprasubduction zone ophiolite–arc

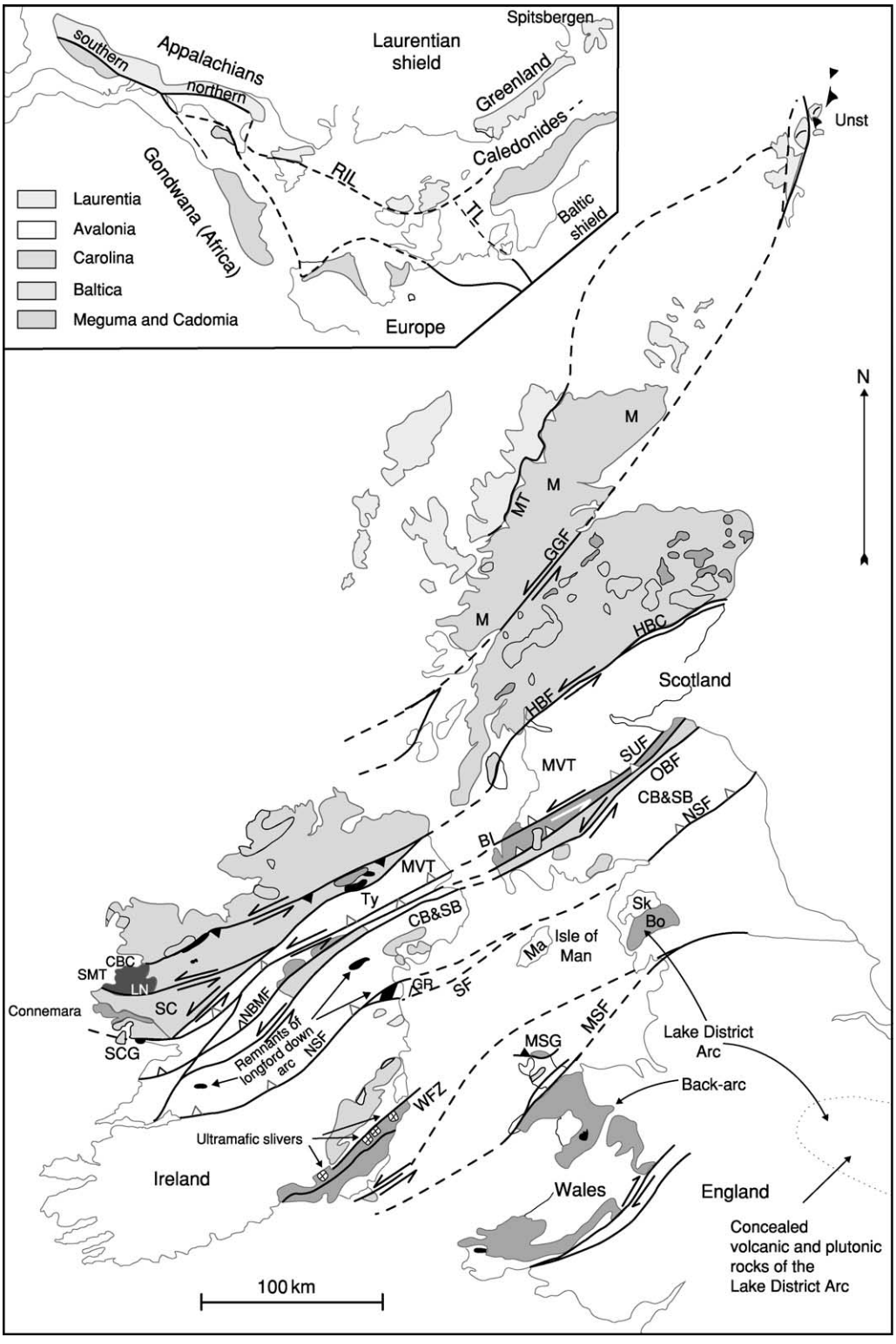

Figure 1 Simplified Caledonian tectonic map of the British Isles with their Appalachian continuation shown in the inset. BI, Ballantrae Ophiolite; BO, Borrowdale Volcanics; CB, Central Belts; CBC, Clew Bay Complex; GGF, Great Glen Fault; GR, Grangegeeth Terrane; HBC, Highland Border Complex; HBF, Highland Boundary Fault; LL, Leadhills Line; M, Moine; Ma, Manx Group; MSF, Menai Straits Fault; MSG, Monian Supergroup; MT, Moine Thrust; MVT, Midland Valley Terrane; OBF, Orlock Bridge Fault; RIL, Red Indian Line; SC, South Connemara Terrane; SCG, South Connemara Group; Sk, Skiddaw Group; SL, Slane Fault; SMT, South Mayo Trough; SUF, Southern Uplands Fault; TL, Tornquist Line; Ty, Tyrone Ophiolite; WFZ, Wicklow Fault Zone.

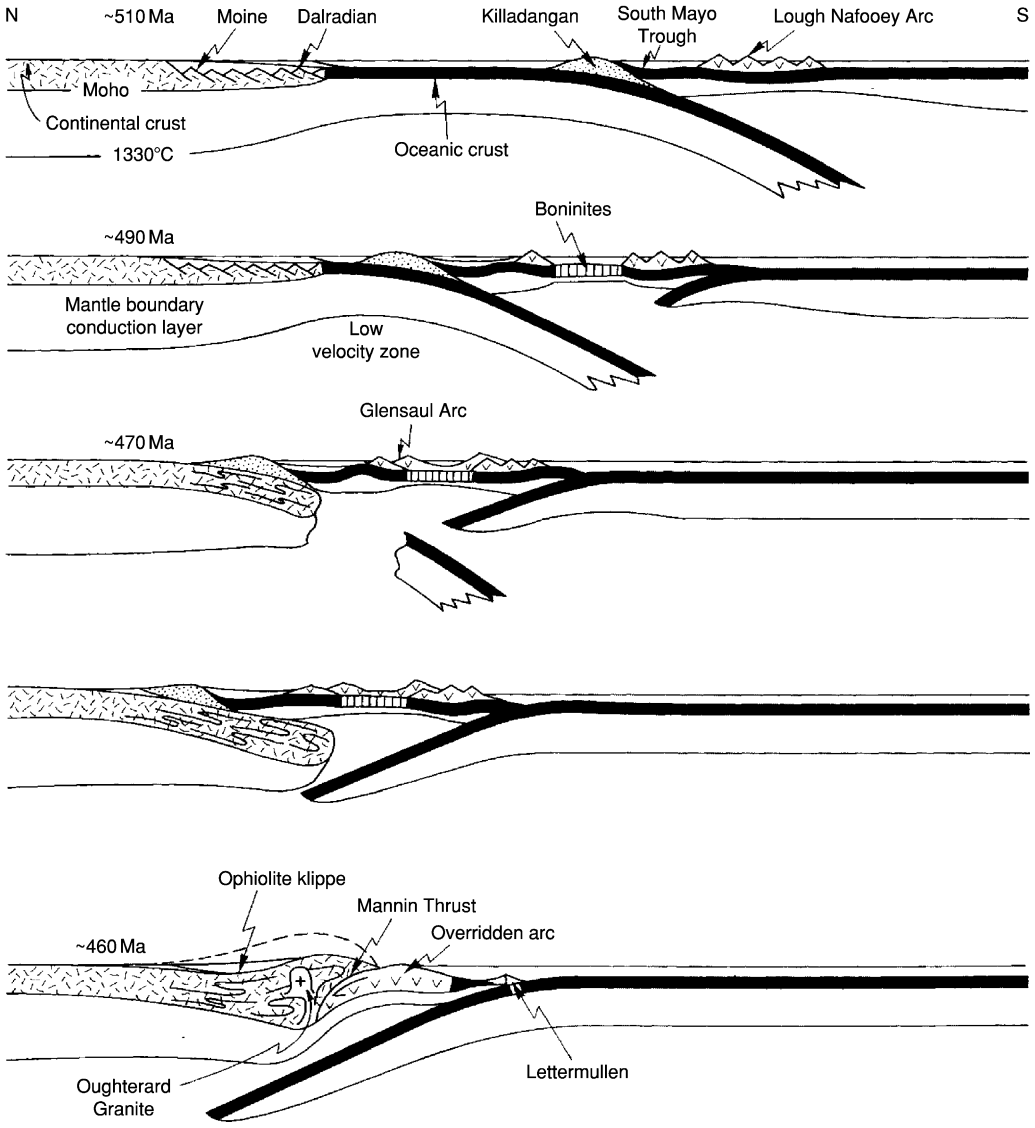

Figure 2 Schematic sections illustrating the Ordovician tectonic evolution of the Grampian Zone.

complex was obducted onto the Eastern Avalonian margin during that margin's collision with a northwards-dipping subduction zone, followed by polarity flip to southwards-directed subduction. The oceanic tract that opened between Eastern Avalonia and Gondwana is known as the Rheic Ocean. At 460 Ma, Eastern Avalonia was probably about 1000 km west of Baltica, and the width of the Iapetus Ocean was reduced to approximately 2000 km across the British sector. The intermediate position of Avalonia during its transit across the closing Iapetus Ocean is reflected in the changing affinities of its brachiopods, from Gondwanan to a mixture of genera with ancestors from Baltica and Laurentia, through the Ordovician. By Late Ordovician–Early Silurian times (440 Ma), the Iapetus Ocean and the Tornquist Sea had narrowed sufficiently to allow the interchange of the larvae of most benthic animals. Eastern Avalonia collided with Baltica during the Ashgill. By this time, the width of the Iapetus Ocean across the British sector had been reduced to around 1300 km.

Sinistrally oblique collision between the combined Avalonia–Baltica landmass and Laurentia occurred between 435 Ma and 425 Ma to form the continent Laurussia. The 'hard' collision of Baltica with the eastern Greenland–northern Scotland segment of Laurentia resulted in the Scandian orogenic event. In contrast, the 'soft' collision of Eastern Avalonia with Laurentia was not associated with regionally

significant shortening, suggesting that Eastern Avalonia and Baltica may have been only loosely coupled during the final collision. The Iapetus Suture is referred to as the Solway Line, because it is apparently located in the Solway Firth, albeit obscured entirely by unconformably overlying Carboniferous strata.

Between 425 Ma and 410 Ma, sinistral relative motion between Laurentia and Baltica–Avalonia became orogen-parallel and was associated mainly with displacement along the Great Glen, Highland Boundary, and Southern Uplands faults. From about 410 Ma, the Caledonides went into regional sinistral transtension, resulting in the formation of a series of transtensional Old Red Sandstone basins. These events were contemporaneous with the rapid contraction of the Rheic Ocean as Gondwana approached Laurussia. During the Early to Mid-Devonian, Eastern Avalonia was affected by widespread Acadian deformation. Although this has traditionally been assigned to the Caledonian orogenic cycle and the closure of Iapetus, it postdates the latter by *ca.* 20 Ma. Alternatively, the Acadian event could be the result of the collision of Armorica with the southern margin of Avalonia. The collision of Armorica with Avalonia and the collision of Iberia with the southern margin of Armorica during the Mid-Devonian could be viewed as the early stages of the protracted Variscan Orogeny, which ultimately resulted in the assembly of Pangaea.

The along-strike continuation of the Caledonides in Newfoundland provides, arguably, the best-exposed section across the orogen, which can be used as a template to aid the understanding of other sectors such as the British Isles. The Caledonides of the British Isles are subdivided by major faults into a series of terranes, each with a coherent internal history. The correlation of geological units and events across terrane-bounding faults is commonly problematic. These structures display evidence of long and complex reactivation histories, although the last major displacement for most faults north of the Iapetus Suture was during Silurian to Devonian time. Although the detail of the tectonic template is extremely complex, there are three main groups of terranes: those north of the Fair Head–Clew Bay Line and Highland Boundary Fault, which have Laurentian affinities; those south of the Solway Line, which have Gondwanan affinities; and the intermediate terranes, which represent fragments of continental margin, island arc, and oceanic lithosphere within a composite complex suture zone. Seismic imaging indicates that the Iapetus Suture dips moderately to the north, separating reflective Avalonian crust from overthrust non-reflective Laurentian crust.

Terranes and their Geotectonic Affinities

From north to south, the main terranes are characterized as follows.

Hebridean Terrane

In north-west Scotland, the Hebridean Terrane forms the foreland to the Caledonian belt and is limited to the east by the Moine Thrust Zone. The oldest component is the Archaean–Palaeoproterozoic Lewisian Gneiss Complex, which is correlated with Laurentian basement in south-east Greenland. The unconformably overlying continental Torridonian sedimentary rocks were deposited from 1200–1000 Ma and comprise two successions separated by an angular unconformity. The Lewisian and Torridonian rocks are overstepped by a highly distinctive succession of Cambrian–Ordovician shallow-marine quartzites and limestones, which accumulated on the Laurentian margin of Iapetus and correlate closely with similar sequences in north-western Newfoundland and eastern Greenland.

Northern Highland Terrane

The Northern Highland Terrane is bounded in north-western Scotland by the Moine Thrust Zone and the Great Glen Fault. The terrane is dominated by the Early Neoproterozoic Moine Supergroup, a thick succession of strongly deformed and metamorphosed marine sediments that were deposited in an intracratonic rift within the Laurentian sector of the Rodinia Supercontinent at 1000–870 Ma. Early deformation and metamorphism during a Knoydartian tectonothermal event at 800 Ma may have resulted from rift closure. Inliers of Archaean orthogneisses, variably reworked at 1000 Ma during the Grenville orogeny, represent the basement on which the Moine sediments were unconformably deposited.

Grampian Terrane

In Scotland and north-western Ireland, the Grampian Terrane occurs between the Great Glen Fault and the Fair Head–Clew Bay Line or Highland Boundary Fault. The terrane is dominated by the Dalradian Supergroup, a thick succession of variably deformed and metamorphosed metasandstones, metasiltstones, and metalimestones with minor contemporaneous mafic igneous rocks. The duration of sedimentation is uncertain, but it probably spanned at least the period 750–520 Ma. Tillites have been correlated with the widespread Sturtian and Varangerian glacial events. The Dalradian succession shows a transition from shallow-water to deep-water sedimentation,

reflecting the progressive thinning of the Laurentian crust during rifting of the Rodinia Supercontinent and the evolution of a passive continental margin adjacent to the developing Iapetus Ocean. Inliers of Palaeoproterozoic gneisses in the Inner Hebrides and north-western Ireland can be linked with similar units in south-eastern Greenland and probably represent the Laurentian basement on which the Dalradian sediments were unconformably deposited. Shear zone-bounded inliers of Early Neoproterozoic Moine-like rocks occur in the northern Grampian Highlands and may provide linkage across the Great Glen Fault.

Midland Valley Terrane

The Midland Valley Terrane is bounded to the north by the Fair Head–Clew Bay Line and the Highland Boundary Fault and to the south mainly by the Southern Upland Fault (in the west of Ireland it lies north of the Doon Rock Fault). Much of the pre-Late Palaeozoic geology, particularly in the Scottish Midland Valley, is obscured by Devonian and Carboniferous cover. However, the exposed Early Palaeozoic rocks have oceanic affinities. Early Ordovician ophiolites occur on Shetland, along the Highland Boundary Fault, and at Ballantrae, Tyrone, and Clew Bay. In western Ireland, remnants of an accretionary prism are present in Clew Bay and on Achill Island, locally associated with blueschists. Immediately to the south are the fore-arc Ordovician sediments of the South Mayo Trough and the mafic to intermediate calc-alkaline volcanics of the Lough Nafooey Group. Whether the unexposed continental basement that underlies the terrane has Laurentian affinities or is entirely exotic is unknown.

Connemara Terrane

The Connemara Terrane is located in western Ireland between the Doon Rock and Skirds Rock faults. It consists of metasedimentary rocks that have been correlated with the Dalradian Supergroup, and thus the terrane is interpreted as a tectonic slice of the Laurentian margin that became detached and interleaved with units of the Midland Valley Terrane during strike-slip displacements.

Southern Uplands Terrane

Located between the Southern Uplands Fault and the Solway Line, the Southern Uplands Terrane is characterized by thick sequences of Ordovician and Silurian sediments, which were deposited in deep-marine environments and subjected to complex deformation and low-grade metamorphism. The terrane itself comprises three major units bounded by strike-slip faults: the Northern, Central, and Southern belts. The Northern Belt comprises Ordovician sediments and rare volcanics; the Central Belt is formed of Ordovician and Silurian sediments, and the Southern Belt is entirely Silurian in age. Although opinions vary as to the tectonic setting of sedimentation, the balance of evidence suggests that the sediments represent an accretionary prism developed above the northwards-subducting Iapetus Ocean. In eastern Ireland, the Iapetus suture is drawn between the Ordovician inliers of the Grangegeeth and Bellewstown terranes, which show Laurentian and Avalonian affinities, respectively, in their brachiopod and trilobite faunas.

Lake District–Leinster Terrane

The Lake District Terrane is situated between the Solway Line and an unexposed boundary thought to lie to the north-west of Anglesey. It contains Cambrian–Arenig clastic rocks, mid- to Late Ordovician basic and acid volcanic and volcaniclastic rocks, such as the Borrowdale Volcanic Group of the English Lake District, and the unconformably overlying Silurian sediments of the Windermere Supergroup of northern England. The Lake District represents the northern edge of Eastern Avalonia, and the volcanic rocks are thought to have originated in a volcanic arc created by southwards-directed subduction on the Gondwanan side of the Iapetus Ocean.

Monian Terrane

The Monian Terrane is bounded to the south-east by the Menai Strait Fault System and comprises the Mona Complex of Anglesey and the Llyn Peninsula in north-western Wales and the Rosslare Complex of south-eastern Ireland. The terrane is highly segmented by shear zones and brittle faults. Proven Precambrian rocks include high-grade metasedimentary gneisses, a calc-alkaline granite pluton, and a belt of blueschist facies metamorphic rocks, which may represent an accretionary prism. Thick low-grade metasedimentary sequences, including a major melange unit, have been viewed as Precambrian but may be Cambrian, albeit very different from the Cambrian rocks of the adjacent Welsh Basin Terrane. The Monian Terrane may be an Allochthonous Gondwanan Terrane that was amalgamated with Eastern Avalonia by the Early Cambrian at the latest, after which it formed part of the southern foreland of the orogen.

Welsh Basin Terrane

Bounded to the south-east by the Welsh Borderland Fault System, the Welsh Basin Terrane comprises Cambrian–Silurian sedimentary successions, largely deposited in deep-water environments, and thick sequences of Ordovician tholeiitic to calc-alkaline

volcanics. Volcanism and sedimentation probably occurred in a back-arc basin floored by extended Avalonian basement, behind the Lake District–Leinster volcanic arc. A range of Ordovician calc-alkaline volcanic and plutonic rocks underlie the Mesozoic and younger cover of eastern England and may represent continuations of the Welsh Basin and/or Lake District volcanic belts.

Midlands Terrane

The Midlands Terrane is a triangular terrane that represents the southern foreland of Eastern Avalonia during the Caledonide Orogen and acted as a rigid indentor during the Acadian event. Late Neoproterozoic calc-alkaline igneous rocks and associated low-grade metasedimentary rocks, which developed along an active plate margin of Gondwana, are overlain unconformably by relatively thin sequences of Cambrian–Silurian shallow-marine platform sediments.

Tectonic Evolution of the Caledonides

The tectonic evolution of the Caledonides began in the Early to mid-Ordovician, with the commencement of closure of the Iapetus Ocean, and finished with the Early Devonian Acadian event. The main stages are as follows.

Early to mid-Ordovician Rifting of Eastern Avalonia and Arc–Continent Collision on the Laurentian Margin

Eastern Avalonia rifted away from Gondwana in the Early Ordovician (*ca*. 475 Ma), initiating closure of the Iapetus Ocean and opening, to the south, of the Rheic Ocean. A major southwards-dipping (in the present reference frame) subduction zone developed beneath the leading northern margin of Eastern Avalonia, and arc volcanism began in the Welsh Basin in the Early Ordovician. Sedimentary sequences deposited on Eastern Avalonia vary from shallow-marine on upstanding blocks such as the Midlands terrane and the Irish Sea landmass (effectively the Monian terrane) to deeper-marine sequences in the Welsh Basin.

By the Late Cambrian–Early Ordovician, oceanwards-dipping subduction zones had developed along the margins of Laurentia and Baltica, to form intraoceanic volcanic arcs. Localized orogenic events reflect the collision of these volcanic arcs with the continental margins. These include the Finnmarkian event (505 Ma) along the Baltica margin and the Grampian event (470–460 Ma), which affected the Northern Highlands and Grampian terranes. In western Ireland, the Grampian Arc is represented by the Lough Nafooey Volcanic Group, and the existence of a similar arc beneath the Late Palaeozoic cover of the Scottish Midland Valley is indicated by the presence within the Ordovician sediments of clasts of contemporaneous calc-alkaline plutonic rocks derived from a proximal source. By analogy with a similar-aged event in Newfoundland (the Taconic event), collision of the Laurentian margin with the arc at the subduction zone was associated with northward obduction of a major ophiolite nappe onto the Laurentian margin. Ophiolitic remnants of this nappe lie along the north-western margin of the Midland Valley Terrane, which effectively represents the Grampian Suture; the Ballantrae Ophiolite was probably obducted at about the same time. Within the Grampian Terrane, ophiolite obduction resulted in regional deformation and Barrovian metamorphism at greenschist–amphibolite facies of the Dalradian Supergroup. In north-eastern Scotland and Connemara, this was accompanied by the emplacement of major gabbros and granites. Late-stage backfolding and underthrusting of the Dalradian Supergroup formed south-eastwards-directed regional-scale fold nappes such as the Tay Nappe in Scotland and the Ballybofey Nappe in north-western Ireland. Within the Northern Highland Terrane, similar-aged folding and high-grade metamorphism of the eastern parts of the Moine Supergroup is assigned to the Grampian event. Following arc–continent collision, the polarity of subduction reversed to northward.

Mid-Ordovician–Silurian: Collision of Eastern Avalonia, Baltica, and Laurentia

On the Avalonian side of Iapetus, south-eastwards-directed subduction beneath Avalonia continued into the Late Ordovician. A major calc-alkaline volcanic arc lay through south-east Ireland and the Lake District, with the Welsh Basin being a volcanically active back-arc basin. Volcanism and subduction ceased during the Late Ordovician, probably because the Avalonian margin overran the ridge system in the Iapetus Ocean. Throughout the Late Ordovician and Silurian, the stable Midland Platform and Irish Sea landmass hosted shallow-marine or emergent conditions surrounded by deeper-marine basins, which were often filled with turbidites. Eastern Avalonia collided with Baltica during the Late Ordovician (440 Ma) as shown by palaeomagnetic data and evidence of progressive faunal integration. Southwestern Baltica records evidence of a Late Ordovician thermal event, contemporaneous with open folding and uplift in the Welsh Borderlands (the Shelveian event). This event is also synchronous with low-grade metamorphism in the North Sea, which was

probably also related to the collision between Baltica and Eastern Avalonia.

On the northern side of Iapetus, the uplands created by the Grampian Orogeny remained emergent through the Late Ordovician and Silurian. In the Midland Valley Terrane, the former volcanic arc was mostly buried under a blanket of marine and nonmarine sediments, most of which were sourced from the emergent Grampian Highlands to the north. Sedimentation occurred in a series of localized sinistrally transtensive basins. Outboard, to the south-east, the Southern Uplands Terrane is dominated by thick fault-bounded sequences of complexly deformed trench sediments, which define an accretionary prism. The dominant folds, cleavages, and associated detachments within these sediments formed progressively as an integral part of the development of the accretionary prism, rather than as the result of a distinct collisional event. A switch from early approximately orthogonal shortening to sinistral transpression within the accretionary prism occurred in the Early Silurian at 430 Ma.

The earliest linkage of Laurentian-derived and Gondwanan-derived crustal blocks occurred in Newfoundland in the mid-Ordovician, at approximately 450 Ma. However, the earliest closure events in the British Isles appear to be Silurian (*ca*. 425 Ma). With progressive collision of the two margins of Iapetus through the Silurian, deep-water basins tended to shallow whilst shallow-marine basins became nonmarine or emergent. In the Lake District, the Silurian Windermere Supergroup was deposited in a flexural foreland basin that resulted from overthrusting of the Southern Uplands Terrane onto the leading edge of Eastern Avalonia during the terminal stages of collision. The oblique collision between Eastern Avalonia and Laurentia along the Solway Line, which resulted in the final eradication of the Iapetus Ocean, was complete by the end of the Silurian. The collision here was relatively 'soft' and did not result in major folding or cleavage development in the immediately adjacent terranes. In western Ireland, the collision was 'harder' and was associated with sinistral transpression, which deformed the Ordovician and Silurian strata of the South Mayo Trough.

Silurian: Oblique Collision of Laurentia and Baltica, and Closure of Northern Iapetus

The Northern Highlands Terrane was probably located 700 km along strike and to the north-east of the Grampian Terrane when this part of Laurentia collided obliquely with Baltica at 430–425 Ma to result in the Scandian orogenic event. This was associated with regional nappe stacking in Scandinavia and eastern Greenland, with intense folding, ductile thrusting, and metamorphism of the Moine rocks in the Northern Highlands Terrane, and with amalgamation of the Northern Highlands and the Hebridean terranes along the Moine Thrust. A total north-west–south-east shortening displacement across the Moine Thrust of at least 150 km seems likely, and an equivalent total amount of shortening may also have occurred along internal ductile thrusts within the Moine. Analysis of Scandian structures in Scandinavia, eastern Greenland, and north-west Scotland is consistent with overall sinistral transpression, which became progressively partitioned into orogen-orthogonal components and orogen-parallel left-lateral strike slip.

Regional-scale nappe stacking was therefore followed by major sinistral strike-slip displacements from 425 Ma onwards along the Great Glen, Highland Boundary, and Southern Uplands faults. The magnitude of the displacements is uncertain, although movement of 700 km along the Great Glen Fault and minimum movements of 200 km along both the Highland Boundary Fault and the Southern Uplands Fault seem likely. Strike-slip faulting was largely synchronous with the emplacement of the Newer Granite Suite, a series of calc-alkaline mainly I-type plutons probably derived from the melting of lithospheric mantle and lower-crustal sources above the north-westwards-dipping subduction zone. Major plutons crop out extensively in the Grampian Highlands and in north-western Ireland, and eruption of coeval lavas and volcanics occurred in the area between Glencoe and Lorne in the south-west Grampian Highlands. Plutons were mainly emplaced in transtensional pull-aparts along relatively minor faults that were splays of, or Reidel shears related to, the major displacement faults.

Early to mid-Devonian: the Final Caledonian (Acadian) Collision – Closure of the Rheic Ocean?

Sinistral relative displacement of the terranes north of the Solway Line and subduction-related plutonism and volcanism continued into the Early Devonian. By this time, the marine basins on both margins had been largely uplifted following crustal shortening. In the Scottish Highlands, Early Devonian continental sediments were deposited unconformably on deeply eroded Moine and Dalradian rocks. The Early Devonian sediments of the Moray Firth–Orkney–Shetland area and eastern Greenland probably accumulated in transtensional basins, reflecting a change from orogen-parallel displacements to sinistrally oblique divergence between Laurentia and Baltica–Eastern Avalonia between 410 Ma and 395 Ma.

A similar transtensional setting may also apply to the Early Devonian basins of the Midland Valley and the Lake District. Fluvial and alluvial sedimentation also occurred on the Irish Sea landmass and in the Anglo-Welsh Basin, with major rivers sourced from uplifted segments of the Caledonides to the north and north-east.

In southern Britain, the Cornubian basins record south-deepening Devonian marine sedimentation on the southern rifted passive margin of Avalonia, which faced Armorica across an already very narrow arm of the Rheic Ocean. East–west trending Early Devonian growth faults have been identified in South Wales and North Devon. In southern Cornwall, Devonian sediments are characterized by thick sequences of distal turbidites, which were deposited either on highly thinned continental crust at the edge of the shelf or on oceanic crust. The ultramafic and associated rocks of the Lizard Complex in Cornwall have been interpreted as an ophiolite derived from the Rheic Ocean basin, which is inferred to have existed to the south.

During the Early to Mid-Devonian, widespread Acadian deformation and low-grade metamorphism occurred south of the Solway Line, forming the slate belts of the Lake District, south-eastern Ireland, and north-western Wales. In contrast to the area north of the Solway Line, where the Caledonian structural grain is mainly north-east–south-west, the trend of folds and cleavage in Avalonia is much more variable, showing a distinctly arcuate form. This structural pattern is apparently strongly controlled by the triangular shape of the old rigid continental block that underlies the Midlands terrane, which did not experience Caledonian deformation. The Welsh Borderlands Fault System broadly defines the south-eastern limit of Acadian deformation. There is a common tendency in the slate belts for the steeply dipping Acadian cleavage to cut gently across associated folds in a clockwise-deflected sense, indicating that the collision direction was sinistrally oblique. Although the Acadian phase of the Caledonian Orogeny has been ascribed to the closure of Iapetus, it is not clear why the shortening and uplift associated with this event should occur as late as the Early to Mid-Devonian. It is unlikely that forceful northward collision of Avalonia continued for a further 20 Ma after the last remnant of Iapetan crust was subducted, especially as there is growing evidence for sedimentation in sinistrally transtensive basins at this time, both south and north of the suture. Another possibility is that the Acadian deformation resulted from the collision of Armorica with Avalonia in the Early Devonian. This is supported by isotopic data that indicate that initial exhumation and northward-directed thrusting of the Lizard Complex in southern Cornwall occurred between 400 Ma and 380 Ma, overlapping in time with cleavage development in the slate belts to the north.

See Also

Europe: Scandinavian Caledonides (with Greenland); Variscan Orogeny; The Urals. **North America:** Northern Appalachians; Southern and Central Appalachians. **Palaeozoic:** Ordovician; Silurian; Devonian. **Pangaea**.

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