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The Geology of Middle-earth

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Abstract

A preliminary reconstruction of the geology of Middle-earth is attempted, utilizing data presented in text, maps and illustrations by its arch-explorer J.R.R. Tolkien. The tectonic reconstruction is developed from earlier findings by R.C. Reynolds (1974). Six plates are now recognized, whose motions and collisions have created the mountains of Middle-earth and the rift structure down which the River Anduin flows. The stresses involved in the plate collisions have produced patterns of faults, whose lines have determined the courses of the other rivers and the occurrence of the richest ore deposits. However, the time of Bilbo and Frodo is a period of tectonic quiescence. Volcanic activity is at a minimum and confined to four “hot-spots”, all at some distance from plate margins, while seismic activity is minor. Tolkien’s paintings, in particular, show how glacial and riverine erosion have shaped Middle-earth’s topography.

Additional Keywords

earthquakes; erosion; faulting; Middle-earth geology; tectonics; topography; volcanic eruptions

The Geology of Middle-earth

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Keywords: earthquakes, erosion, faulting, Middle-earth geology, tectonics, topography, volcanic eruptions

The period of the rise of geology, in the late eighteenth and early nineteenth centuries, coincided with the epoch during which this Earth of ours was being fully explored for the first time. Most of its explorers were able to furnish quite accurate accounts of the geography of the lands they had visited, but few were trained geologists. The geological information those explorers brought back tended therefore to be incidental and imprecise. Even so, the geologists of their homeland did their best to utilize these scraps of data, to begin formulating a picture of geology on a global scale.

In seeking to elucidate the geology of Middle-earth, our task is similar. We have a good general picture of its topography, drawn by Christopher Tolkien on the basis of the information furnished by his father, as prime explorer of that special world. We have also the excellent paintings done by the explorer himself, representing his vision of Middle-earth and published in the 1973 and 1977 Tolkien calendars and subsequent compilations. In addition, we have the scraps of geological information to be found in *The Hobbit* and *The Lord of the Rings* – incidental observations only, but nevertheless helpful.

In contrast, the supplementary material brought together in the successive volumes of *The History of Middle-earth* must be viewed as the equivalent of a geologist's field notes – unrevised and not to be trusted; so this must be discounted. (In any case, the additional geological information to be found therein is quite remarkably meagre.) Moreover, though it is possible to determine the sequence of tectonic events, lack of information concerning fossils precludes any precise determination of the sequence of strata and geochronology.

The first person to attempt a geological history of Middle-earth was Margaret Howes (1967), in her survey of "The Elder Ages and the Later Glaciations Of the Pleistocene Epoch". In this, she strove to trace the successive geographies from the overthrow of Morgoth to a period beyond the time of Aragorn's rule in Gondor – indeed, into the late Pleistocene Epoch, when the geography of Middle-earth had been reshaped into present-day Eurasia and north Africa. Her work was original and imaginative, but it strayed far from Tolkien, utilizing data of such questionable authenticity that, in the last analysis, her conclusions must be set aside.

The truly seminal work on Middle-earth geology was written by Robert C. Reynolds for *The Swansea Geographer* in 1974. Though entitled "The Geomorphology of Middle-earth", it is much more than that, for it applies the concepts of plate tectonics then current to the whole geography of Middle-earth (Figure 1).

Four plates were recognized – the Eriador Plate in the west, the Rhovanion Plate in the north, and the Harad and Mordor Plates in the south. The River Anduin was considered as flowing through what was then styled an aulacogen and would now be regarded as a rift valley. Reynolds viewed the bounding faults as being transform faults, i.e. faults along which movement had been essentially lateral but occurring at different times in contrary directions. He considered the region south of the Emyn Muil and north of the line of the White Mountains to be a tectonic basin, the Nindalf Basin, while Rohan constituted a stable block of ancient rocks – a craton.

It is Reynolds' work that forms the basis for my own analysis of the geology of Middle-earth. However, our

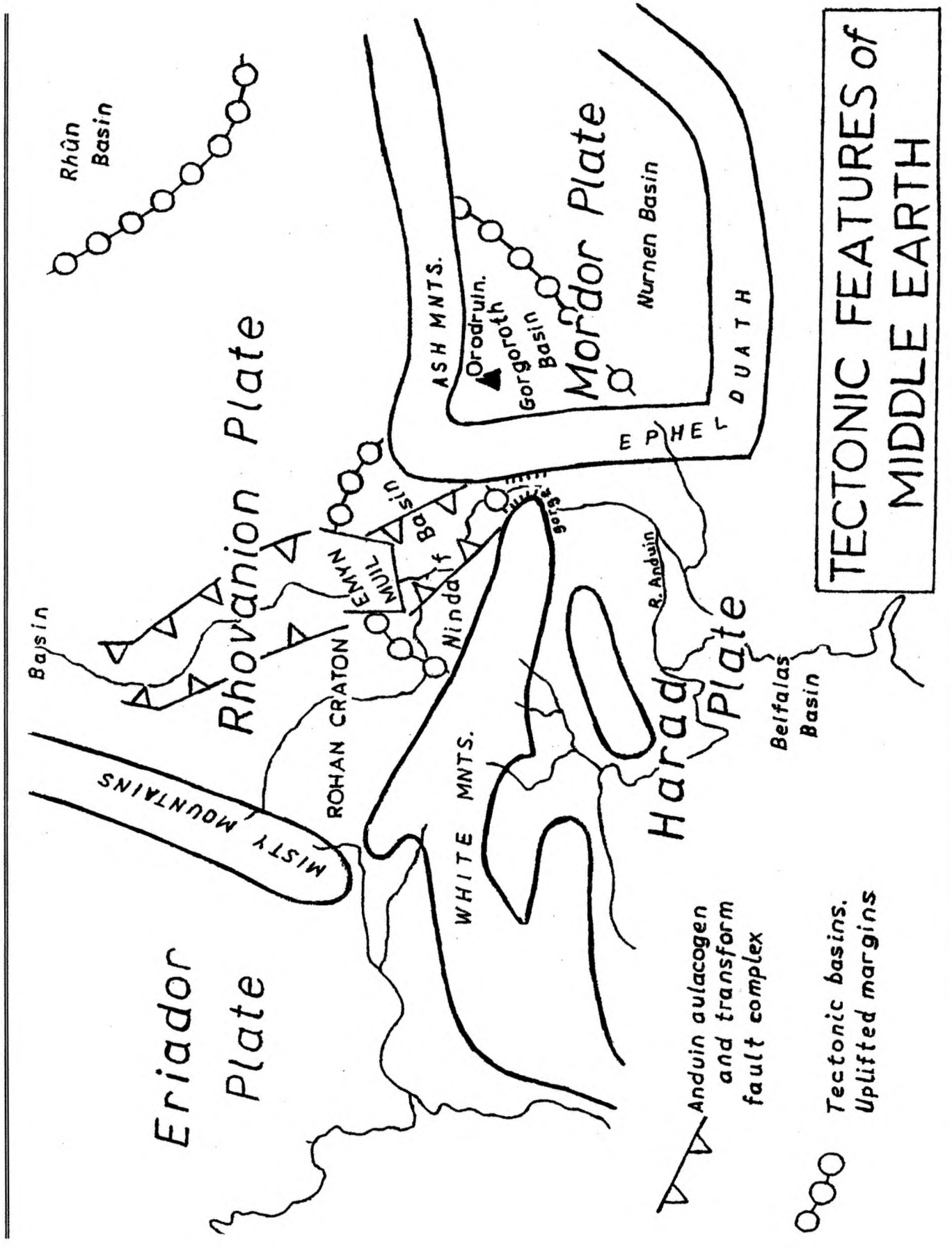

Figure 1: Reynolds' reconstruction of the tectonic features of Middle-earth. Modified after Reynolds, 1974.

knowledge of plate tectonics has grown, and the concepts have changed greatly, since Reynolds' work was published.[1] Moreover, in my view he pays too small a regard to the north and north-west of Middle-earth and to the many major faults, most of them normal faults with a trend from south-west to north-east – usually, indeed, from west-south-west to east-north-east – that control so much of Middle-earth geography.

My modified concepts (Figure 2) recognise not four, but six plates (or in modern terminology, as applied to American Cordilleran tectonics, six terrans) as being involved in the shaping of Middle-earth geography. The most ancient of these are the Forlindon Plate and the Eriador Plate, whose collision caused the orogeny – the mountain-building phase – that produced the Ered Luin or Blue Mountains. Since that time, the Forlindon Plate has been largely subsumed; that is, drawn down into a subduction zone at the continental margin, its materials reincorporated into the earth's mantle. Indeed, only two blocks west of the Ered Luin – the regions of Forlindon and Harlindon – still persist. Moreover, both plates have moved north, producing the many strike-slip faults that have furnished courses for westward-flowing rivers.

The collision of the Eriador Plate with two other plates, the Rhovanion Plate to eastward and the Harad Plate to southward, caused two further orogenies that, no doubt, overlapped in time. Between the Eriador and Rhovanion Plates, there arose the Misty Mountains and between the Eriador and Harad Plates, the White Mountains, the three plates forming a triple junction against the stable basement rocks of the Rohan Craton.

A second triple junction was formed by the collision of the Eriador and Rhovanion Plates with the Forodwaith Plate. The consequent orogeny produced the Ered Mithrin, the Grey Mountains, together with their westward extension through the region of Angmar toward the Ice-Bay of Forochel; Mount Gundabad surely represents a rotated block of erosion-resistant rocks at the exact position of the junction. Unfortunately, we know too little of the geology of these mountains to speculate further.

The most recent major tectonic event has been the collision of the rapidly moving Mordor Plate with the northern part of the Harad Plate and the southernmost part of the Rhovanion Plate. The Mordor Plate is bounded on north and south by transform faults, their motion at first westward and then, more prolongedly, eastward. A major consequence has been the formation of the Anduin Rift Valley, caused by the resultant tearing-apart of the crust. Despite the claims of Reynolds (1974), this rift is bounded not by transform but by normal faults. At its southern end, it has buckled against the stable Harondor Craton and has been turned westward.

Essentially this rift is, of course, a region of subsidence, most markedly in its northern portion – the "Gladden Basin" of Reynolds – and in the triangle between the Emyn Muil, the White Mountains and the Ephel Dúath – the Nindalf Basin. As Reynolds noted, the marshy nature of the Nindalf Basin – it incorporates the Dead Marshes, the Wetwang and the many mouths of the Entwash – indicates that this basin once contained a lake, since silted up.

However, the complex interaction of the plates has also produced three horsts (fault-bounded, elevated blocks) within the rift. Two of these – the Emyn Muil and Emyn Arnon – respectively determine the northern and southern limits of the Nindalf Basin; they control the Anduin's course and character, producing such dramatic features as Tol Brandir, with its "grey faces" of stone (Tolkien, 1954a, p. 412) and the Rauros Falls. The third occurs at the rift's southwesternmost end, forming the mountainous island of Tolfalas, beyond the depression marked by the many mouths of the Anduin.

Though no doubt there was much volcanic activity during the earlier orogenies, the only recently active region was associated with the crumpling of the Mordor Plate after collision, causing fissure vulcanism and some explosive activity around its rims. The spoiling of the landscape that so distressed Frodo and Sam was, I suspect, largely a consequence of the initial vulcanism and not just of the spoil-heaps produced by mining. (The solfatara fields around Namafjall, Iceland, afford just as grim a prospect.) It is likely that the Udûn Basin of northwesternmost Mordor is an enormous crater, a caldera, the product of a cataclysmic eruption like that of Krakatoa in 1883. (Reynolds' alternative suggestion, that it is an independent small plate, seems much less probable in view of its position and shape.) However, the only volcano recently active in this region is Mount Doom – Mount Orodruin – which, by its great height in proportion to its basal diameter (cal., 1977), must have been built up rapidly by basic lava, scoria and ash.

Mount Doom is indeed one of four isolated volcanoes, each representing a "hotspot" at some distance from a plate margin and all of them associated with evil-doing – Dol Goldur in Mirkwood, Orthanc in Isengard and Erebor, the Lonely Mountain. Isengard, with its black rocks (Tolkien, 1954b, pp. 159-160), was certainly a vast volcanic crater, while Orthanc itself (cal., 1977) must have been an aiguille – a column of solidified lava thrust up from the vent in a last spasm of an eruption within the crater of Isengard, to be afterward shaped by human hand or magic. (The so-called "spine" produced in the last phases of the eruption of Mont Pelée, Martinique, is comparable.) The Lonely Mountain, from its shape and with its "grey and silent cliffs" (Tolkien, 1951, p. 215) within a landscape "bleak and barren", was certainly a volcano (see cal., 1977); there are many present volcanoes of closely similar outline, e.g. La Tungar, Argentina. The huge cave in which the dragon piled his ill-gotten gains within the Lonely Mountain was surely a lava-tube ere the dwarves reshaped it, and so must have been the smaller tunnel down which Bilbo unwillingly went to seek the dragon. (A comparable structure is the Thurston lava tube of Kilauea Volcano, Hawaii.)

Yet of these recent volcanoes, only Mount Doom was still

[1] The later study by Pat McIntosh (1973) treats only surface outcrops, while the short papers by Duncan McLaren (1985) and Mike Percival (1985) deal with Númenor.

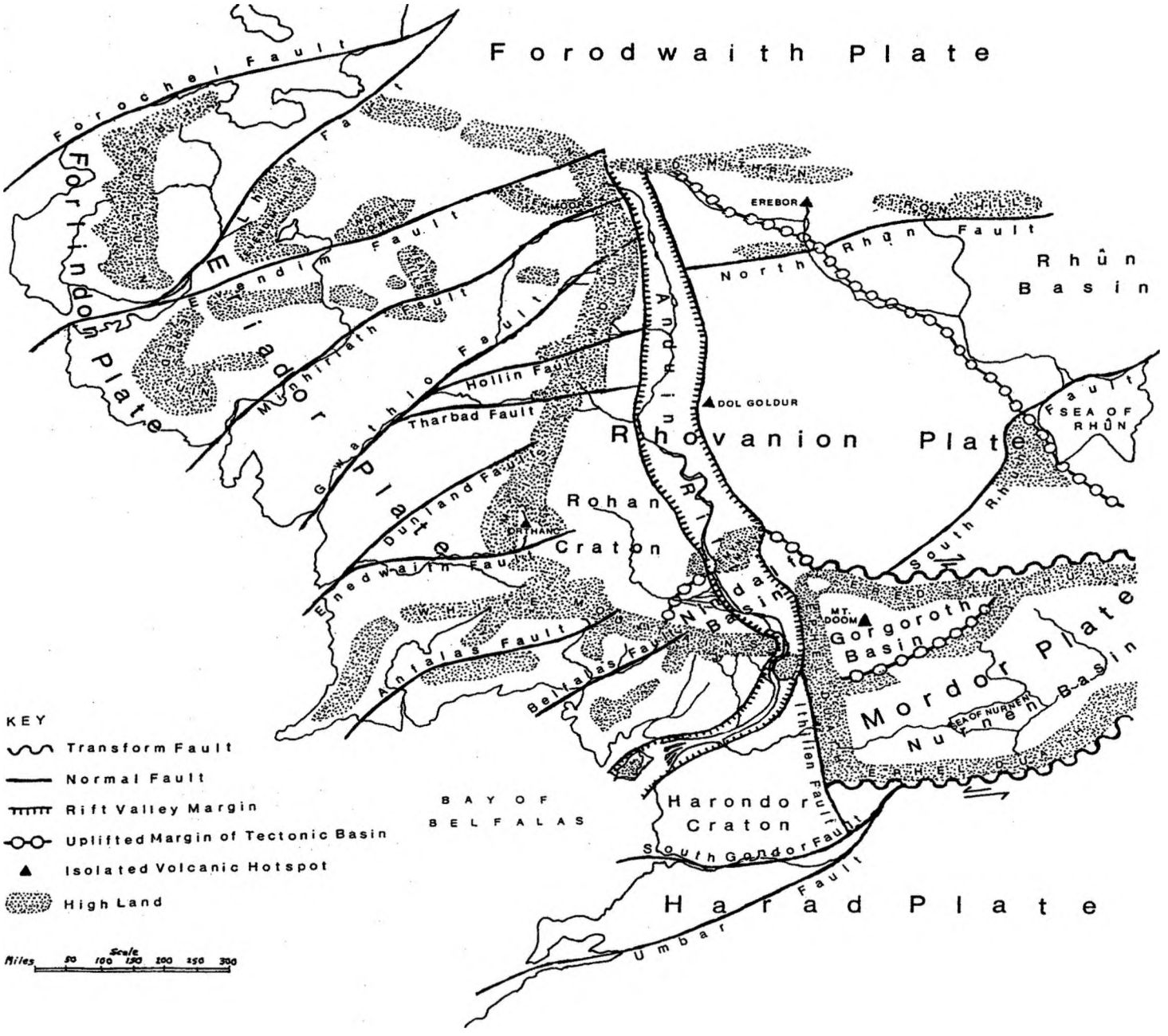

Figure 2: The principal tectonic features of Middle-earth: a new interpretation.

active in the time of Bilbo and Frodo. Moreover, the only "seismic events" recorded in the chronicles are those caused Gandalf's throwing-down of the balrog (Tolkien, 1954b) and Gollum's fall with the ring into the fires of Mount Doom (Tolkien, 1955). Of other earthquakes, we have no record. All in all, this time must have been one of unusual tectonic quiescence.

However, in the present topography of Middle-earth, the effects of earlier tectonic events are patent. Rivendell, for example, is positioned where the Misty Mountain foothills are intersected by the great Gwathlo Fault. The entry to the valley (see cal., 1977) is through a canyon reminiscent of the Black Canyon of the Gunnison River, Colorado, but the valley broadens beyond (cals., 1973, 1977). Helm's Deep (cal., 1977) must also be a canyon, within a terrain essentially of limestones; its situation and fortifications are comparable to those of the castle of Aigle, Switzerland. The troll-haunted Ettenmoors are a block of resistant rocks displaced between the Evendim and Minhiriath Faults. The rich mineral veins of Moria, with their priceless mithril, were developed where the Tharbad and Hollin Faults intersected the Misty Mountains. (Mithril itself, crystallizing out at so high a temperature that it is only found in veins at great depths, may well be a naturally-occurring alloy of platinum and another metal, perhaps palladium.) The almost equally rich mineralization of the Mordor Plate resulted from the fault movements along its rims, while the much less rich mineral deposits of the Iron Hills, worked by Dáin and his dwarves, are associated with the North Rhûn Fault.

Elsewhere, economic deposits are not common. There is iron in the Ered Luin; coal somewhere in the Shire (see Sarjeant, 1993, p. 64); limestone to be quarried for the buildings of Gondor in the White Mountains, chalk to be had in the Shire's White Downs and good building stones of other kinds in Arnor, Hollin and many other regions. (As Gimli said (Tolkien, 1954b, p. 137): "This country has tough bones.") Of the occurrences of precious stones, we have no details; perhaps the dwarves have kept that information to themselves!

The shaping of the landscape is, of course, dependent on the interplay of structure and rock type with erosion. It is glacial erosion that has shaped the northern mountains and the highest mountains of the south. The varied rocks of the Misty Mountains, as seen by Gandalf, Bilbo and the dwarves from the eagles' eyrie (cals., 1973, 1977), are strikingly comparable to the Nepal Himalayas of today. The volcanic Ephel Dúath, the Ash Mountains, as seen from near Shelob's Lair by Frodo and Sam (cal., 1977), have also been reshaped; the result is quite comparable to the Grand Tetons of Wyoming, even though their rocks are dissimilar. Moreover, the effects of glaciation have also modified the lowlands. As Reynolds (1974, p. 70) pointed out:

> . . . large areas of Rhovanion east of the Anduin . . . have been sculptured by these processes for considerable periods: the Iron Hills may be monadnock remnants of a former higher land surface, as may also be the hills near the Sea of Rhûn. Dagorlad, from its veneer of quartzitic regolith, could be a fossilised gravel-covered pediplaned surface (Tolkien, 1954b, p. 232). Extensive piedmont glaciation of the lowlands in the south seems unlikely from their latitude, but valley glaciation in the White Mountains has been very important. Over-deepened glacial troughs abound – Morgul Valley (Tolkien, 1954b, p. 319), Morthond Vale (Tolkien, 1955, p. 62), Harrowdale (Tolkien, 1955, p. 64); with overflow channels (Tarlang's Neck; Tolkien, 1955, p. 63) from one trough to another, and other classical glacial features such as arêtes and pyramidal peaks (Starkhorn and Irensaga; Tolkien, 1955, p. 68). Periglacial conditions are suggested in the lowlands and mountain fringes from unconsolidated materials incorporating coarse regolith (Tolkien, 1954b, p. 258). Northwards, glacial processes become more severe. Piedmont glaciers fed from the Misty Mountains stripped large areas of Eriador, producing its bleak ill-drained and stoney landscape (Tolkien, 1954a, pp. 294, 313) with ungraded tumbling streams (Tolkien, 1954a, pp. 295, 299). Caradhras is a fine pyramidal peak at the head of a U-trough whose snows still feed an icy stream, and the lake Mirrormere is an ice-scooped hollow (Tolkien, 1954a, p. 296) . . .

Reynolds noted also that the Long Lake on the River Running (Tolkien, 1951, p. 194), Lake Evendim and the hollow occupied by the Midgewater Marshes are probably of glacial origin. He considered that the extensive fluvio-glacial sands and gravels of the Shire (Tolkien, 1955, p. 296 and cal., 1973) were deposited under periglacial conditions and with localised lowering of groundwater base-level, consequent upon erosion by the Gwathló and Baranduin valley ice-tongues. The erosional deepening of the valleys on the chalk downs of the Shire (Tolkien, 1954a, pp. 126, 147) was another consequence. In addition, as he remarked (p. 70):

> Post-glacial eustatic changes have affected the whole coast, creating rias and small fjords and flooding low-lying basins (Belfalas) although delta formation by the Anduin has kept pace with this. Alluviation by the rivers has also occurred; the peats and clays of the Baranduin . . . being famous for turnips but especially mushrooms (Tolkien, 1954a, p. 100), as also is the Marish (Tolkien, 1954a, p. 112).
>
> In the north, areas of lithologically controlled high relief occur abutting glacially stripped lowlands (Tolkien, 1954a, pp. 211-212) occupied by bogs (Midgewater Marshes; Tolkien, 1954a, p. 194) and mis-fit streams in glacially enlarged valleys (Tolkien, 1954a, p. 212). The Weather Hills (Tolkien, 1954a, p. 197) are a rugged escarpment and the Trollshaws (Tolkien, 1954a, p. 213) a deeply dissected upland which includes rocks of probably red-bed facies (Tolkien, 1954a, p. 225).

The Carrock, by which Beorn once dwelt (Tolkien, 1951, p. 125), is surely an especially massive erratic block transported to its present position by a since-vanished glacier

Elsewhere, riverine erosion has predominated. Subsurface erosion has produced the troll-hole in the Trollshaws

(Tolkien, 1951, p. 53), the "goblin-holes" in the Misty Mountains where Gandalf, Bilbo and the dwarves encountered trouble (Tolkien, 1951, p. 70), and the cave that serves as palace for the King of the Wood-elves (Tolkien, 1951, p. 178). Striking products are the underground lake once haunted by Gollum (Tolkien, 1951, p. 82), very like that underlying Australia's Nullarbor Plain today, and the Glittering Caves of Aglarond that so much delighted Gimli (Tolkien, 1954b, pp. 152-154) and would put even the Carlsbad Caverns to shame.

Many other deductions are possible. The West Gate of Moria appears, from the illustration (cals., 1973, 1977), to have been cut through a massive volcanic sill – a sheet of lava intruded between strata underground, to be brought to the surface by earth movements and exposed by erosion. (The Great Whin Sill of northern England is an example.) The staircase below the East Gate (cal., 1973) surely traverses a series of beds dipping westward at a low angle like steps, producing the Stair Falls (Tolkien, 1954a, p. 314). Bree-hill, "tall and brown" (Tolkien, 1954a, p. 193), and bleak Weathertop appear to be monadnocks, isolated hills within a landscape reduced by prolonged river action almost to the condition of a peneplain. Bree-hill is lower and formed probably of sandstone, Weathertop much higher and formed of more ancient indurated rocks, perhaps slates.

All in all, in geological terms, Tolkien's descriptions and pictures of Middle-earth are of a world that, geologically at least, is very like our own.

Acknowledgements

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