The Edinburgh Geologist

No.27

Autumn 1993

Pterichthyodes milleri, Achanarras quarry, Caithness

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Cover Illustration

Pterichthyodes milleri. A Middle Old Red Sandstone fish collected from the Achanarras quarry, Caithness. From the Royal Museum of Scotland collection (R.S.M 1897.55.3). BGS photograph MNS 3884, reproduced with the permission of the Director of the Geological Survey, NERC copyright reserved.

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Editorial

The 27th edition of The Edingurgh Geologist must start on an apologetic note to our readership and, most importantly, the contributors for the delay in publication. We shall profer no excuses, but with the creation of an editorial team it is hoped that issues will appear on amore regular basis. May I take this opportunity to express my thanks to Clive Auton for his sterling efforts and enthusiasm over the past years in the, often single handed, production of this publication.

The scope of the articles included in this issue are as diverse as the science of geology and as Bill Baird's contribution on the subject of 'tektites' reminds us, not solely confined to this earth. I hope that the selection of topics covered in this edition will provide both interest and, as with Joanne Cavill's view of the Yellowstone National Park, a stimulation to the Society's members to explore the natural wonders which our world has to offer. For those with an interest in riches of another kind, Mike Gallagher and Don Cameron bring us up to date with the state of gold exploration in Britain. Mike Cotterill, on the other hand, delves into the rich but diverse world of micro-organisms throughout geological history.

I would like to express my thanks to the Director of the British Geological Survey for permission to reproduce the plate of *Pterichthyoides milleri* form the photographic collection at Murchison House. This fine specimen from the Achanarras quarry in Caithness, held in the custodianship of the Royal Scottish Museum, provides our link to John Hamptons' celebration of the 150th anniversary of Hugh Miller's *The Old Red Sandstone*, and testimony of one of Scotlands most passionate geological thinker.

In our book reviews, Mike Browne expresses the general sense of disappointment felt by many in the 3rd edition of the 'Geology of Scotland'. The 'Directory of mineral and gemstone locations in Scotland' by Kenneth Pickering has similarly been received with mixed feelings by many mineral collectors. Whether any new works will suplant 'Heddle' as our fountain of mineral knowledge remains to be seen.

The remainder of Issue 27 includes an addendum to the Proccedings of the Society for the 156th Session (1989-90) presented in Issue 26, together with the Proceedings for the 157th Session (1990-91). The former completes the statuary listings of Council, office bearers and membership of standing committees of the Society during the 156th Session. The Proceedings of the Society for the 157th

Session presents a resume of the activities and buisness during 1990-91. Tucked away in the 'Council Notes' is a rather short reference to the guided walk of Holyrood Park. This event deserves greater mention for its importance in increasing public awareness of the geological sciences. The fact that 70 people had, regrettably, to be refused is testimony alone. I feel we must express our appreciation to David McAdam and David Land for their time, effort and enthusiasm in presenting the history of perhaps Edinburgh's most famous landmark.

Andrew Highton
November 1993

The OLD RED SANDSTONE or NEW WALKS IN AN OLD FIELD

BY HUGH MILLER

LONDON & TORONTO
PUBLISHED BY J·M·DENT
& SONS LTD & IN NEW YORK
BY E·P·DUTTON & CO

'The Old Red Sandstone'

J S Hampton
Gullane

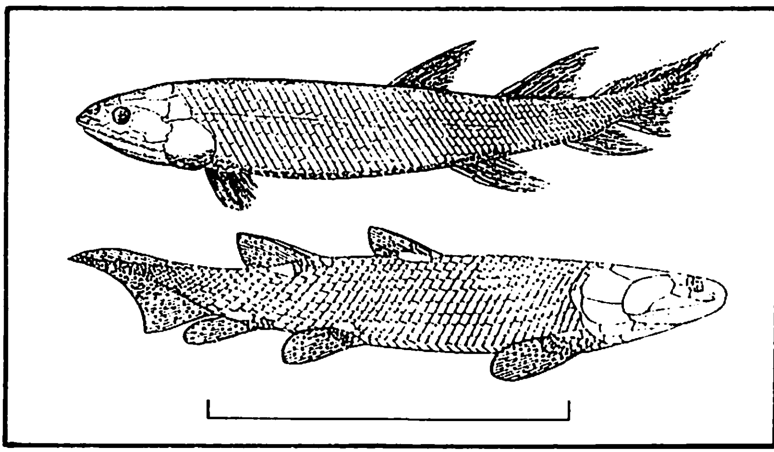
1991 marked the 150th anniversary of the publication in Edinburgh of Hugh Miller's *The Old Red Sandstone* in 1841[1], a book central in the 19th century popularisation of Scottish geology.

Hugh Miller, Scottish geologist, writer and religious reformer extraordinary, was born in the Black Isle village of Cromarty on 10 October1802. His father, a seafarer, died at sea when Hugh was only 5 years old. In February 1820, at the age of 17, and after a somewhat rebellious education in several schools as described in his *My Schools and Schoolmasters or, The Story of My Education* (1854), Miller became an apprentice stonemason and started work in the local quarries of the Black Isle. He soon found his first fossil, an ammonite, near the South Sutor of Cromarty and this, with other finds along the south shore of the Black Isle at Eathie, completely fired his imagination: "Wonderful to relate, it contained inside a beautifully finished piece of sculpture, - one of the volutes"... "Was there another such curiosity in the whole world?"... "Of all Nature's riddles, these seemed to me to be at once the most interesting and the most difficult to expound"... "I was lost in admiration and astonishment, and found my very imagination paralyzed"... "My curisoity, once fully awakened, remained awake..." (1841, p. 10, 12 and 13). Miller's course to fame in Scottish 19th century geology was set firm.

For over 14 years until 1834 Hugh Miller worked with stone. In 1823, his apprenticeship complete, he set off as a journeyman mason. During his travels he observed and noted the geology of Ross and Cromarty in ever increasing detail. As early as 1830 he discovered, along with several others later elsewhere, a fossiliferous fish bed in the Old Red Sandstone at the village of Cromarty itself. Greatly encouraged by John Malcolmson (1802-1844) in May 1838 Miller passed, via (Sir) Roderick Murchison (1792-1871), some of the fossil fish he had collected to Louis Agassiz (1807-1871), who, having first described Scottish Old Red Sandstone fish in 1835, later named (1841) and described (1844-1845)

[1]The beautifully decorated title page (opposite) from the 1922 reprinting by J.M. Dent & Sons Limited of the *Old Red Sandstone*. Issued as Number 103 in their famous 'Everyman's Library' of classic English literature, Dents's version, which first appeared in 1906, was based on Lydia Miller's 1859 7th edition of the book. By 1922 *The Old Red Sandstone* had been continuously in print for over 80 years and was an established classic, reflecting its astonishing popularity and sucess.

them. In particular *Pterichthys milleri* was established in Miller's honour. However, Miller himself went on to describe his finds and observations, first as a series of 7 articles in *The Witness* (see below) in late 1840, and then in his book *The Old Red Sandstone or, New Walks in an Old Field*, which was published in Edinburgh in 1841. This was dedicated to Roderick Murchison, and of *Pterichthys* Miller wrote: "... there are none of the fossils of the Old Red Sandstone which less resemble anything that now exists than its *Pterichthys*. I fain wish I could communicate to the reader the feeling with which I contemplated my first found specimen. It opened with a single blow of the hammer; and there, on the ground of light-coloured limestone, lay the effigy of a creature fashioned apparently out of jet, with a body covered with plates, two powerful-looking arms articulated at the shoulders, a head as entirely lost in the trunk as that of the ray or the sunfish, and a long angular tail. My first-formed idea regarding it was, that I had discovered a connecting link between the tortoise and the fish..." (1841, p. 46). The *Old Red Sandstone* established Miller's reputation as a geologist and as a major popularizer of Scottish geology in the 19th century.



A notable feature of *The Old Red Sandstone* is the attractive illustrations of fossil fish. In view of the infancy of palaeontology when these were drawn, many are of remarkable quality and accuracy. For example, the illustration (top) of *Osteolepis* (his original Plate IV, Figure 1 in the book) compares well with modern palaeontological reconstructions (bottom) of the genus (from Saxon (1975)). The scale bar (modern reconstruction) represents 10 cm.

The rigours of quarry work threatened Miller's health, and he was obliged to turn to other occupations. From November 1834 until late 1839 he worked as an accountant in the Cromarty branch of the Commercial Bank of Scotland. He married Lydia Falconer Fraser (c. 1811-1876), the daughter of an Inverness businessman, in January 1837. Over the years from 1820 Miller had developed a talented writing and journalistic skill. He published his first book *Poems written in the Liesure Hours of a Journeyman Mason* in 1829, and his second *Scenes and Legends of the North of Scotland or, The Traditional History of Cromarty* in 1835. Miller became involved in disputes over church appointments and, following his brilliant *Letter from one of the Scottish People to the Right Hon. Lord Brougham and Vaux, on the opinions expressed by his lordship on the Auchterarder case* (1839), in 1840 he was invited to edit the new anti-patronage newspaper *The Witness* in Edinburgh. Through this he became the key lay figure in the Disruption of the Church of Scotland in 1843. Miller was a religious man with strongly conservative views. Through his writing he fought bitterly against the evolutionary ideas then emerging in biological and geological science, and in *The Old Red Sandstone* he wrote "... there is no alternative between creation and metamorphosis. The infidel substitutes progression for Deity ..." (1841, p.45). His important *Footprints of the Creator or, The Asterolepis of Stromness* (1849), *The Testimony of the Rocks or, Geology in its bearing on the Two Theologies, Natural and Revealed* (1857) and *Sketch Book of Popular Geology* (1859) all expound a very strong defence of traditional creationalist philosophy. These works, in stating the then current majority view, greatly enhanced Miller's standing as a Victorian writer of note, and won wide popular acclaim.

Hugh Miller, shooting himself whilst the balance of his mind was disturbed, died in Edinburgh on 24 December 1856 by his own hand in tragic circumstances. His death may well have been due to mental exhaustion arising from the tensions raging between science and religious orthodoxy at the time, and in which he was deeply and personally involved.

Lydia Miller, and others, continued to edit and publish Miller's work. Among these *The Cruise of the Betsey or, A Summer Ramble among the Fossiliferous Deposits of the Highlands*; together with *Rambles of a Geologist or, Ten Thousand Miles over the Fossiliferous Deposits of Scotland* (1858), and *Edinburgh and its Neighbourhood Geological and Historical; with The Geology of the Bass Rock* (1864) still have some geological interest today. His other works include *First impressions of England and its People* (1846), *Geology versus Astronomy or, The Conditions and the Periods; being a view of the Modifying Effects of Geological Discovery on the Old Astronomic Inferences* *respecting the Plurality of Inhabited Worlds* (1855), *Essays* (1862) and *Tales and Sketches* (1863). A 14 volume set of Miller's collected works was published by William P. Nimmo, Hay and Mitchell of Edinburgh between 1871 and 1876.

The Old Red Sandstone was a popular and singular success. It caught the Victorian imagination and stimulated a wide public interest in fossil collecting and geological science in general. The 2nd edition of this work was published in 1842, and the 3rd in 1846. A 6th edition had appeared before Miller's death in 1856, and a revised 7th edition was prepared by Lydia in 1857. The book remained in print throughout the latter years of the 19th century, with impressions being issued by William P Nimmo, Hay and Mitchell as late as 1887 and 1892. In 1902 a centenary edition in celebration of Miller's birth appeared, whilst in 1906 Dent issued a popular "Everyman's Library" version of the 7th edition which remained in print at least until 1922. Before finally going out of print *The Old Red Sandstone* was to pass through some 26 editions in all. It was also widely translated and published abroad.

Challinor (1977, p. 119) states that *The Old Red Sandstone* "...is a classic of geological literature..." and "Its significance in the progress of geology is that, by the charm of its personal narrative and description, it awoke a widespread interest in the methods and results of geological inquiry". Whilst Hugh Miller's other geological writings were to be almost entirely superseded by the general acceptance of Darwinism, *The Old Red Sandstone* was not. In presenting the first widely and wholly accessible popular description of Old Red Sandstone fish it was a seminal contribution to palaeontology and the 19th century popularisation of geology in general. It remains today, 150 years on, a beautifully written readable classic, and almost certainly Hugh Miller's greatest work.

Hugh Miller, the Cromarty stonemason, was an individualistic, eccentric and self-made man. As with James Hutton (1726-1797) before him, and his famous contemporaries Sir Charles Lyell (1797-1875), Sir Roderick Murchison (1792-1871) and Sir Archibald Geikie (1835-1924), he stands well among the giants in the history of Scottish geology.

A recent biography of Hugh Miller is that by Rosie (1981). A good general summary of Devonian fish palaeontology is given by Benton (1990, pp. 15-45), whilst an important discussion of Old Red Sandstone fish bed formation is that of Trewin (1986). A modern description and revision of *Pterichthyodes milleri* (Miller ex Agassiz MS) appears in Hemmings (1978), and those of Miller's fish figures by Agassiz (1844-1845) are listed in Andrews (1982, pp. 42-44). Mykura (1991), provides the most comprehensive contemporary review of the Scottish Old Red Sandstone, while an up-to-date resume of the geology of the Black Isle and its regional context is presented by Johnstone and Mykura (1989; Old Red Sandstone pp. 122-124 and p. 136; Jurrassic (Kimmeridgian) p. 157). However, fuller descriptions of the geology of the Old Red Sandstone and Jurassic sediments of the Black Isle are given by Armstrong (1977) and Waterston (1951), respectively.

In 1711 the buccaneer John Fiddes and his wife Jean Gallie built the cottage in which their great-grandson Hugh Miller was later to be born. It was first opened to the public in 1900, and has been in the keeping of the National Trust for Scotland since 1938 (Prentice 1966, p. 240). Today it is the only thatched cottage in Cromarty, and attracts about 10,000 visitors a year. It has an important collection of Miller's letters, manuscripts, books and fossils.

Hugh Miller's grave can still be visted at Grange Cemetery in Edinburgh. After his death, the people of Cromarty erected a superb monument, a tall stone column topped by a magnificent statue of Hugh which stands in the village to this day. A bust of the writer can be found in the Room of Scottish Heroes at the Wallace Monument near Stirling, and happily renewed interest in Hugh Miller's work ensures his continued fame.

In May 1843 some 474 ministers of the Church of Scotland signed the Deed of Demission and formed the Free Church of Scotland (Donaldson and Morpeth 1977 p. 56). Alexander Stewart, the minister of Cromarty, was involved in the Disruption and knew Hugh Miller well, greatly influencing his religious beliefs (Waterston 1966, p. 16).

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* The page references cited in the text from *The Old Red Sandstone* are taken from the First edition of 1841, a copy of which is held by the National Library of Scotland, Edinburgh.

Geology From A Bicycle : Yellowstone National Park

Joanne E Cavill
British Geological Survey, Edinburgh

"...and behold! The whole country beyond was smoking with vapour from boiling springs, and burning with gases issuing from small craters".

These are the words of early explorers who stumbled over the geyser basins of Yellowstone National Park, in the Rocky Mountains of Wyoming, USA. Vivid descriptions brought back by the explorers and trappers, whose reputations for telling tall tales were widely accepted if not altogether deserved, fell upon the disbelieving ears of the American nation for more than half a century. Yet the intriguing rumours persisted, and during the years 1869-71 several expeditions covered this unique region astride the backbone of the nation.
In the summer of 1991, over a century later, I decided to visit Yellowstone country as part of a much longer cycling expedition with a friend to see these geological wonders with my own eyes. So with bicycles, tent and sleeping bags we set off on what was to be 1500 miles of peddling in a 'geological wonderland'.

Arriving in Yellowstone gave us a taste of real wilderness in which buffalo roam on wide open prairies and moose laze around in marshy lakes set before a spectacular backdrop of snowcapped mountains, thundering waterfalls and deep canyons. Immediate attention, of course, was drawn to the remarkable array of geysers, hot springs, and other thermal phenomena which in terms of sheer numbers and variety are unsurpassed throughout the world. So cycling from one roadside exhibit to another we discovered the story behind the scenery of America's first National Park.

Geological History

The story begins in the Precambrian when 2.7 billion year old granites and sediments were subject to uplift and metamorphism in a major orogenic event that produced the gneisses and schists of the northern mountain ranges today. Erosion and flooding by a Cambrian sea some 570 million years ago deposited widespread beds of sand, silt and limey mud that compacted to form a 10,000ft thick succession of sandstones, shales and limestones. Trilobites have been found in some of these formations. A series of transgressions and regressions in the Palaeozoic and Mesozoic eras was followed by deformation in later mountain building movements of the Laramide orogeny about 65 Ma. The with volcanic ash and lava. Eruptions were intermittent and in the periods of quiescence the volcanic debris was deeply eroded so that widespread forests could establish. Today these forests are preserved as petrified trees in the famous fossil forests of Specimen Ridge. Here up to twenty-five separate forests have been successively smothered by lava flows over an area of forty square miles producing the worlds largest fossil forest.

Some 600,000 years ago the ominous rumblings of an impending volcanic eruption sounded across Yellowstone country. Then, in an mighty crescendo of deafening explosions, tremendous quantities of hot volcanic ash and pumice were ejected from giant cracks at the earths surface. Towering dust clouds blackened the sky, and vast sheets of volcanic debris spread out rapidly across the countryside, covering thousands of square miles in a matter of minutes with a blanket of utter devastation. Abruptly, a vast smouldering caldera some 45 miles long, 30 miles wide and several thousand feet deep, appeared in the central Yellowstone region, the ground having collapsed into the huge underground cavern left by the earth shaking eruptions. Lava then began oozing from the cracks to fill the still smoking caldera. Thus, in one brief moment of geological time there was initiated that incredible chain of events which has led to the creation of the natural wonders of Yellowstone. Heat from the enormous reservoir of molten rock which produced the massive eruption still remains deep within the earth beneath Yellowstone, sustaining the spectacular hot water and steam phenomena for which the Park is so justly famous.

The need for preservation

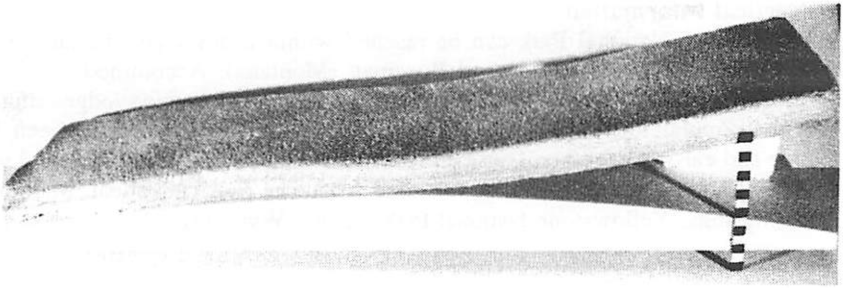
Geologists have long been interested in geothermal energy development in the greater Yellowstone region. There are three areas of particular interest, refered to as Known Geothermal Resource Areas (KGRA). Two are situated along the western boundary of Yellowstone, while the third lies adjacent to the northern park boundary near Gardiner, Montana. The relationship between the thermal features of Yellowstone and the nearby KGRA's outside the park is not well understood. It is suspected that these areas share a similar geological history with Yellowstone and concern is focused upon the danger that geothermal drilling might affect the geysers and other thermal features of the park. Concern is warranted, with seven of the world's major geyser basins having been destroyed or seriously damaged through geothermal exploration and development. In New Zealand, The Geyser Thermal Valley, which ranked fifth among the major geyser areas on earth, died shortly after the Wairakei plant was installed nearby. In 1965 the last known geyser eruption occurred there, and in 1972 the valley was closed as a tourist attraction. There was a time when New Zealand had 130 geysers but now it has only 5 because of geothermal drilling.

Coarse breccias and conglomerates of Eocene age from the Absaroka Volcanic Group. Tower Falls, Yellowstone National Park, Wyoming.

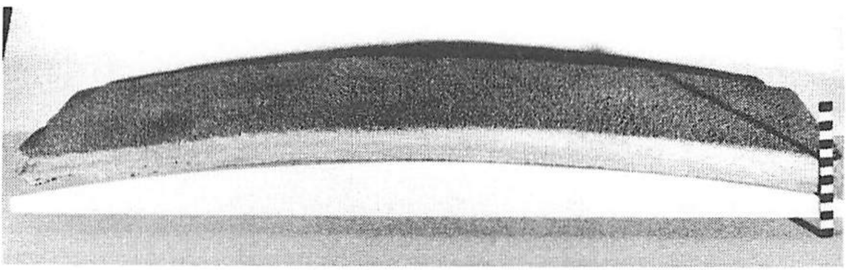
Similar circumstances have been recorded in Iceland, Italy and Nevada. Geysers are extremely rare and are the most fragile of all geothermal phenomena. They require the occurrence of a highly unusual combination of factors and are easily disrupted. The case for extreme caution and preservation in Yellowstone is strong. The region contains the largest concentration of geysers in the world (there are more geysers here than on the rest of the earth combined), and probably represents the last remaining major undisturbed geyser area on earth.

Practical Information

Yellowstone National Park can be reached within a day from the airports of Cody (Wyoming), Missoula and Bozeman (Montana). Accommodation is by camping, recreational vehicle or bed and breakfast at old hunting lodges situated in the popular tourist centres. The best time to visit the park is between late June and early September. Outside these months the roads may be blocked with snow. More information can be obtained from The Superintendent, Mammoth Hot Springs, Yellowstone National Park, 82190, Wyoming, USA.



Sandstone slab from Jind, India, in non-'flexed' state.



Sandstone slab in 'flexed' state.

Strange Earth, No.12: Flexible Sandstone (Itacolumites)

Bill Baird
Royal Museum of Scotland

The general public think of rocks as being hard, rigid and with a permanent unchanging form. Geologists know that the term rock can be extended to include less hard and rigid substances such as clays. However even geologists are surprised when they come across flexible rocks. Flexible sandstone occurs in several countries but the most famous is that from India. The peculiar rocks from Jind, near Delhi were originally formed from the decomposition of gneisses which contained a proportion of feldspar grains. On the subsequent decomposition of the feldspar grains the rock became a mass of loosely interlocking grains of quartz, with wide interspaces around them. Where the quartz grains of the sandstone interfinger with their neighbours, growth of the quartz crystals has taken place. This growth has created sites of articulation, rather like that of a human knee or elbow joint, thus allowing a surprising amount of flexibility in the rock.

Although the flexible sandstones from Jind do contain small quantities of the accessory minerals, kaolinite and mica, their unusual property is due solely to the overgrowth contacts created between the quartz grains during diagenesis.

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Strange Earth, No.13: Singing Sands

Bill Baird
Royal Museum of Scotland

When Hugh Miller and his companions first experienced the sand singing beneath their feet at Laig Bay on the Isle of Eigg they were filled with scientific curiosity. There is also a clear indication in Miller's description of his sense of wonderment and real pleasure at encountering this strange phenomenon.

Sounds emanating from sands, both those of the beach and the desert, have been recorded by travellers since ancient times. Indeed such tales appear in the most ancient legends of the desert caravans which travelled across the trade routes of the Orient. The type of sound described seems to have been as varied as the locations at which it occurred. Sometimes it would be described as a roaring thunderous sound and at other locations as clear bell-like notes or even a humming noise. The booming sands of the desert produce sounds at a much lower frequency than the noise produced by beach sands. This may be related to the extremely smooth surfaces of desert sand grains.

Early explanations of how these sounds might be caused concentrated on supernatural origins. The first practical suggestions were that they were caused by the action of the wind. Although indeed the wind may well be implicated in sound production at some locations it alone does not provide a full explanation. In fact "singing sands" on some beaches will "sing" when walked on, even on a windless day. Other factors which have an effect on the "singing" ability of sands are moisture content and most important, well sorted grain size.

From experimental work on beach sands it seems that well sorted, clean, rounded grains of medium size are fundamentally important in sound production. The addition of a small percentage of water, perhaps up to 2 per cent, can add to the sound qualities, sometimes changing the pitch. If sands meeting these criteria are brought under pressure and a shearing force exerted, then definite notes can be produced even in the laboratory.

As one who has heard the sound produced by such "singing sands" on a lonely West Coast beach I can assure the reader I was not surprised that early travellers had opted for a supernatural origin.

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Strange Earth, No.14: Tektites

Bill Baird
Royal Museum of Scotland

The origin of tektites has aroused curiosity for more than a millennium. They are such strange things that more than a thousand papers have been published on them. Suess derived the name for these exotic bodies from the Greek word tektos (melted). Ancient people believed they fell from the sky, and regarded them as objects of magic, collecting them as talismans. They were described in China as early as the tenth century by Liu Sun who wrote "In Leichow, after sudden rainstorms, people collect black stones in the field which they call 'lei-gong-mo', meaning inkstone of the thunder-god."

The first mention of tektites in scientific literature describes them as a form of volcanic glass. Those who believed in their volcanic origins included Darwin, who compared australite buttons to volcanic bombs. Some speculated that they were the products of prehistoric glass manufacture or from the burning coal seams. Others considered that they might have been either ejected from volcanoes on the moon or a kind of meteorite or aerial fulgurites caused by lightning fusion during dust storms or desiccation of silicate gel masses.

It is now generally accepted that tektites are the result of some kind of impact on Earth by meteorites or comets. However, searches made in relation to the Tunguska event, now generally believed to have been a comet airburst, have not yet found any tektite type material.

Work on the isotopic composition of argon (Ar) in bubbles from gas-rich, splash-form tektites (Muong Nong type tektites) and Darwin glass, has revealed an atmospheric origin for this gas.

Most tektites are about the size of a walnut, but range from much smaller specimens to blocky lumps up to 12.8 kg in weight. They are generally black in appearance, but when held to the light some are translucent. Those recovered in Czechoslovakia are often a beautiful clear light green in colour (faceted gems have been cut from moldavites up to 25 carats in weight), while those from the Libyan Desert are generally of greenish yellow. Tektites which appear opaque in whole specimens may be translucent or yellowish brown in thin plates.

In form they may be the shape of a teardrop, dumbbell, rod, sphere, disc or flanged button. Often the original is modified by spalling, breaking or etching.

A special type of blocky, layered tektite was first described from Muong Nong, Laos.

Tektites are found from over a large part of the world, occurring as strewn fields but within defineable areas. Each group appears to be associated with specific, but widely separated arrival events, with no evidence for inter-group activity. These groupings vary in age from around 15 thousand years for those in Australia, to 40 million years for North American tektites.

Tektite from specific occurrences have usually been assigned distinctive names. For example those found in Czechoslovakia are termed 'moldavites' after the Moldau River, while 'bediasites' from Texas are named after the Bedias Indians. Others have acquired names from their places of occurrence ie. australites, javanites, and philippinites.

The question of where and how tektites originated is still a matter of controversy, however most workers agree that they result from impact. Some argue that the impacts originally occurred on the moon, and that tektites represent ejected droplets of melted lunar rock which splashed onto the earth. However, none of the geological specimens collected from the moon during the Apollo missions could be regarded as the source of tektite glass. Many studies, though, relate them chemically and otherwise, to terrestrial materials.

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Principal gold locations in the United Kingdom.

Gold Exploration in Britain

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The momentum of gold exploration in Britain has been high since the discovery in 1979 by Consolidated Goldfields of gold-bearing stratabound base-metal sulphides in the Archean at Gairloch, NW Scotland. A location map of the main gold occurrences in Britain appears below. Targets subsequently drilled by Riofinex North and BP Minerals International lie in late Silurian to early Devonian igneous rocks offering possibilities for porphyry deposits at Comrie and Lagalochan and in SW Scotland at Hare Hill, Fore Burn and Moorbrock Hill. Geologically comparable targets at Glen Devon and Glenhead were also investigated under the BGS Mineral Reconnaissance Programme. Much of the company work from the early 1970's to the mid 1980's was carried out with support from the DTI-funded Mineral Exploration Grant Scheme and the information now lies in the public domain together with the reports, geochemical atlases and open-file reports. More recently, Navan Resources, Cambridge Consultants, Doelcam-Echo Bay and Camon Consolidated, as well as Ennex and Colby, have demonstrated interest in Scotland's exploration potential. The Crown Licence system for gold and silver exploration and development enables new entrants to see the current areas of activity and can give secure rights to precious metal exploration at reasonable cost. Information on how to undertake mineral exploration in Britain has been collated in the BGS booklet: *Exploration for metalliferous and related minerals in Britain: a guide.*

Close interval drainage sampling for up to 30 elements has been completed over Scotland and northern England by the BGS's Geochemical Survey Programme and further analyses for gold and pathfinder elements (As, Bi, Sb) are available for certain areas. Records of gold in panning concentrates from the Aberfeldy area, published by BGS, led to Colby Gold's discovery of a swarm of thin but rich gold veins in Dalradian metamorphics at Calliachar Burn, about 5 km south of M-I GB's bedded baryte deposit at Foss. These vein deposits are believed to be Lower Devonian, the same age as the gold occurrence in fossiliferous chert at Rhynie, Britain's only known epithermal hot spring gold location.

The principal gold deposit recently found in Britain is Ennex International's Cononish vein structure, near Tyndrum, which cuts Dalradian (late Proterozoic) rocks. About 750,000 tonnes of ore, grading 10g/t gold (uncut) and 43 g/t silver, are indicated from drilling and underground development. In the past, alluvial gold was extracted on a small scale, principally around Leadhills and Helmsdale.

Leadhills gold was used to fashion the Scottish Regalia in the sixteenth century, and around 1860 the Helmsdale district was the scene of a minor gold rush with quite extensive diggings.

Three mines in the Dolgellau gold belt of North Wales account for the bulk of Britain's past gold production, perhaps 5 tonnes in all (mainly from 1870 to 1910). The gold occurs in quartz veins cutting Cambrian to Silurian sediments. There is no current production from these mines, two of which were open as tourist attractions until recently. Polymetallic mineralisation, including gold, has recently been located by BGS in several new areas of Wales. At Treffgarne in SW Wales, highly pyritiferous dark mudstones containing enhanced gold levels (up to 2.5ppm) are associated with Lower Ordovician acid volcanic rocks. On Anglesey, a complex zone of Precambrian to Ordovician rocks, near the Parys Mountain volcanogenic massive sulphide deposit under investigation by Anglesey Mining (a subsidiary of Imperial Metals), was drilled on VLF-EM, IP and geochemical soil anomalies; polyphase base metal mineralisation was located, locally accompanied by gold.

The most recent gold discoveries have been made in SW England. At Wadebridge in Cornwall, arsenopyrite-bearing quartz veins commonly contain up to 1 ppm gold in Middle Devonian volcanic and sedimentary rocks associated with basic igneous intrusions. At Hope's Nose in Devon an occurrence of filligree palladium-gold in calcite veins was considered to be unique until gold, platinum and palladium-gold were shown to be widespread in streams in the surrounding South Hams district. This area of Lower to Middle Devonian sediments and acid to basic igneous rocks was sampled by drainage and overburden surveys which yielded not only abundant gold but also unusual dendritic, layered, precious metal grains. These layered grains usually contain gold, gold-palladium or gold-mercury cores with platinum-rich rims. The platinum in the rims is alloyed with gold or copper; mercury may also be present, or a combination of mercury, palladium, gold and platinum. Mercury is also found as cinnabar particularly in Middle Devonian mafic volcanics. The gold is believed to have been concentrated in the weathered zone of the Devonian strata by circulating groundwaters during tropical weathering periods in the Permo-Trias or Tertiary. This deeply weathered zone has not been stripped off by the Pleistocene glaciation as the ice sheets never reached this part of England. It is also of interest to note that small-scale gold production was recorded as a by-product of tin extraction from alluvial deposits in both Devon and Cornwall.

Geojots: Youngest Oil

Mike Cotterill
Freshwater, Isle of Wight

Most of the petroleum exploited commercially is many millions of years old. Typical North Sea oil originated from organic matter deposited in Kimmeridge Clays during an Upper Jurassic marine transgression, about 150 million years (Ma) ago.

Much older but more tar-like oils do exist where ancient sediments have escaped metamorphism. At Nonsuch on the North American Great Lakes, bitumen seeps from Pre-Cambrian shales, and similar deposits occur in the Soviet Union. In 1986 Australian geologists found, by drilling, substantial quantities of lighter, less tarry oils, in a sequence of shales, limestones and stromatolites over 1400 Ma old in the McArthur Basin of the Northern Territories (1). Unlike the Shetlands, where oil of less than 200 Ma has migrated and accumulated in much older (400 Ma) reservoir rocks, the Australian oil is believed to be at least as old as the rocks in which it is now found. Although it contains traces of steranes, a "chemical fingerprint" indicating some was derived from advanced organisms (eukaryotes), most of the oil probably came from primitive (prokaryotic) organisms like bacteria.

In complete contrast, the youngest oil in the world is only 4240 years old according to radiocarbon dating (2). It was discovered in 1991 by a research team from Toronto and Oregon, seeping out of sediments in the Guaymas Basin of the Gulf of California. This is on a constructive plate margin, where new crust is being created by igneous intrusions. But is also an area with very rapid deposition of sediments, flowing off the land mass of Mexico and enriched with an abundant supply of marine organic matter descending from highly productive surface waters. High heat flow underground alters or 'cracks' the organic compounds into oil exceptionally quickly.

To put this date in context, the first cut-stones were devised by architect Imhotep in Egypt about 4700 years ago. Roughly 5100 years ago, when First Dynasty Egyptians were building brick tombs, the village of Skara Brae in Orkney was already inhabited. Jericho was a walled town 10,000 years ago, and stone tools were being used to cut wood into flat planks over 24,000 years ago at Gesher Benot Ya'aquov in the Jordan valley (3).

References from New Scientist: (1) 11/9/1986; (2) 6/4/1991; (3) 20/7/1991.

Invasion of the Biocrats

Mike Cotterill
Freshwater, Isle of Wight

Sophisticated techniques from biology and biotechnology are increasingly carving a very interesting niche in palaeontology and environmental geology. A better understanding of genetic material (DNA), and the tiny structures called 'organelles' within cells of living organisms, has permitted some remarkable deductions to be made about evolution. When Hans Ris of Wisconsin first took electron micrographs of the chloroplasts responsible for photosynthesis in an alga cell in 1962, he recognised their close resemblance to cyanobacteria, and the possibility that they represented a modified bacteria living symbiotically within the algae. This revived discredited ideas first put forward in Germany by Andreas Schimper (1893), and in Russia by K.C. Merschkovsky (1905). In 1925 E.B. Wilson had also speculated that another tiny organelle within cells, the energy-conversion "power-houses" called mitochondria, were derived from symbiotic bacteria. The new champion of these highly controversial ideas was Lynn Margulis, a biologist at Berkeley. She argued persuasively in a 1970 book on the 'Origin of Eukaryotic Cells' that at least three organelles (chloroplasts, mitochondria and centrioles) in the cells of complex organisms were relics of once free-living bacteria which had arrived at that arrangement by 'endosymbiosis' (1). This is now widely accepted.

The taxonomy or classification of living organisms begun by Carl Linneaus in the 18th century, attempts to show relationships and evolutionary 'family trees'. Based on cell biology and fossil evidence, it defines five Kingdoms of life: animals, plants, fungi, protoctista (micro-organisms with chromosomes of DNA enclosed within a cell nucleus), and prokaryotes (micro-organisms without a separate cell nucleus, including bacteria). All organisms with a cell nucleus, varying from protoctists like protozoa and yeasts to plants and animals, are termed eukaryotes. Only one extraordinary bacterium species, recently discovered and called *Gemmata obscuriglobus*, has a cell nucleus (2). Protozoa are tiny aquatic animals (0.002 to 2 millimeters in size). They include the earliest animals on Earth, and the foraminifera sought by oil geologists (3). Viruses are excluded from classification. Simply pieces of nucleic acid (DNA or RNA) wrapped in protein coats, they may have originated as bits of cellular material that "escaped" and took up an independant existence (4).

During the 1980s analysis of mutations in nucleic acid molecules (RNA) from protein-making organelles (ribosomes) in bacteria enabled an evolutionary family-tree to be constructed for bacteria (5). Of particular interest was a fragment of RNA called 16S which allowed very ancient varieties of bacteria, the Archaebacteria, to be distinguished. Some researchers consider these a separate kingdom. They include the strict anaerobes which cannot live in oxygenated air, like the methanogens which give off methane, the thermoacidophiles which need hot, acid environments, and the halobacteria which thrive under very salty conditions. Nearly a dozen new genera of sulphate-reducing bacteria were discovered in the 1980s (6). Chemoautotrophic bacteria thrive at the 'black smokers' on ocean ridges. Feeding on hydrogen sulphide issuing from volcanic vents, they are the base of a unique local food chain supporting a variety of bizarre deep-sea animals (7). Biologists like Carl Woese of Illinois, studying the genetic code sequence of base-pairs in DNA, have recently proposed a complete and very controversial reclassification of all living organisms (8).

Microbes (micro-organisms), the earliest life forms, are fascinating (9). They remain of great importance in global geochemical cycles, affecting the rates of soil formation and rock weathering, the mobilization and translocation of elements, and the conditions required for fossilization to occur. In 1986 palaeontologists found colonies of the oldest oxygen-producing plant microbes. These 3500 Ma organisms form stromatolites in the Warrawoona formation near Port Harcourt in Western Australia (10). Modern living cyanobacteria forming stromatolites at Hamelin Pool (Shark Bay) and in Lakes Thetis and Clifton in Western Australia, are of great interest in the interpretation of their fossil counterparts (11).

The role of microbes in oxygenating the Earth's early atmosphere has long been accepted. Chemoautotrophes that gained energy through the reaction between hydrogen and methane, probably evolved a form of photosynthesis as the air became depleted in the hydrogen. Consequently they expelled a then rather toxic gas, oxygen, and by 2000 Ma ago sedimentary red-beds containing oxidised iron indicate that at least some oxygen was present in the atmosphere. Tyler Volk at Harvard has recently emphasised how important thermophilic bacteria were during an even earlier period, helping to cool the Earth sufficiently for other organisms to evolve (12). About 4000 Ma ago the atmosphere held no oxygen, but so much carbon dioxide (compared to only 0.03 per cent today) that it gave 10 to 20 times the modern atmospheric pressure of 1 bar at sea-level. It produced a 'greenhouse effect' that kept the Earth's surface at almost 100 degrees centigrade. Only thermophilic bacteria, now restricted to specialized environments like Yellowstone hot springs in Wyoming, could be comfortable under such conditions. Volk claims that when such bacteria first colonized the land, creating soil, they increased the rate of chemical weathering of rocks by a hundred fold, and absorbed much carbon dioxide. In the oceans plankton thrived on the solute washed from the land, absorbed more carbon dioxide, and their detritus began the accumulation of limestones which today hold trapped vast quantities of carbon dioxide. More complex, eukaryotic organisms have never evolved thermophilic varieties because their proteins degenerate at high temperatures. The thermophilic bacteria thus played a vital role in the history of organic evolution. Precambrian river sediments derived from soils and containing what may be fossils of lichen and fungi 2300 Ma old have been found in the Witwatersrand Group of South Africa.

In more recent times, one winter about 11,000 years ago, a bemused and perhaps dispeptic four ton mastodon completed its meal of shallow-water plants like water lilies just before taking a terminal plunge into an acidic peat bog in Ohio. Bacteria in its intestines, entombed in suspended animation, have now been cultured by Gerald Goldstein. These *Enterobacter cloacae* have the distinction of being the oldest living organisms ever isolated (13). Comparison of their DNA with that of modern bacteria may provide useful information on bacterial evolution.

One extraordinary living bird is the South American stinkbird (*Opisthocomus hoazin*). It has microbes in its exceptionally large foregut (the oesophagus and crop) which enables it to live entirely on leaves, and to ferment these in the same way as ruminant mammals. Did some extinct birds do likewise? Stinkbirds are poor fliers, and their young are unique in having functional claws on the first and second digits of their wings (rather like those of *Archaeopteryx*) which they use to clamber up trees (14).

British hydrologists propose a new use for microbes. Half of British drinking water is obtained from aquifers, which are increasingly being penetrated by agricultural nitrate fertilizer, chlorinated organic solvents, and industrial disinfectants. In some industrial regions, trichloroethane solvent is already present in boreholes at levels exceeding European guidelines. Hydrologists like Keith Halden of Cambridge are testing the feasibility of introducing methanotroph bacteria, and hydrogen peroxide or ozone, directly into aquifers to degrade chlorinated hydrocarbons (15). Some microbes may even be able to breakdown the hazardous synthetic chemical dioxin (16).

American research at Reston, Virginia, has shown that a natural bacteria called GS-15, from Potomac River sediments, can convert soluble uranium into an insoluble form. It may be used to extract uranium from polluted water around uranium mines, and the researchers believe that geological deposits of uranite may indicate ancient colonies of this microbe in streams rich in dissolved uranium (17). Researchers at Macquarie University, Australia, believe the positive electrical charge on tiny gold particles causes them to congregate into grains around certain negatively charged bacteria colonies living on river sediments, producing alluvial gold deposits like those in Venezuela.

Biohydrometallurgy is the technology of using microbes to extract useful minerals cheaply from low grade ores (18). In 1947 the bacterium *Thiobacillus ferrooxidans* was found to obtain its energy by oxidizing the sulphides of metals like copper, zinc or uranium, and converting them to sulphates. Industrial recovery of metal from the sulphates is far cheaper, and about a third of United States copper is now obtained using bacteria and methods rather similar to the ferrous-sulphate industry of seventeenth century Britain (19). An experiment is now in progress at San Manuel, Arizona, pumping bacteria in an acidic liquid down boreholes for underground extraction of copper sulphate solution.

Bacteria were used in the late 1970s to extract uranium from old mines in Canada, and gold mines in South Africa. Recently Canadian researchers at Giant Yellowknife Mines have been treating crushed gold-bearing sulphide ores at 30 °C with *Thiobacillus ferrooxidans* which has raised the rate of successful gold extraction from 70 per cent using chemical methods like sodium cyanide, to almost 100 per cent (20). In British Columbia, gold prospectors can purchase a 'Gold Probe' which uses antibodies manufactured by biotechnology (21). These latch onto spores of a bacterium, *B.cereus*, which grows preferentially in mineral rich soil, particularly that rich in gold. The antibodies release a blue indicator dye when they catch their target spores. Some plants similarly thrive in metal-rich soils, e.g. *Haumaniastrum*, which prefers copper and cobalt, and the "copper-flower" *Becium homblei* (22).

Materials scientists, keen to mimic biomineralization in the laboratory, are expanding knowledge of the microstructure of components that are often fossilized (23). Each intricate spine of a sea-urchin, for example, is grown as a single crystal of calcium carbonate, while the abrasive radula ('teeth') of limpets are made of the hard iron oxide geothite.

Clues to the diet of extinct animals have been gained by comparing the wear-marks and scratches on fossil teeth with the pattern on teeth of modern animals whose diet is known. Recently, D.R. Piperno of the Smithosonian Institute has applied a new method to *Gigantopithecus blacki*, the extinct great ape of China. Using a scanning electron microscope he has found and identified tiny silicified fragments of food (10 to 100 micrometers wide) wedged in the scratches they made in the tooth enamel (24). Known as phytoliths, these silicified remains of stems, leaves and fruit are of great interest to palaeobotanists. Plants absorbed soluble silica together with nutrients in ground water, and in some species, particularly grasses and palms, this is deposited as opaline silica around cells. Distinctive phytoliths are well preserved in ancient soils.

Under exceptional conditions of fossilization, particularly those restricting the ingress of oxygen and bacteria, some fragile organic material, even amino acids and DNA, may be preserved for considerable periods of time. In eukaryotes each cell has genetic DNA in its nucleus, but it also has abundant mitochondria each with its own DNA. Normally the hydroxyl (OH) radicals in water rapidly degrade DNA, but rapid burial in acidic bogs, hypersaline pools, or permafrost may protect these fragile molecules from decay. Molecular biologists have been intrigued with the possibility of such preservation. To study the genetic code, they have developed techniques (by cloning inside bacteria, and more recently in 1985 by the polymerase chain reaction, PCR), to obtain many identical copies of fragments of these large polymers. In 1984, Alan Wilson of the University of California extracted mitochondrial DNA from a museum specimen of Quagga, a zebra-like animal which became extinct a century ago. DNA is thought to accumulate changes (mutations) at a roughly constant rate over time, and Wilson deduced that the Quagga and Zebra had a common ancestory 3 to 4 Ma ago. During the late 1980s Svante Paabo successfully extracted and analysed DNA from an Egyptian mummy 2400 years old, from the extinct marsupial 'wolf' of Tasmania, and from a giant ground sloth 13,000 years old from Chile (25). The DNA showed variable degrees of degradation. C.S. Cockell at Oxford in 1989 extracted DNA from a Russian mammoth entombed 40,000 years in permafrost (26). Peter Parham at Stanford has examined well preserved DNA from human remains 7000 years old out of a wet peat burial ground at Windover, Florida.

Estimates based on the genetic change in mitochondrial DNA suggest that the human and chimpanzee lineages may have diverged as little as 5 Ma ago (27). The mitochondrial DNA of every individual is inherited entirely from its mother, and it mutates far faster than the genetic DNA in the cell nucleus (derived equally from both parents). Researchers at Berkeley estimate a mutuation rate of 2 to 4 percent per million years. They claim that the mitochondrial DNA of all living humans may be derived from a single woman who lived in Africa between 140 and 290 thousand years ago (28).

In 1990 Edward Golenberg of the University of California astounded colleagues by extracting fragments of DNA from the chloroplasts of a Magnolia leaf out of Miocene lake clays at Clarkia, Idaho. At more than 16 Ma it is by far the oldest surviving DNA claimed so far, and had to be amplified by thirty cycles of P.C.R. before there was sufficient to analyse (29).

References mostly from New Scientist:

(1) 3/7/1986 One Woman and Her Theory; (2) 25/1/92 Bizarre Bacterium; (3) 1/7/1989 Everlasting Picnic for Protozoa; (4) 16/1/1986 Viruses and Cells; (5) 21/1/1989 Microbial Happy Families; (6) 14/7/1988 Bacterial Worlds Built on Sulphur; 19/2/1987 Superbugs Spring from Hot Water; see also 31/7/1986; (7) 24/3/1988 Patterns on the Ocean Floor; (8) 1/6/1991; see also 16/1/1986, 27/7/90; (9) 16/2/92 The Malleable Microbe; 6/7/1987 Cannibal's Relief: Origins of Sex; 22/9/1988, 16/2/91; (10) 31/7/1986; (11) 18/12/90; (12) 13/7/1991 When Soil cooled the World; (13) 1/6/91; see also 21/7/90; (14) 30/9/89 Secret of the Stinkbird's Stink; (15) 16/3/91; see also 29/4/1989 Laying Ground Rules for Nitrate; (16) 25/2/88; (17) 26/1/91; (18) 4/1/92 Mining with Microbes; (19) Edinburgh Geologist No. 25; (20) 12/5/1988; (21) 25/3/89; (22) 10/3/88; (23) 10/3/90; (24) 10/11/90; (25) 9/3/91; (26) 25/5/91; (27) 2/6/1986, 3/12/1988; (28) 14/5/1987 All about Eve; (29) 11/5/91.

Review: Geology of Scotland (3rd edition)

As the owner of all three, comparison of the quality of production of each edition is easy. Unfortunately the 1991 version is in third place by some distance. In my opinion the font size is too small and made more uncomfortable to read by the variable inking strength. Standardised artwork for the diagrams would also have helped and these too have their share of problems with illegibility and omissions. Some of the plates are dreadful and look as if they have been xeroxed twice from one edition to the next. I'm sure these problems are not the fault of the editor. If this book goes to another edition, the publishers must improve the plates and, as a standard source book for Scottish geology, think of including colour photos of the classic views. The new cover doesn't appeal to me either.

There are sixteen chapters:-

A L Harris	The growth and structure of Scotland
R G Park	The Lewisian Complex
A D Stewart	Torridonian
A L Harris and M R W Johnson	Moine
M R W Johnson	Dalradian
E K Walton and G J H Oliver	Lower Palaeozoic
E K Walton and G J H Oliver	Lower Palaeozoic Structure and Palaeontology
P E Brown	Caledonian and earlier magmatism
W Mykura	Old Red Sandstone
E H Francis	Carboniferous
E H Francis	Carboniferous-Permian igneous rocks
J P B Lovell	Permian-Triassic
A Hallam	Jurassic, Cretaceous and Tertiary sediments
H Emeleus	Tertiary igneous activity
G S Boulton, J D Peacock and D Sutherland	Quaternary
R Beveridge, S Brown, J Merritt and M Gallagher	Economic Geology

It is always difficult to review a book which covers so many topics . It is hard to know if every chapter is a reasonable statement of present knowledge and existing schools of thought. This is a problem because of the delay in publication of the book, although some authors were able to incorporate material published as late as 1989. The most conspicuous example of this, is the effect the Ben Vurich Granite radiometric dating has had on Dalradian thought. Unfortunately the Dalradian chapter has reference to this only as a footnote. However, the introductory account does take cognisance of the fact(?) that the Dalradian is entirely Precambrian in age and that the Highland Border Complex, including Leny Limestone equivalents at Callander, is wholly younger.

This is the only generally available text on Scottish geology. Given the wide-ranging audience this book addresses, I find Professor Harris' key introductory chapter over-influenced by Lewisian to Dalradian matters. More important, his chapter should set the scene for all and be easily understood by the amateur or school geologist. I don't think that this chapter fulfils such a function. Indeed I had to consult other sources for the divisions of the Precambrian. Perhaps it is a pity that T N George's original eloquent introductory chapter is so out of date, especially as it had 12 more figures and 3 (50%) more plates.

I found the 4 new, as against revised, chapters on the Lewisian, Torridonian, Quaternary and Economic Geology a mixed batch. The Torridonian one was enjoyable to read and well illustrated. The Quaternary one made me nostalgic for J B Sissons' original chapter. It was sad to see Scotland's geomorphology and also the lithostratigraphy of the sediments dismissed in so few words. Some of the best and worst plates were present in this modellers paradise. The economic chapter seemed to underplay the geology of coal and hydrocarbons; the latter only serving to emphasise the inadequate description by Hallam of the recent boom in information available about the Jurassic, Cretaceous and Tertiary rocks offshore. In the same chapter, there was no mention of the substantial Scottish contribution to the assessment of geology in relation to our health, safety and welfare (other than mineral resources). The impact that shallow mineworkings, landslides, landfill, natural and biogenic methane gas etc. may have on national, regional and local planning issues is not discussed. Neither is their impact considered in terms of loss, damage or financial blight of property, or restriction of landbanks or urban renewal. The omission of global issues is not surprising but geological and biogeological cycles operate as much in Scotland as elsewhere. City air pollution may not be seen as a geological problem but atmospheric processes return heavy metal traces to the soil and to the rocks through groundwater. Doubtless other readers may note the omission of their favoured subject (and not just the environmental subdivision of geochemistry, Lewisian chapter excepted).

Of the revised chapters, along with Hallam's, I would suggest that Lovell's on the Permian and Triassic also fails to reflect the significant increase in data since the publication of the 2nd Edition. It contains possibly the best printing error, apparently the Stocksfield Chert is 5 km(m) thick. No wonder this unit is so conspicuous on the offshore seismic. The Old Red Sandstone needed the addendum from M Armstrong and its contents should have been adjusted to reflect the age of the rocks (into the Silurian and Devonian chapters). The uppermost Upper Old Red Sandstone (Kinnesswood Formation) is rightly shifted into the Carboniferous chapter to which much is added. The palaeontological content is itself almost fossilised (e.g. *Curvirimula* for *Modiolus latus* in the Ballagan Formation). An oversight in the Permo-Carboniferous igneous chapter means that Murchison and Raymond's work on the quartz- and olivine- dolerite sills and their very different metamorphic effects on the country rocks is missed out.

I hope the authors of the chapters singled out above will forgive me. It is very difficult to bring together so much geology and please all the pundits. Whether you are interested in ring dykes, older granites or F3 folds, this comprehensive summary is a must for anyone interested in Scottish geology and the paperback good value at £29.

M.A.E. Browne

Review: A Directory of Mineral and Gemstone Locations in Scotland

Kenneth L. Pickering,

"Avalon", 3 Combe Green, Croscombe, Wells, Somerset, BA5 3QP.

This volume is that modern rarity, the privately produced book. Allowances have been made for that factor in this review. The Directory, as Pickering says in his introduction, records the specimens and localities from field trips and visits to museums, private individuals and collections over a period 30 years residence in Scotland. The forward and introduction are well thought out and the author puts forward a good, if arguable case for collecting. Localities are listed alphabetically by Region and District over 145 pages printed only on one side. Mineral occurrences recorded are interesting rather than exhaustive and localities are often fairly vague eg. Fintry Hills. However, this must be one of the most comprehensive locality lists since Heddle's *Mineralogy of Scotland* (1901) and I would be surprised if it did not contain some gems of information.

One of the problems with privately printed books is that they can escape the rigorous attentions of a proof reader. This is apparent in Pickering's mineral names which show many spelling errors which should have been corrected at the proof stage eg. Cerrusite for Cerussite and Garsdorffite for Gersdorffite.

There are two maps included: at page 25A "Mineral Locations at Leadhills-Wanlockhead" and at page 33A "Agate Locations of Perth, Dundee and North Fife Hills". These should have been key attributes for the book and could have helped to pin down some of the rather imprecise localities. However, they are rather sketchy and poorly reproduced, not even showing Regional or District boundaries.

So is this volume worth £10 plus £2.50 post and packing? Well, I leave that up to mineral collectors. It is unlikely that other than at a library will they ever get their hands on the two volumes of Heddle. If this book might, just might, have a locality they have never visited, with the mineral they always failed to collect, well show me the mineral collector who would not count it a cheap buy at twice the price.

Bill Baird

Addition to Proceedings of the Edinburgh Geological Society No.20, 156th Session 1989-90.

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Finance	Dr D. Gould (Convenor), Dr I.R. Basham, Dr W.D.I. Rolfe, Mr D.H. Land, Dr D. Grant, Prof. G.Y. Craig, Mr D.C. Greig, Dr C.D. Waterston.
Publications	Dr D. Grant (Convenor) Dr G.M. Biggar, Dr S.S. Brown, Dr W.D.I. Rolfe, Mr D.H. Land, Dr J.D. Peacock.
Clough Memorial	Mr D.H. Land (Convenor), Dr W.D.I. Rolfe, Dr D. Gould, Prof. G.S. Boulton, Dr A.H.F. Robertson, Dr P. Stone.
Excursions	Mr J.K. Oakley (Convenor), Mr S.I. Hogarth, Dr W.D.I. Rolfe, Dr E.N.K. Clarkson, Mr A.A. McMillan, Mr A.D. McAdam, Mr N.E. Butcher, Mr D.H. Land, Dr D. Gould, Dr P.M. Dryburgh, Dr S.K. Monro, Mr J.W. Merritt.
Planning	Mr D.H. Land (Convenor), Dr W.D.I. Rolfe, Dr D. Gould.

Neither the Finance Committee, the Planning Committee nor the Publications Committee met during this session.

Proceedings of the

EDINBURGH

GEOLOGICAL SOCIETY

157th Session

1990-1991

No.21 November 1993

INTRODUCTION

This, the twenty first issue of the *Proceedings*, covers the 157th Session 1990-1991 of the Society.

MEMBERSHIP

Total membership at 30 September 1991 was 568, which represents a decrease of two from 570 in the year 1990. The membership comprises as follows:

Honorary Fellows	9(9)	Senior Fellows	14(15)
Corresponding Fellows	8(8)	Family Fellows	34(34)
Life Fellows	27(27)	Glasgow Associates	12(9)
Ordinary Fellows	458(460)	Junior Associates	6(8)

Twenty three ordinary new fellows were elected, while 27 resigned, deceased or were removed.

PUBLICATIONS

Two parts of the *Scottish Journal of Geology*, Volume 26 part 2 and Volume 27 part 1, were published during this session. Issue Number 25 of the Society's magazine, *The Edinburgh Geologist*, was published. Most regrettably, Scottish Academic Press, the long standing publisher of the *Scottish Journal of Geology*, went into receivership in May. New arrangements were made for publication to be continued, with the contract awarded to the Geological Society Publishing House at bath.

CLOUGH and MYKURA MEMORIAL FUNDS

The Clough Medal was awarded to Dr K.W. Glennie for his work on the Scottish continental shelf. Dr R.P. Barnes received the Clough Award for his contribution to our understanding of the geology of the Southern Uplands area. Grants were made from the Mykura Fund for work on skarn rocks in Scotland, and from the Clough Fund towards studies in Gran Canaria, Iceland and the Okavango delta in Botswana.

LECTURE MEETINGS

The following open meetings were held during the seession:

10th October 1990:
Engineering geological aspects of Edinburgh Castle and Castle Terrace developments.
Mr T.P. Davies, James Williamson and Partners.
24th October
Volcanism in Hawaii and its implications for the geology of Mars and Venus.
Professor L. Wilson, University of Lancaster
7th November
Caledonian Orogeny in Canada, Scotland and Poland.
Dr G.J.H. Oliver, University of St. Andrews
21st November
The shape of Fife
Dr A.R. MacGregor, University of St. Andrews
This presentation was followed by the Annual General Meeting of the Society.
5th December
Molecular palaeontology: the study of a fossil protein.
Dr L.B. Halstead, University of Reading
16th January 1991:
Hydrogeology and waste management: geology, water and the environment.
Ms T. Henton, Aspinwall and Co.
30th January
Taking limestones apart.
Dr J.Marshall, University of Liverpool
20th February
Fellow's evening
13th March
Deserts and the Permian Rotliegend.
Dr K.W. Glennie, Ballater
On this occasion Dr Glennie was presented with the Clough Medal.
17th April
Gold exploration in Scotland.
Mr R. Parker, Fynegold

RECORD OF FIELD EXCURSIONS

4 May	Thornhill Leader: Mr A McMillan
17-25 May	Orkney Leader: Dr N Fannin
1 June	Leadhills Leader: Mr R Gillanders
12 June	Kilspindie Leaders: Mr A D McAdam and Mr D Land
15 June	Ben Vuirich Leader: Dr R Smith
22 & 23 June	Elgin area and Aviemore Leader: Mr S Ross
29 June	Rough Castle and Alva Leaders: Mr D H Land, Mr Pollock and Dr M J Gallagher
17 July	Bathgate Hills Leader: Dr S K Monro
31 August	Kincraig Neck Leaders: Dr C Donaldson and R Garton
14-16 September	Portpatrick area Leaders: Dr P Stone and Dr B C Lintern
28 September	Glasgow area Leader: Mr A McMillan

COUNCIL

Following nominations at the AGM on the 21st November 1990, the elected members of Council for the session were:

President	Dr W D I Rolfe, FRSE
Vice-presidents	Mr S I Hogarth and Mr A A McMillan
Secretary	Mr D H Land
Treasurer	Dr D Gould
Assistant Secretary	Dr S K Monro
Membership Secretary	Mr J W Merritt
Excursions Secretary	Mr J K Oakley
Meetings Secretary	Mr J A Fairhurst
Convenor of the Editorial	Dr D Grant, FRSE
Editor of the Proceedings and	Mr C A Auton
Librarian	Dr W B Heptonstall
Publications Sales Officer	Mrs C M Taylor
Six Ordinary Members	Dr P M Dryburgh, Mr R D Gillies, Mrs
S W T Representative, co-opted	Mr M C Smith
Office-bearers not on Council	
Trustees	Professor G Y Craig, FRSE, Mr D C
Scientific editors	Dr B C Lintern, Dr J D Peacock, FRSE,
Auditor	Mrs M McLeod

COUNCIL NOTES

The Society's written archive was gifted to the University of Edinburgh and is now held in the Special Collections in the George Square library, where it may be freely consulted (see Edinburgh Geologist No. 25, 32-34).

During the Science Festival a guided walk of Holyrood Park attracted 130 people, with another 70 having to be turned away.

The Society has now affiliated with the Geologists' Association, joining with more than 20 other societies for the exchange of information and consultation on matters of mutual interest.

Conservation of geological sites has begun in Scotland and the Society is taking an active part in this work in conjunction with the Scottish Wildlife Trust and Nature Conservancy Council for Scotland. Work at various stages is in progress at Petershill, Torphin, Comiston, Jedburgh and Siccar Point.

Representations were made against the proposal to remove the palaeontological collections from BGS Murchison House to Keyworth, urging that the collection should remain in Scotland as an integral part of Scottish palaeontology and that there should continue to be palaeontologists at Murchison House.

At the end of the session, Dr Gouglas Grant, FRSE, demitted office as convenor of the editorial board of the Scottish Journal of Geology, after 27 years in that position and 40 years as editor, first of the Transactions and then the Journal. The Society is deeply indebted to Dr Grant's friendly counsel, expert knowledge and generous devotion to its interests.

Summary of Accounts

Notes:

Council has decided that the accounts should be simplified and made more realistic by ceasing to have separate accounts for the Sime and Wright bequests which now become subsumed in the General Fund, and also the Peach and Horne Fund which, together with the Day and Hart bequests, now become subsumed in the Publications Fund.

The Society owns the following items not considered realiseable: a silver snuff and cup box presented to Alexander Rose, a specimen cabinet and chair made by Rose, together with library and geological books (including the manuscript of Hutton's *Agriculture*).

Report of the Auditor to the members of the Edinburgh Geological Society

I have audited the Accounts in accordance with approved auditing standards. Imformation supplied by individual Council members has been accepted as correct where independant confirmation could not be obtained. The valuation of the Investments by the Bank of Scotland.

In my opinion the accounts which have been prepared under the historical cost convention, give a true and fair view of the state of the Society's affairs at 30 September 1991 and of the net Revenue for the year ended on that date.

M. McLEOD C.A.
74 Colinto Road
Edinburgh EH14 1AT
17 November 1993

The full listings of the Society's Accounts are available and open for inspection through the Treasurer.

Statement of Balances at 30 September 1991

	1991		1990	
	£	£	£	£
Fixed Assets				
Investments at Market Value		59,767		44,402
Current Assets				
Stock of Publications	6,323		6,677	
Other stocks	503		14	
Debtors	289		604	
Tax recoverable	230		934	
Bank accounts	5,589		10,406	
	12,934		18,635	
Less:				
Creditors due within one year				
Sundry	681		698	
Loan (Necker Map)	700		700	
	1,381		1,398	
Net current assets		11,553		17,237
Net assets		71,320		61,639
Representing:				
Funds				
At 1st October 1991 (1990)		61,639		61,002
Increase (decrease) in value of		3,201		(3,454)
Additions to Mykura Fund		-		1,228
Scottish Journal of Geology		-		1,197
Surplus per Revenue Account		6,480		4,924
		71,320		64,897
Less:				
Specific Expenditure				
(Scottish Journal of Geology)		-		(3,258)
		71,320		61,639

Revenue Account for the year ending 30 September 1991

	General	*Publ's*	*Clough*	*Mykura*	Total 1991	Total 1990
	£	£	£	£	£	£
INCOME						
Income from Investments	2,483	2,168	500	314	5,465	4,619
Bank Interest	544	476	110	69	1199	815
Subscriptions	6,069	-	-	-	6,069	5,771
Tax recovered on Deeds of	423	-	-	-	423	388
Sundry	-	-	-	-	-	100
Profit on sales	-	419	-	-	419	700
	9,519	3,063	610	383	13,575	12,393
EXPENDITURE						
Lectures	1,024	-	-	-	1,024	1,100
Excursions (net cost)	640	-	-	-	640	382
Audit fee and expenses	500	-	-	-	500	418
Billets	1,580	-	-	-	1,580	1,496
Bank charges	432	-	-	-	432	330
Stationery, postage, etc..	250	20	-	-	270	238
Insurance	108	-	-	-	108	104
Reception	63	-	-	-	63	4
Scottish Journal of	**	-	-	-	**	1,197
Medal and awards	-	-	137	-	137	244
Celebrity lecture	-	-	-	-	-	345
Edinburgh Geologist	111	1,181	-	-	1,292	1,332
Additions to Library	179	-	-	-	179	186
Leaflet guides	-	75	-	-	75	43
Borders Guide	-	345	-	-	345	-
Grants made	-	-	350	100	450	50
	4,887	1,621	487	100	7,095	7,469
Surplus for year	4,632	1,442	123	283	6,480	4,924

**Scottish Journal of Geology: Draft accounts for volume 26 show a surplus, but the receivers of Scottish Academic Press indicate that this will not accrue to the Society. The Society guarantees its half share of costs of volume 27 which are estimated could ammount to £2,500.

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