

PIONEERING SCIENCE IN THE PENNINES

a regional heritage in science
explored and celebrated with the aid of museum material at
CLIFFE CASTLE MUSEUM
KEIGHLEY

Weekend course/conference, 30 June/1 July 2001

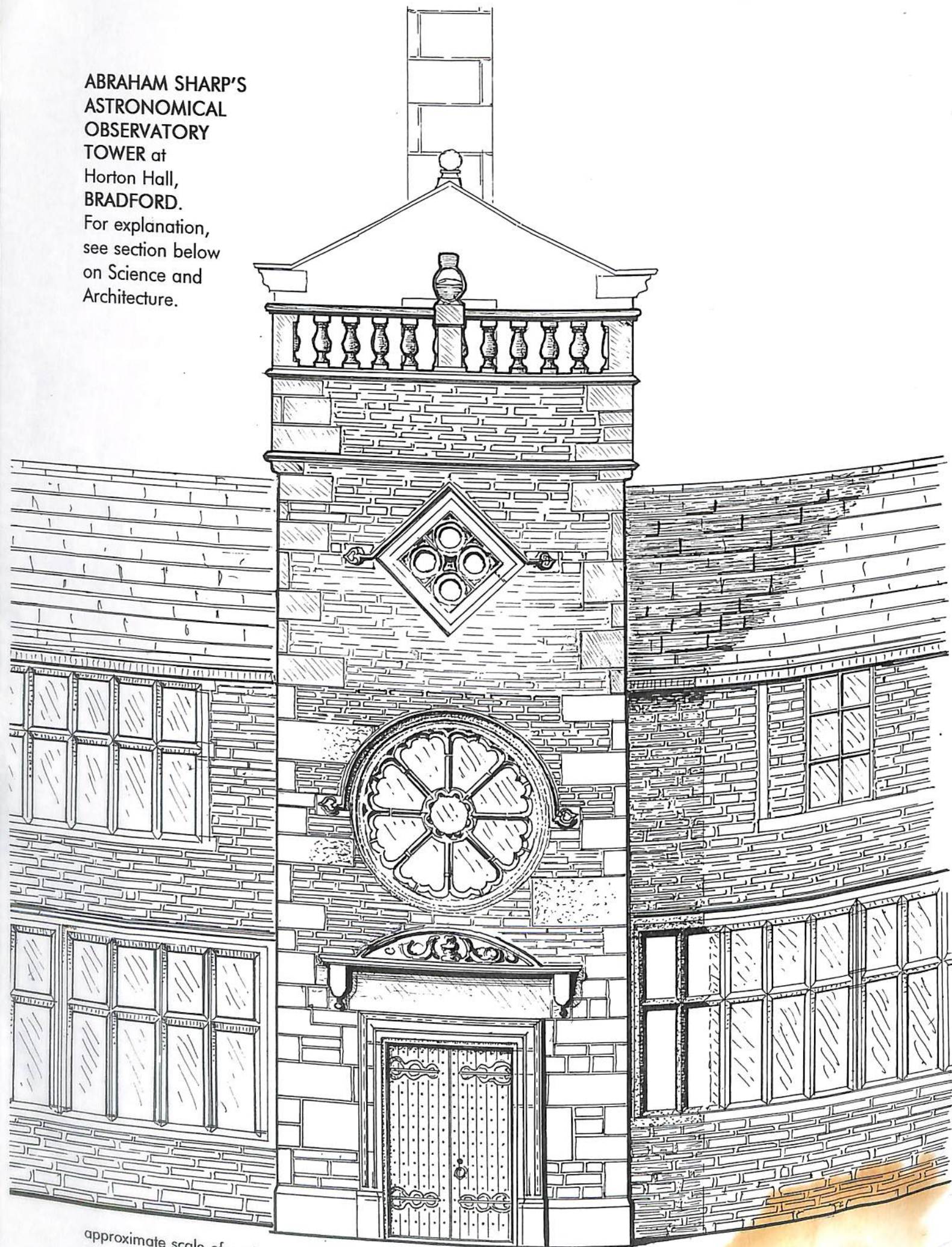
The weekend has three components - discussion papers or lectures; studies of material in the museum; and a coach excursion. Topics will be examined through these different activities roughly as follows:

ASTRONOMY & ARCHITECTURE
in museum (with Astrid Hansen), excursion (with Arnold Pacey).
SOCIAL/RELIGIOUS BACKGROUND OF SCIENCE
lecture (Dr. Charles Webster)
GEOLOGY & LOCAL PHILOSOPHICAL SOCIETIES
lectures, museum (Alison Armstrong)
ALCHEMY; also GENDER IN SCIENCE
lecture (Penny Bayer)
SCHOOLS, MATHS, GEOLOGY
lecture (Professor Robert Fox)
BOTANY - museum, also excursion
MICROSCOPY, BAROMETERS - excursion

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ABRAHAM SHARP'S
ASTRONOMICAL
OBSERVATORY
TOWER at
Horton Hall,
BRADFORD.

For explanation,
see section below
on Science and
Architecture.



approximate scale of metres

INTRODUCTION

REGIONAL STUDIES OF EARLY SCIENCE

The early development of science is usually presented as a European movement with an English contribution coming entirely from the golden triangle of London, Cambridge and Oxford.

But there was scientific activity in all the regions of England, reflecting a range of geographical and social influences. Study of early science in its various regional settings is therefore essential to the social history of science, and can make us more aware of the variety of social and other factors stimulating scientific development. Here we are concerned with a region extending from the western fringes of Leeds over the Pennines to Burnley, and north to the limits of the former West Riding around Sedbergh.

In the Pennines, geographical conditions were obviously important. There was a great deal here to stimulate anybody with an interest in geology or botany (or meteorology and barometers), and there was a particular stimulus from lead mining in the Dales. In the seventeenth century, John Ray's several visits (in 1660, 1668 and 1671) illustrate well how the area could attract people with relevant scientific interests.

SOCIAL & RELIGIOUS BACKGROUND

However, we also need to notice a contrast between people who were born in the area, but left it to go to university or to pursue their careers, and people who did important scientific work within the Pennine region. Some Roman Catholics, for example, stayed in the area because they were excluded from the ancient universities, and from many aspects of public life. Towneley Hall became an important centre of scientific activity in the seventeenth century partly because the Towneleys were Catholic.

In the **seventeenth century**, religion could often motivate people positively in their study of science, as we may see with John Webster, with the brothers Thomas and Abraham Sharp, minister and astronomer respectively, and with the famous botanical visitor to the region, John Ray (1627-1705). He was author of The Wisdom of God Manifested in the Works of Creation (1691), a book proposing a wonderfully holistic view of nature, enthusiastic for Galileo, critical of Descartes, and awed by the 6,000 species of plants and 10,000 of insects which Ray believed to exist.

John Webster (1610-1682) began life as a schoolmaster in Clitheroe, and became curate at Kildwick Parish Church. But his preaching there was too controversial for his congregation, and he found more in common with the "Grindletonians", a sect regarded as forerunners of the Quakers. His parallel interest in a Paracelsan approach to chemistry and mineralogy is evident in books he wrote on university reform and on mining.

In the **eighteenth century**, nonconformist religious traditions colour the scientific interests of Joseph Priestley in Leeds, and Joseph Dawson in Bradford (who attended a chapel which Abraham Sharp, the astronomer, had helped to found).

It is in the **nineteenth century**, however, that one sees a more negative influence from religion, with a vicar of Bradford speaking against the formation of a philosophical society in 1823, and geologist Adam Sedgwick's piety bringing him into conflict with Darwin in 1859.

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SCHOOLS, GENDER, AND PATRONAGE

Significant for the social background of science were the surprisingly numerous grammar schools in the region, but in the seventeenth and eighteenth centuries, boys who wished to learn mathematics, and girls who wished to learn anything much at all, usually needed private tuition. Lady Anne Clifford of Skipton included portraits of her tutors in the "Great Picture" of her family she commissioned in the 1650s. The noble families of the area and their patronage of schools and science are another part of the social background. Apart from the Cliffords of Skipton, they included the Saviles (in Halifax), the Towneleys (Burnley), and later the Boyles (at Bolton Abbey). The Saviles and Boyles were both involved in founding grammar schools.

The effect of gender on roles in science is evident when we notice women who were knowledgeable as herbalists (Mrs. Thomazin Tunstall before 1600), or who illustrated the work of scientific husbands or fathers (Anna and Susanna Lister in the 1680s, and Mary Smeaton a century later). Several of the Cliffords had interests in astronomy, alchemy and mining. Lady Margaret Clifford (1560-1616; also known as Lady Margaret Russell, Countess of Cumberland) invested in mining and practised alchemy, in a life that challenges stereotypes about gender restrictions. She appears to have obtained contemporary alchemical knowledge, and access to commercial mining circles, through partnerships, patronage, and friendships with men (such as Richard Cavendish, John Dee, and perhaps Christopher Tylour). However, her alchemical interests also emerge from female culture to a greater extent than is sometimes recognised, since they bear a relationship to household technologies, including the making of medicines, distillation, perfumery, dyeing and brewing, and to the daily prayer and meditation that were a normal part of a noblewoman's spiritual practice.

We also need to notice the role of professional people, including clergy (such as Miles Gale, Rector of Keighley from 1680 to 1720), and physicians or doctors (Sir Thomas Browne in Halifax from 1634 to '36, Henry Power at Elland, and Martin Lister in the Skipton area).

SCIENTIFIC SOCIETIES

Much later, around 1800, "philosophical societies" began to appear, the first in this area being in Leeds, founded by William Hey, a surgeon who also helped found Leeds Infirmary (1767-8), and who was a close friend of Rev. Joseph Priestley. The Leeds society began to function in 1783 with Hey as president and John Smeaton and Joseph (not John) Dawson as members. Bradford Philosophical Society had to be founded three times before it took off, the first time in 1808 with Joseph Dawson as president, then in 1823, when the vicar opposed it, and finally in 1839. After that the society gained momentum rapidly, soon with 172 members. The society began a museum, mainly of minerals and geology.

The social background of science in the nineteenth century is too complex to summarise here, and is beyond the scope of our weekend course, but we need to note one important trend: collections of scientific material belonging to private individuals or to scientific societies such as Bradford Philosophical Society gravitated first to the new educational institutions of the later nineteenth century (e.g. technical colleges), and then, during the twentieth century, to public museums such as Cliffe Castle. Some of these collections still have a scientific function as "reference collections", and are used by geologists and biologists for purposes of identification, comparison or standardisation. The Cliffe Castle geology collections are particularly important in this respect, and the final points that have to be made by way of introduction have to do with Cliffe Castle Museum itself.

CLIFFE CASTLE MUSEUM

Cliffe Castle was a large Victorian house (not a real castle) that was given to the town of Keighley in the 1950s to provide more spacious accommodation for an existing public museum. It serves as a local and general museum as well as a science museum. Some rooms are notable for their Victorian architecture or decoration. The sculptured clock with conical pendulum in the entrance hall is part of the original decorative scheme.

However, there are three galleries devoted to geological themes which show where the real importance of this museum lies, and the natural history gallery also has significance for the history of science.

The GEOLOGY section includes first the **AIREDALE GALLERY** which describes the formation of the earth and its rocks, with reference to the geology of the Aire valley, and then illustrates the origins of life, leading on to the first humans, ice-age animals and plants. The highlight is a diorama representing one of the earliest vertebrate animals to walk on land, an amphibian called *Pholiderpeton*. It is shown in a swamp with plants recognisable from Carboniferous fossils. Thus it is much earlier than the dinosaurs of the Jurassic period.

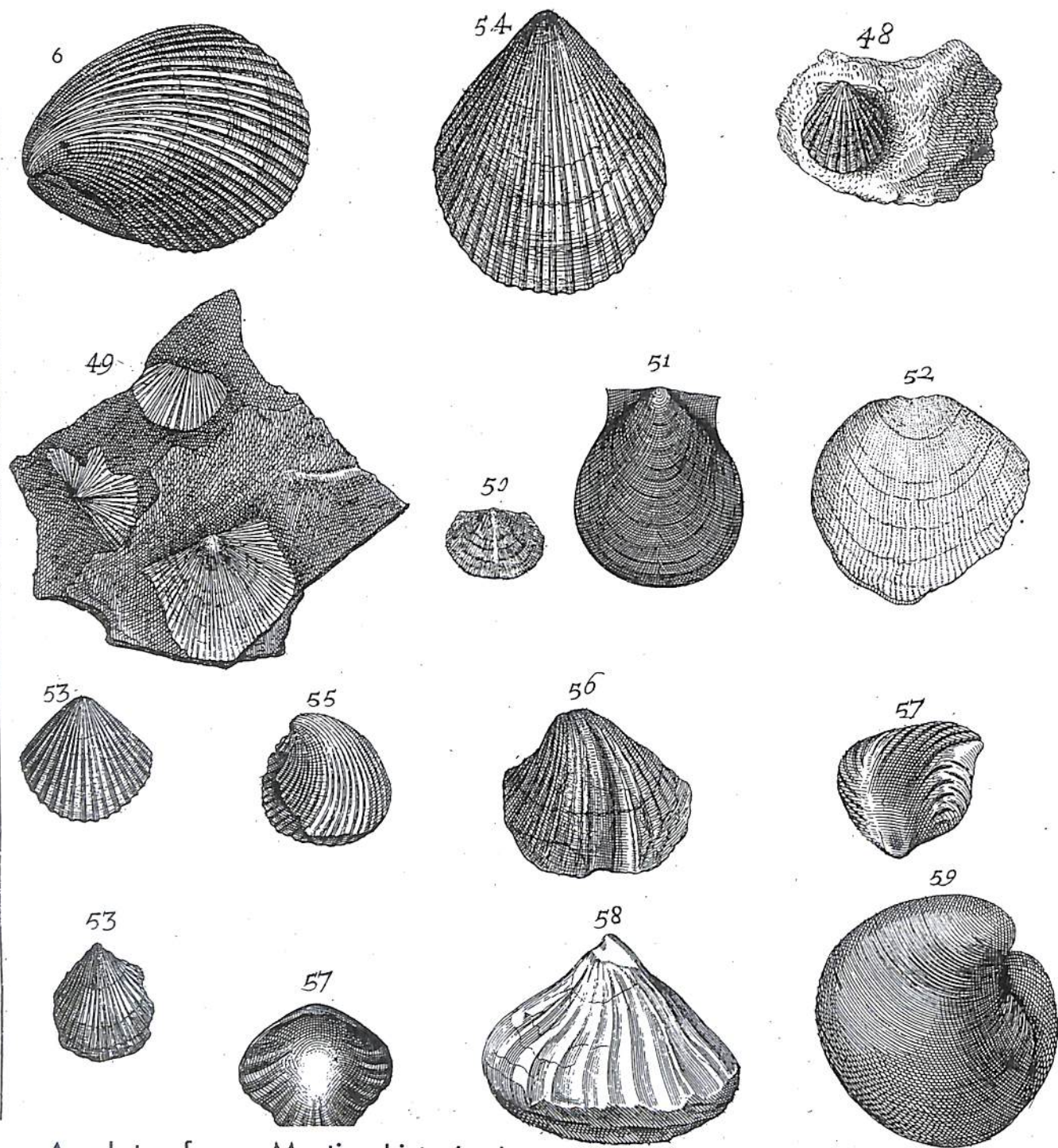
Exhibits near the diorama describe how the fossilised skeleton of this creature was found in a Bradford coal mine in 1868. Other material in this gallery was discovered in limestone quarries, so it is appropriate that the gallery in the next room is devoted to mining, quarrying and other mineral resources. Entitled **RICHES UNDERFOOT**, this gallery gives us further insights into the Carboniferous rocks of the locality and also has outstanding displays of quarrying tools.

The third gallery with a broadly geological theme is **MOLECULES TO MINERALS**, which displays a remarkable collection of minerals, many of them colourful and beautiful. Each display includes models of the molecular structures of the mineral crystals shown, so that the symmetry of the crystals can be better understood. The molecular structure of *beryl* is particularly striking, and the model for *mica* clearly shows why this material has a laminated form.

There are several glimpses of the historical development of geology, particularly in the nineteenth century. Most important is the small exhibit on *Joseph Dawson* in **MOLECULES TO MINERALS**. His collection of minerals, with its meticulous catalogue dated 1810, is an unusually good example of an early private collection. Then we may note that discovery of the fossil amphibian in 1868 led to Huxley being consulted. This was at a time when enthusiasm for geology was at high tide in Bradford.

The other topic that historians of science should consider is how science has been presented at various times in museums. The hundred-year-old ornithology dioramas in the **NATURAL HISTORY** gallery are signed and dated by their creator, "Hutchinson in the NATURAL HISTORY gallery in the bottom corner. Their design was influenced by the Booth Museum at Brighton.

It is also noteworthy that, at the time of the weekend course, there will be a temporary exhibition in the large octagonal room entitled "Woodlands Road Show". This will present woodland ecology in a popular manner, with hands-on exhibits for children.



A plate from Martin Lister's book *Historiae Animalium Angliae* (London, 1678).

The subtitle explains that the book represents just three "treatises" from a much larger project - one treatise on spiders and the other two on molluscs, creatures with shells and "stones" or fossils of related form. Among local examples on this plate, with Lister's Latin names for them, are:

55 *Pectunculites subsphaericus* from near Keighley ("juxta Keighley" in the Latin text). This could be one of the fossils given to Lister by Miles Gale, but he doesn't say.

56 *Pectunculites anomis*, a "stone" from Stock in Craven (which is between Barnoldswick and Gisburn, and gives its name to Stock Beck).

INDIVIDUAL BRANCHES OF SCIENCE

GEOLOGY AND ITS ANTECEDENTS

Geology did not emerge as a science until the eighteenth century, and did not reach maturity until the middle nineteenth century. However, lead miners in the Dales had empirical knowledge of rocks and minerals long before that.

The Clifford family of Skipton had mines on their estates, and Lady Margaret Clifford (1560-1616) is important as one of the first members of the family to take a serious interest in their development. She made investments (1) in lead mines near Cononley; and (2) in experiments using coal or coke to smelt iron, with Richard Cavendish (died 1601) as her business partner from 1589. Both Richard Cavendish and Lady Margaret took an interest in alchemy during the 1590s, and it is probable that they saw a relationship between mining and alchemy (see R.T. Spence, "Mining and Smelting by the Cliffords", reference in bibliography below).

John Webster (1610-82), one-time schoolmaster at Clitheroe and controversial Puritan, settled down in later life to write a useful survey of mining in England, with special attention to assays for silver in lead from local mines. Webster refers to Paracelsus several times in his book, entitled *Metallographia* (1671), and was quite frank about taking a quasi-alchemical approach to metals and minerals.

Turning from minerals to fossils studied as natural history, the York physician Martin Lister (1639-1712) spent his summers during the 1670s at Carleton near Skipton, collecting fossils and doing other fieldwork. Later, he was able to produce books on shells and fossils, molluscs and spiders, illustrated by his wife and daughter(s) Anna and Susanna Lister, with the help of expert engravers (see opposite). Lister's own favourite fossil-hunting places around Skipton included a quarry at Winterburn; also Middop, south of Gisburn; and Malham.

Miles Gale (1647-1720), Rector of Keighley, corresponded with Lister and seems to have collected some fossils for him.

During the eighteenth century, Rev. Joseph Dawson (1740-1813) was a non-conformist minister at Idle near Shipley at the same time as Rev. Joseph Priestley (1733-1804), born at Birstall, south of Leeds, was minister at Mill Hill Chapel in what is now City Square, Leeds. Some years before, Joseph Dawson may have been taught by Priestley at a dissenters' academy in the Midlands, and certainly shared Priestley's unitarian tendencies in religion, as well as his interest in chemistry. However, Dawson was less a scientist, more an industrialist, with interests in coal mines and ironworks south of Bradford. About 1810, he assembled a large mineral collection whose catalogue shows great awareness of current geological controversies (particularly those surrounding Werner's "Neptunist" theories of rock formation).

At the turn of the nineteenth century, Joseph Dawson, with Samuel Hailstone (solicitor, botanist, 1768-1851), and another Joseph Priestley (canal surveyor, 1746-1817) were trying to form a philosophical society in Bradford and were also exchanging geological specimens. From 1837-51, Samuel Hailstone lived in Abraham Sharp's former house (Horton Hall), and there was a feeling among these men that Bradford had a distinct scientific tradition.

Hailstone had moved to Bradford from York, the city in which he had grown up with his brother Rev. John Hailstone (1759-1847), who was Woodwardian Professor of Geology at Cambridge, 1788-1818. It may be this connection that made Joseph Dawson aware of the controversies surrounding "Neptunist" geology.

In 1818, Adam Sedgwick (1785-1873) of Dentdale was elected Woodwardian Professor in succession to John Hailstone. Sedgwick had been taught maths by Dawson of Sedbergh (see below on maths teaching) and was good at maths, but was only really happy doing fieldwork. He spent much of each summer studying the rocks of the Lake District and North Wales, as a result of which he was able to define the **Cambrian System** of rocks. He combined "a Dawsonian mathematical training with the skill of a field geologist" to solve "very complex problems" (Speakman, p. 70, see bibliography). He was also keen to introduce students to fieldwork. A printed notice issued from Trinity College, Cambridge, in 1835 begins with the words: "The Woodwardian Professor invites his class to meet him on horseback..." for an excursion to various gravel pits and quarries.

A formative experience for Charles Darwin (1809-82) in his youth was fieldwork in Wales with Sedgwick, but later on, Sedgwick could not accept evolution, and there was a painful exchange of letters between the two during Darwin's two-month stay at Ilkley in 1859. Darwin wrote: "I grieve to have shocked a man whom I sincerely honour". Somebody Darwin met during this stay later sent him geological specimens from Brazil together with reminiscences about: "conversing together at the Ilkley fire-side over... your Naughty Book". Both men had been taking a water cure. (see Correspondence of Charles Darwin, vol. 7, Cambridge UP, 1991, pp. 343-414; also see vol. 11, 1999, pp. 358-9).

The maturing of geology as a science in the hands of such men as Sedgwick, Murchison and Lyell was accompanied by a remarkable surge of popular interest in the subject, clearly evident in Bradford Philosophical Society, Ilkley Museum Society and other local bodies. Every community seems to have had its local geologists, from William Gilbertson (1788-1845) and John Phillips (1800-1874) at Clitheroe, to James Ellison at Steeton (a shoemaker by trade), and many of the collections made by these individuals and societies have found their way into local museums, most notably Cliffe Castle, but also museums at Clitheroe and elsewhere.

A SUCCESSION OF BOTANISTS IN THE PENNINES

Most early botanists were really herbalists (such as Gerard, author of a famous Herbal published in 1597), or gardeners (such as Parkinson, author of Theatrum Botanicum, 1640). In the Pennine region, Mrs. Thomazin Tunstall, an otherwise unknown "gentlewoman" knowledgeable about herbs, provided information about plants growing on Ingleborough that was quoted by Parkinson.

Scientific botany was less concerned with the uses of plants in medicine or in gardening, but had more to do with cataloguing, classifying, and noting habitats. John Ray (1627-1705) made an especially important contribution to botanical studies of this type, and was one of the major figures of the so-called "scientific revolution". His career at Cambridge preceded Newton's by a few years. Otherwise, he lived in Essex, and for a time in the Midlands, but visited the Pennine area of Yorkshire to study botany in 1660, 1668 and 1671. One other trip to Yorkshire, in 1661,

included the liquorice fields of Pontefract, but not the Pennines.

Ray's closest friend locally was Martin Lister (see p. 7). Some of Ray's most memorable botanical discoveries in the Pennines were those where Lister had previously suggested he might find certain flowers, most famously, Jacob's Ladder at Malham, and also Dame's Violet, near Gisburn. Ray was also helped in finding interesting or unusual plants by an "old soldier" named Thomas Willisel - probably somebody who had fought in the Civil War. Willisel had himself collected plants extensively in the Dales and helped an earlier botanist, Christopher Merret, to find Mountain Scurvey Grass, not on Ingleborough (where Mrs. Tunstall had collected it), but: "On the top of Penigent Hill". Ray refers to Willisel in connection with one kind of Solomon's Seal: "Shown me by Th W. growing on the ledges and scars or cliffs near Wharfe and Settle plentifully".

Ray's work was written in Latin and was studied closely by Linnaeus, working in Sweden, and was a formative influence on the Linnaean system of Latin names for plants. Linnaeus also received information by letter from: Richard Richardson, (1663-1741), a physician who became a Fellow of the Royal Society in 1712. He had a hot-house or greenhouse for botanical research at his house at North Bierley, Bradford, and raised a remarkable collection of rare plants. This is said to have been only the second such hot-house in England.

Later botanists methodically cited earlier records of plants, and hence quoted Lister and especially Ray, as well as citing Linnaeus. Two such botanists especially worth considering are Samuel Hailstone (1768-1851) a solicitor who had the second greenhouse in the Bradford area in the 1790s, and Arnold Lees (1847-1921), a surgeon who, in 1888, published the definitive book on the flora of West Yorkshire. Each man collected pressed/dried specimens in a herbarium. Hailstone's herbarium is today preserved at York, and that of Lees in Bradford Museums.

Samuel Hailstone was proud to put the letters FLS after his name - Fellow of the Linnaean Society. When writing about the "rarer plants growing in Craven", in a supplement to Whitaker's History of Craven, he followed Linnaeus's classification of plants very closely. Although Linnaeus's Latin names for many species are still used as their scientific names, his method of classification by sexual characteristics is no longer regarded as valid. Hailstone's way of organising his material looks archaic because it follows Linnaeus so closely, even though his descriptions of many species are still full of interest.

By looking at a number of Pennine species and how they are described by Ray (and Lister), then by Hailstone and Lees, we can get an impression of how these people approached their fieldwork -- Ray riding the country on horseback, and climbing on "scars of the mountains near Settle", and on Ingleborough. He was clearly fascinated by the limestone country. Of the two nineteenth century botanists, Lees is meticulous and scientific, whilst Hailstone is willing occasionally to express delight in flowers. The following examples illustrate some of these points more fully.

MOUNTAIN (or ALPINE) SCURVY GRASS (or SCURVY CRESS), Cochlearia officianalis, subspecies alpina

In the oldest record to be quoted here, Gerard's Herbal of 1597 says that this plant occurs: "Upon a great hill... called Ingleborough". Parkinson also cites Ingleborough Hill, as was "assured me by a worthy gentlewoman, Mrs. Thomazin Tunstall". John Ray knew what these earlier authors said, and in his book Catalogus Angliae (1670), wrote that the plant grows near rills "upon Penyghent and Ingleborough Hills".

Two centuries later, Arnold Lees quoted this and said that there can be no mistaking the species, as there are so few cresses growing on the summit of Pen-y-Ghent (The Flora of West Yorkshire, 1888, p. 143).

Mountain Scurvy Grass is not actually a grass but is related to the cresses and mustard, and is a rich source of vitamin C: hence its effectiveness when used in herbal medicine as a remedy or preventative for scurvy.

JACOB'S LADDER, Polemonium caeruleum

In 1670, Martin Lister wrote to John Ray describing how he had found this plant at Malham, and following his directions, Ray found it during his next visit to Yorkshire, commenting on how both he and Lister had enjoyed its abundance. Jacob's Ladder, he said, "grows about Malham Cove, a place so remarkable that it is esteemed one of the wonders of Craven, in a wood on the left hand of the water as you go to the Cove from Malham plentifully and also at Cordill [Gordale?] or the Whern, a remarkable cave where comes out a great stream of water" (from Ray's Catalogus Angliae, 2nd edn., 1677, p. 299, quoted by C.E. Raven in his biography of Ray, 1950, p. 154).

Another place where the two men saw the plant was close to the confluence of Carlton Beck and the River Aire. This may refer to Calton Gill Syke at Airton.

Writing 150 years later, Samuel Hailstone says of the flower:

"Found by Dr. Lister in Carlton Beck, in the falling of it into the River Aire; but more plentifully both with a blue flower and a white one about Malham Cove".

Arnold Lees, in The Flora of West Yorkshire (1888), says that this plant was first formally recorded at Malham in 1666. He then notes that Ray only mentioned the Carlton Beck location in the 1670 edition of his book, but in the 1677 edition added the information about Malham Cove which Lister had checked out.

BIRD'S-EYE PRIMROSE, Primula farinosa

John Ray, writing in 1670, originally in Latin, described how this flower was found: "in the mountain meadows in the West Riding of Yorkshire".

Samuel Hailstone, in 1817, is more expansive:

"The British flora cannot boast many more beautiful productions than this elegant Primula, which adorns the hills and wet pastures most abundantly in the... neighbourhood of Malham", and which covers "whole meadows with a fine pinky colour about Conistone".

Arnold Lees, in 1888, is careful to note an early record of the flower in 1650 before quoting Ray's 1670 description, and is then strictly scientific.

This is an exceptionally lovely flower, unique to the limestone areas of northern England: "its southernmost native sites lie on the Lancashire-Yorkshire border south of Skipton". Individually, the blooms are tiny and delicate, but growing together, they give meadows the fine pinky colour noted by Hailstone. Bird's-eye primrose is still common above Conistone, on the upland footpath from Grassington to Kettlewell, near Kettlewell itself, and around Malham Tarn (John Richards, Primulas, Shire Natural History, 1989, p. 7; C.A. Sinker, Proceedings of Leeds Philosophical and Literary Society, scientific section, vol. 8, 1960, p. 148.)

DAME'S VIOLET or DAME'S ROCKET, Hesperis matronalis

The first recorded instance of this plant, which some botanists regard as "alien", was in Ray's Catalogus Angliae of 1670, which Arnold Lees (1888) quoted as follows: "this plant was found and communicated to me by my often-remembered ingenious Friend Mr. Martin Lister, in the beck that parts Yorkshire from Lancashire, as you go from Westby in Craven to Pendle Hill". (This location is just to the south of Gisburn.)

LESSER TWAYBLADE, Listera cordata

When the twayblade orchid was seen by Ray "a mile from Keighley", he called it Bifolium minimum, which is a straight translation of its English name. But Linnaeus re-named it Listera to commemorate Martin Lister.

Arnold Lees repeats most of this information, and suggests that the other Twayblade orchid, Listera ovata was not adequately distinguished until 1789; he quotes another Bradford scientist, L.C. Miall, on its occurrence at Malham. (The Flora of West Yorkshire, 1888, p. 431, quoting Miall from The Naturalist, 1864).

LIVERWORT, Riccardia pinguis

This flowerless plant from among the mosses and liverworts is common in wet places, and is named after Richard Richardson of North Bierley (see p. 9); for its presence in calcareous marsh and fen at Malham Tarn, see C.A. Sinker, Proceedings of Leeds Philosophical and Literary Society, scientific section, vol. 8, 1960, pp. 139, 173

TEACHING MATHS

Deficiencies in the teaching of mathematics seem to have been experienced as a source of frustration by many people with an interest in science from before 1600. At the beginning of this period, Euclid's geometry was seen as fundamental, and friends of the Clifford family of Skipton, working in southern England, had promoted English translations of Euclid (John Dee through a preface in 1570, and Richard Cavendish by making his own translation). Northerners who made more direct contributions to improved maths teaching included:

Sir Henry Savile (1549-1621), from Bradley Hall near Halifax, who founded chairs (professorships) of astronomy and geometry at Oxford 1619. He himself gave an inaugural course of 13 lectures on Euclid.

Henry Briggs (1561-1631), from a farmhouse at Luddenden, also near Halifax, taught maths at Gresham College, London, before becoming the first Savilian Professor of Geometry at Oxford, taking over the Euclid course where Sir Henry left off. Briggs is best known for his work on logarithms.

Jonas Moore (1627-1679) of Burnely had his own difficulties in gaining an education in mathematics, but received some help from a gentry family near home, the Shuttleworths. During the 1640s and 1650s, he earned a living as a private maths