LEGACY OF THE LOCUST—DUDLEY AND ITS FAMOUS TRILOBITE *CALYMENE BLUMENBACHII*

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ABSTRACT—The trilobite *Calymene blumenbachii* from the Silurian at Dudley, England, had a fundamental role in the early study of this prominent group of extinct arthropods. Discovered during the mid-1700s, this was the first trilobite known from numerous complete and well-preserved fossils anywhere in the world. Commonly known as the Dudley Fossil or Dudley Locust, exceptional specimens of this trilobite became widely distributed in collections throughout Europe. As a result, they were central to the most influential trilobite papers of the time including those of Walch (1771) and Brongniart (1822). Many basic characteristics of the group, including their ability to enroll, were first established through the study of these fossils. In turn, this information provided the key evidence used to establish the arthropod affinities of this group. During the late eighteenth century, all trilobites were commonly referred to as Dudley Fossils, and demonstrate the initial importance and prominence of this species. It became the standard of comparison in trilobite research, as well as the textbook example for these fossils. No other trilobite contributed as much to the early understanding of these ancient animals.

The scientific prominence of *Calymene blumenbachii* derived from geologic and economic factors. The limestones at Dudley contained an exceptionally rich biota of well-preserved Silurian fossils, of which this trilobite was the most notable. These specimens, however, only became available to the scientific community through industrial-scale quarrying and mining at Dudley, and the collecting efforts of miners, fossil dealers and amateur naturalists. As the importance and value of these fossils became known, local individuals assembled large collections of exceptional specimens, which were then studied by some of the most prominent scientists of the day. As a result of this research and commercial trade, Dudley achieved worldwide recognition as the best source for exceptional trilobite fossils and for Silurian fossils in general. The Dudley Locust, as it was called by the local miners became a cultural icon in the community, a role that has continued for 250 years.

INTRODUCTION

A vast number of extinct plants and animals have been discovered in the fossil record. Although they all contribute to our understanding of evolution and the history of life, a few taxa have had a disproportionately greater role than others. Because of their uniqueness, excellent preservation, or scientific importance, the discovery of notable fossils provided an opportunity to make important advances in paleontologic knowledge.

The trilobite *Calymene blumenbachii*, popularly known as the Dudley Fossil or Dudley Locust, is one of these notable fossils. Found in the Silurian rocks of Dudley, England, its rise to prominence was not a random event, but resulted from a combination of factors including the need for certain natural resources at the beginning of the Industrial Revolution, the development of scientific knowledge to meet these needs, and the concomitant changes in society. The key role of the Dudley area in these events was described by Chandler and Hannah (1949), "Man has built up an industrial civilization largely on the coal, limestone, fireclay and iron found in Dudley and the Black Country. The geological structure of this area made the Industrial Revolution possible and perhaps also made the British Empire possible." They also observed, "Dudley's history is rooted in the limestone on which it stands." It was the mining of this limestone, linked with the social and economic changes of the Industrial Revolution that resulted in the discovery, fame and importance of this trilobite.

Fossils of *Calymene blumenbachii* were first found at a critical time in the study of trilobites and the establishment of paleontology as a science. Prior to the eighteenth century, little was known about fossils, as superstition, folklore, and speculation were most commonly used to explain many aspects of the natural world. This situation would start to change significantly during the 1700s when the beginnings of the Industrial Revolution necessitated a more comprehensive and accurate understanding of the Earth. Geologic and paleontologic information became critical in locating many of the natural resources required by the expanding industrialized population. As the new economic and societal conditions provided practical reasons to study fossils, they also created new social groups with the interest, leisure time, and money to undertake natural history studies, either for professional reasons or as personal intellectual pursuits. The

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Industrial Revolution also created new opportunities to collect fossils as the rapidly expanding number of quarries, mines, and construction projects provided many new sites where fossils could be collected. At the same time, it added a multitude of potential collectors in the guise of workers employed in these activities. It was under these conditions that the scientific study of trilobites began.

Trilobite fossils had been known for thousands of years (see Peng, St. John, Kihm and St. John, this volume); however, until the end of the seventeenth century, these early discoveries did not result in any important contributions to paleontological knowledge. Edward Lhwyd (1699a, b) was the first person to illustrate and discuss trilobite fossils, although he didn't recognize their arthropod affinities, and even labeled one a fish (Burmeister, 1843, 1846; Vogdes, 1890; Owens, 1998). He referred to a specimen of *Ogygia* as an "ichthyomorphous stone," which "swims spread out on its side," similar to a "sole fish" (Vogdes, 1890). Moreover, he did not believe fossils were truly the remains of animals and plants (Gunther, 1945; St. John, 2006). During the early 1700s, a number of other individuals published illustrations and descriptions of trilobite fossils, while speculating on their origins (see Burmeister, 1843, 1846; St. John, 2006, for reviews). Adhering to earlier ideas such as Lhwyd's, some of these authors continued to support an inorganic origin for fossils during this period. However, many others began to recognize that trilobites and other fossils were the remains of ancient plants or animals.

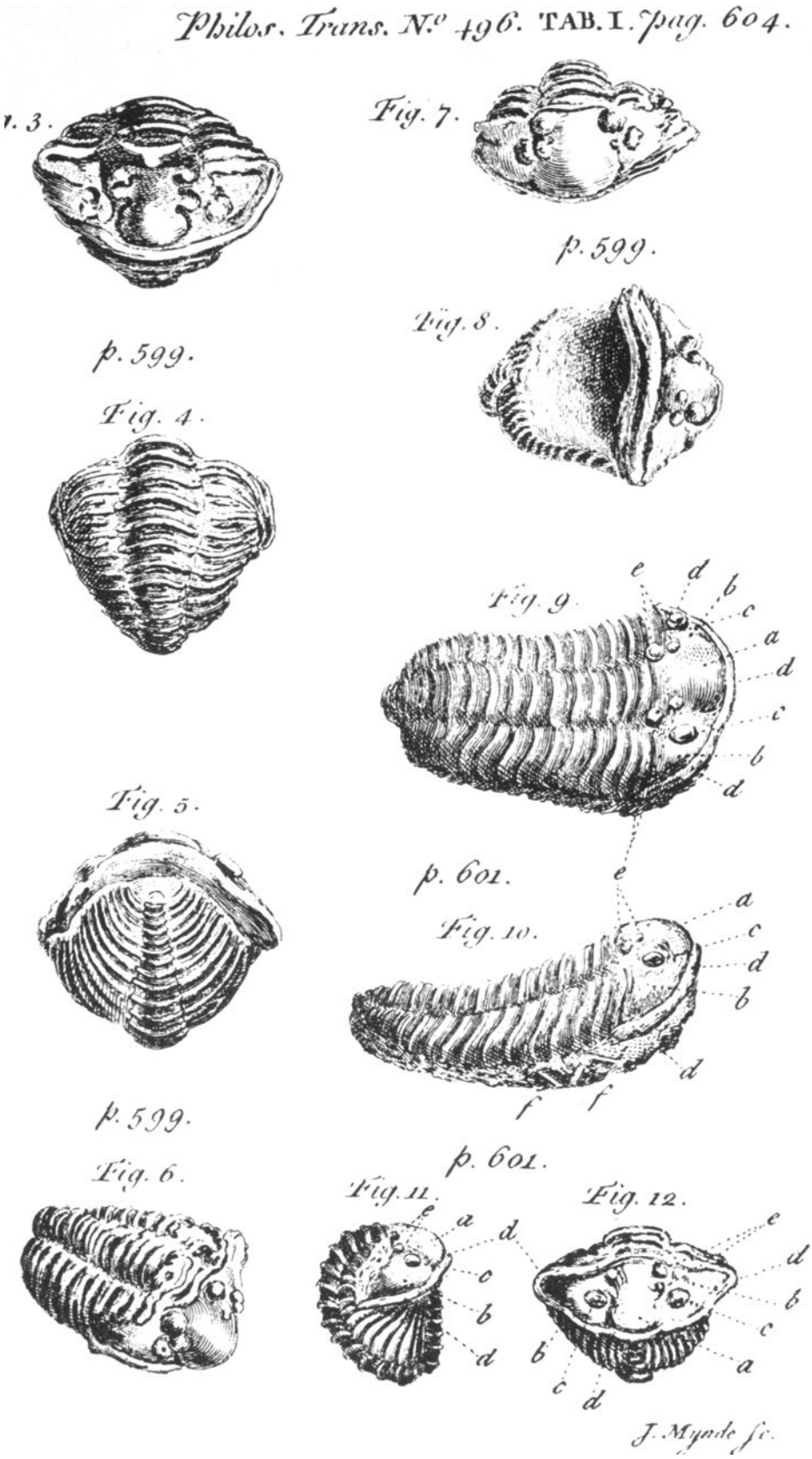
Interestingly, there was little consensus as to the type of animal that trilobite fossils represented, as they were more problematic to interpret than those of many other animals. Representing an extinct life form, trilobites were not as readily compared to living organisms, as were other taxonomic groups with such familiar extant relatives as snails or clams. Perhaps even more important in prolonging the quandary about their affinities was the special nature of the trilobite fossil record itself. Trilobite fossils are preserved primarily as isolated skeletal elements because they, like other arthropods, molted their exoskeleton periodically in order to grow. In turn, these molts, along with the carcasses of dead individuals, disarticulated easily and were scattered across the sea floor before fossilization. As fossils, many of these individual parts no longer conveyed the appearance of the entire animal or their arthropod affinities, but, instead, could be confused with other living creatures. For example, some trilobite pygidia were identified historically as "mollusks" (probably meaning brachiopods in many cases) because they bear some resemblance to the shells of these bivalved animals. Even finding articulated trilobite fossils did not establish their arthropod relationships conclusively. Prior to the late 1800s, none had been found with preserved appendages, which are of prime importance in recognizing and classifying most arthropods, and their general absence in trilobite fossils was one of the main reasons for the initial confusion about the affinities of this group (see Yochelson, this volume).

Following its eighteenth-century discovery and first scientific descriptions, the unique Dudley Fossil rapidly became a primary focus for research on this strange group of extinct marine animals. *Calymene blumenbachii* was the first trilobite known from numerous complete and well-preserved fossil specimens. Other trilobite taxa were known, but even complete specimens of these rare fossils usually were poorly preserved and lacked detail. In contrast, the relatively common and robust specimens of the Dudley Fossil provided the first good information on many of the basic characteristics of the group, while their unrivalled quality and ready availability attracted the attention of scientists and collectors alike. Moreover, they not only represented an unusual type of fossil, but they also were among the oldest known at the time. The scientific prominence of *Calymene blumenbachii* lasted for nearly one hundred years, from the 1750s through the 1840s. This period embraced not only the development of modern paleontology and trilobite studies, but also the establishment of a stratigraphic framework for Early Paleozoic rocks. The role of Dudley and its fossil in these developments was critical to early geologic studies, and involved the efforts of some of the most prominent scientists of the day.

THE DUDLEY FOSSIL: A NAME FOR ALL TRILOBITES

The discovery and description of trilobite fossils from Dudley, England, in the eighteenth century mark the true beginnings of trilobite research. These events would play a central role in determining the arthropod affinities of this extinct group, establishing the general features of their exoskeleton, and helping to define the nature of early marine life. Prior to the mid-1700s, trilobite fossils were usually mentioned only in broad geological works that covered fossils in general. The short initial papers on the Dudley Fossil were the first devoted entirely to this specific group. The earliest of these publications appeared in 1752 in the *Philosophical Transactions of the Royal Society of London* (republished in abridged versions, Lyttleton, 1756, 1809). In 1750, Charles Lyttelton submitted a letter to the Society concerning a "petrified In[s]ect" he had found in 1749 in the "Lime[s]tone Pits at Dudley" (Figs. 1, 2). [Note, the expression "[s]" here and below replaces the letter "f," which was used for the letter "s" at the time.] He hoped that in submitting his letter other members of the society could help to determine "what Cla[ss] of the Animal Kingdom" his specimens represented. Lyttelton stated that these fossils had not been mentioned by any of "our own Writers," but that he had seen similar but imperfectly described fossils by some "foreign Lithographi[s] ts."

Fig. 1. (right) Earliest known illustrations of the Dudley Fossil (Table I, Lyttelton, 1752; Mortimer, 1752). Specimens show "extended" and "rolled" forms. Mortimer described these as follows: "At Fig. 9 is one of these In[s]ects completely extended at its whole Length; wherein it appears, that the Head is cover'd with a Shell or Crust con[s]i[s]ting of three Parts; the middle part is broad and round, a. which I [s]hall therefore call the No[s]e: The two [s]ide Pieces are of a triangular Form b.b. in each of which is [s]ituate a large protuberant Eye, c.c. The anterior Part of the Whole is encompa[ss]ed by a round Border, d.d.d. which looks like an upper Lip; tho' I do not take it to be [s]o; but that the Mouth is [s]ituate lower down, as in the Crab-kind, and does not appear in any of the Specimens I have yet [s]een. On each Side the Crown of the Head, towards the back Part of it, are two [s]mall Knobs, e.e. At f.f. in Fig. 10 appear [s]ome Traces of Feet, which [s]eem to lie under the Belly: But, as the Belly, of under Side, was not di[s]tinct, not being cleared from its [s]tony and earthy Matter, I could not di[s]cern any other Legs."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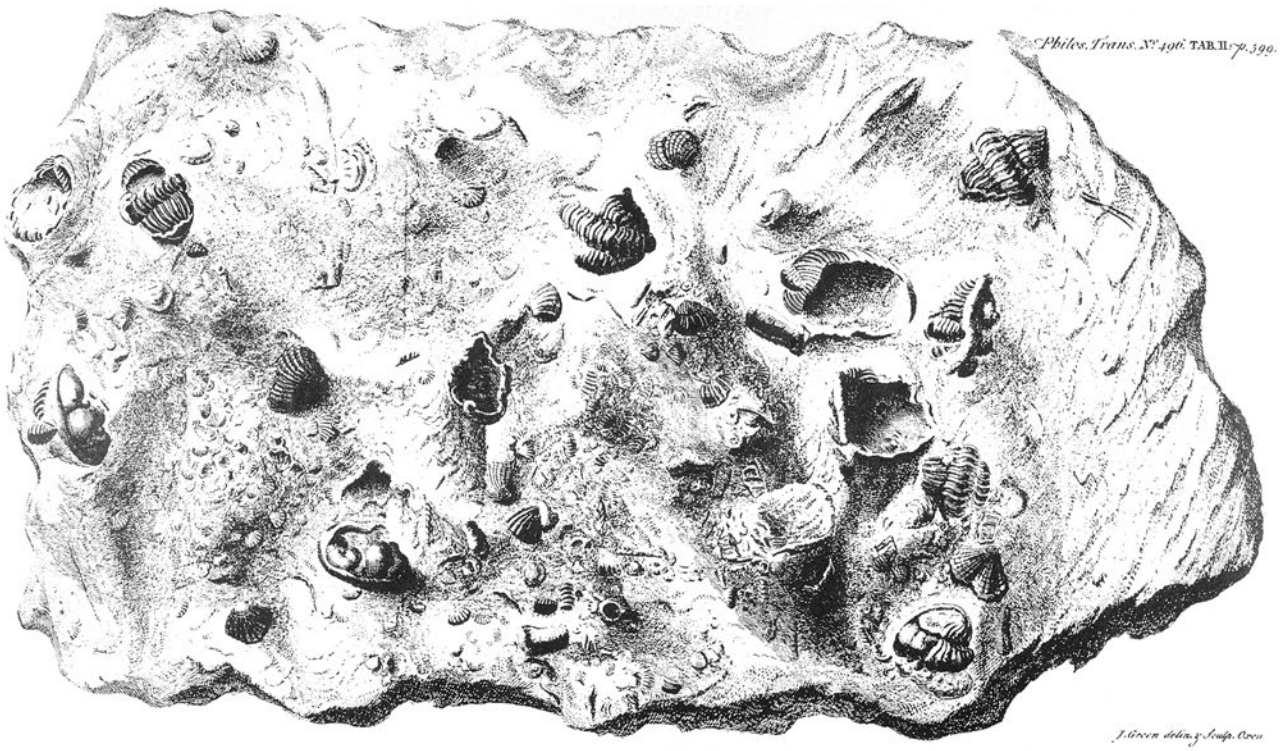


Fig. 2. Table II from Lyttelton (1752) and Mortimer (1752), which they described as "Repre[s]ents a large Ma[s]s of Lime-[s]tone dug up at Dudley, in which are embodied many of thefe Fo[ss]ils, together with [s]everal other petrified Shells."

In a footnote to this paper, the editor of the *Transactions*, Cromwell Mortimer, speculated that one of the unnamed individuals Lyttelton referred to might be a Dr. Bruckmann who had identified similar fossils collected by Mr. Linck as "a [s]ort of *Polypus marinus*" in 1742. It is also possible that Lyttelton was referring to papers by Bromell who used the name "stone insects" for arthropod fossils in general (see St. John, this volume). In an addendum to his paper, Lyttelton discussed the importance of an "extended" specimen of the "Dudley Fo[ss]il" that had been sent to him recently by Dr. Shaw of Oxford. This new specimen contrasted with those he had previously collected, which were all enrolled. He noted that there had been disagreement about their identification among the "Fo[ss]ili[s]ts," with some thinking these fossils were of a bivalve (a name then used for both clams and brachiopods), while others thought they were an "Eruca" (a name then used for arthropods with a caterpillar-like morphology). In view of this controversy, Lyttelton previously "thought it be[s]t to leave the Reader to judge for him[s]elf from the Engravings" as to which group these fossils belonged. After having seen this outstretched specimen, however, he recognized that because the animal could both enroll and outstretch it should be called an "Eruca," which would place it with the arthropods.

The same volume of the *Transactions* contained a follow-up paper by Mortimer (1752, republished in abridged versions in 1756, 1809), in which he further discussed the characteristics and affinities of Lyttelton's fossils. Using additional Dudley specimens that had been submitted to the Royal Society by Rev. Dr. Pocock (Fig. 1), Mortimer was the first person to describe the morphology of these "In[s]ects," and elaborated on features of the head and correctly identified the eyes. Unfortunately, he mistakenly identified "feet" on one of the specimens, which would cause confusion for later authors. After checking the available literature, he suggested that these fossils were similar to the living notostracan branchiopods described by Jacob Klein in 1741 (see Burmeister, 1843, 1846; St. John, this volume), and proposed that the Dudley specimens could be referred to Klein's *Scolopendrae aquaticae facutatae affine animal petrifactum* until more information was obtained. It is important to note that both Lyttelton and Mortimer recognized the arthropod affinities of the Dudley Fossil, based largely on the animal's ability to "roll up."

Following the publication of Lyttelton's and Mortimer's papers, the Dudley Fossil assumed a prominent role in trilobite research, and stimulated interest and commentary by a number of individuals. For example, Emanuel Mendez da Costa (1754a, b, republished in abridged form, 1809) published a note in direct response to the Lyttelton and Mortimer papers; he referred to their trilobite as "the famous fo[ss]il," and indicated its growing reputation. He specifically credited the extended specimens illustrated in those papers (in comparison with those that are enrolled) as proving the Dudley Fossil belonged to "the cru[s]taceous tribe of animals." He further described an "extended" trilobite fossil from Coalbrookdale, Shropshire, which he thought confirmed their views, and proposed that both his and the Dudley specimens should be called *Pediculus marinus major trilobos* because of their resemblance to *Pediculi*

marini (living sea louse; see Burmeister, 1843, 1846; St. John, this volume) which also could enroll. This last name in various forms continued to be associated with the Dudley Fossil well into the nineteenth century.

Mendez da Costa also pointed out that Edward Lhwyd had previously figured similar fossils. Interestingly, a few years later, illustrations thought to be of the Dudley Fossil (Vogdes, 1893; Shirley, *in* Gunther, 1945) were included in the 1760 edition of Lhwyd's (1699) book titled *Lithophylacii Brittanici Ichnographia*. Some authors (e.g., Brongniart, 1822; Burmeister, 1843, 1846) mistakenly thought that these 1760 illustrations of the Dudley Fossil were included in the 1699 edition of Lhwyd's work and, as a result, erroneously extended the first scientific mention of this specific trilobite back more than fifty years.

Although the Dudley Fossil was mentioned or figured in many late eighteenth century publications on fossils and natural history, its most important contribution to trilobite research of the time is found in the classic work by the German naturalist Johann Walch (Kihm and St. John, this volume). In 1771, Walch published the first truly comprehensive investigation of this group, and combined a thorough examination of the appropriate literature with the study of a large variety of fossils available primarily from central European collections. The most noteworthy result of his research was his proposal to use the name "trilobite" for this group of fossils. He chose this name because he believed it was more appropriate to name them after their unique three-lobed character instead of their supposed analogous living relatives or the localities at which they are found, as had been common previously. Walch also made other fundamental contributions to trilobite research by convincingly establishing their arthropod affinities and accurately defining many of their basic characteristics.

Although his study included other European trilobites, the Dudley Fossil had a central role in Walch's paper, and his definition of the group was probably based more on its features than any other single trilobite taxon. Evidence of the importance Walch placed on this trilobite can be derived in part from several noteworthy comments he made in his paper. For example, he observed, "We find in particular beautiful trilobites in England, where they are named Dudley-Fossils, after a place in the County of Worcester with the name of Dudley, where they are extricated from limestone quarries, sometimes loose, and sometimes fixed in their matrices, and often in large and beautiful slabs." (translation from Kihm and St. John, this report). He also referred to Dudley as "the storehouse of trilobites," and, most importantly, he later stated, "we have given preference, above all other trilobites, to those from Dudley, in England, because of their beautiful preservation and of their expressive character." When discussing the features of specimens illustrated on his plates, he pointedly bypassed descriptions of his figures of the Dudley Fossil by stating, "I find it unnecessary to stop here, being that the parts of this insect, … are seen so distinctly that it would be superfluous to restate here what I said above." (translation from Kihm and St. John, this volume).

Walch's prominent use of specimens and the published information on the Dudley Fossil to define various basic trilobite features further attest to the importance of this species in his work. No other trilobite is specifically mentioned by Walch as often as the Dudley Fossil, nor was any represented by more illustrations. His figures of Mr. Andre's Dudley specimens (Supplemental Plate 9f) are the best of his paper, and are among the most detailed and accurate trilobite fossil illustrations of the time period (Fig. 3). Ironically, Walch made one important mistake based on the Dudley Fossil when he used Mortimer's (1752) erroneous report of "feet" to confirm his principal idea that trilobites were not bivalved animals, but were arthropods with "testaceous feet hidden like crayfish" under the shell of their back. Clearly, the Dudley Fossil was a critical component of Walch's study, which, in turn, further enhanced its prominence in later research by others.

The new name "trilobite" for this group of fossils was slow to be adopted and, even when used, was sometimes mistakenly credited to other authors. But other trilobite workers, such as the Danish biologist Morten Thrane Brünnich, readily adopted the name. In addition to being one of the first papers to use Walch's name, Brünnich's (1781) work also has the distinction of being one of the oldest to have defined a still-valid trilobite species, *Trilobus caudatus* (now *Dalmanites caudatus*). Whereas Walch refrained from naming any species in his paper, Brünnich described several under his single genus *Trilobus*. His work included a description, but no illustrations, of the Dudley Fossil, which he named *Trilobus tuberculatus*, the first trilobite named in his paper. Although this work included the earliest species name proposed for the Dudley Fossil, it was little used and, for a variety of reasons, has been suppressed officially (Whittington, 1983; Siveter, 1985; Whittington and Siveter, 1986). The distinction of being the first trilobite species designated in his work is symbolic of its importance in early trilobite studies. The Dudley Fossil would hold the position as the first-discussed species in the succeeding studies of many other authors well into the nineteenth century. Although not stated, it is probable that the reason the Dudley Fossil was placed first in these papers was because of its fame and importance as the best-known and best-preserved trilobite fossil of the time.

In addition to more formal research papers through the late eighteenth and early nineteenth centuries, the Dudley Fossil was mentioned or illustrated in numerous general natural history books and other types of publications. In many of these works, it is the only trilobite figured or discussed, and served as the representative for the entire group. A typical example is found in the works of the famous German naturalist Johann Friedrich Blumenbach. In the 1780 edition of his *Handbuch der Naturgeschichte*, Blumenbach included a brief section on petrifactions of insects (arthropods) listing the "Dudley fo[ss]il[s]" as one of the trilobites. In the 1797 edition of this work, he further discussed the classification of these fossils, and stated that, while trilobites are found at a number of places, they are nowhere more beautiful than at Dudley, where they are preserved with their crab-like shells. Blumenbach (1800) also discussed trilobites under the name *Entomolithus paradoxus* [a name proposed by Linneaus (1753) for trilobites in general; see St. John, this volume] in Part 5 of his *Abbildungen Naturhistorischer Gegenstande*. The Dudley Fossil was the primary example of trilobites used in this discussion, and he illustrated two specimens of this species from his collection (Fig. 4), and noted that the best-preserved trilobites were from Dudley. These figures also were reproduced in a 1803 French translation of his *Handbuch* in an interesting combination of both of Blumenbach's earlier works.

Although Blumenbach's work is not, in itself, unusually

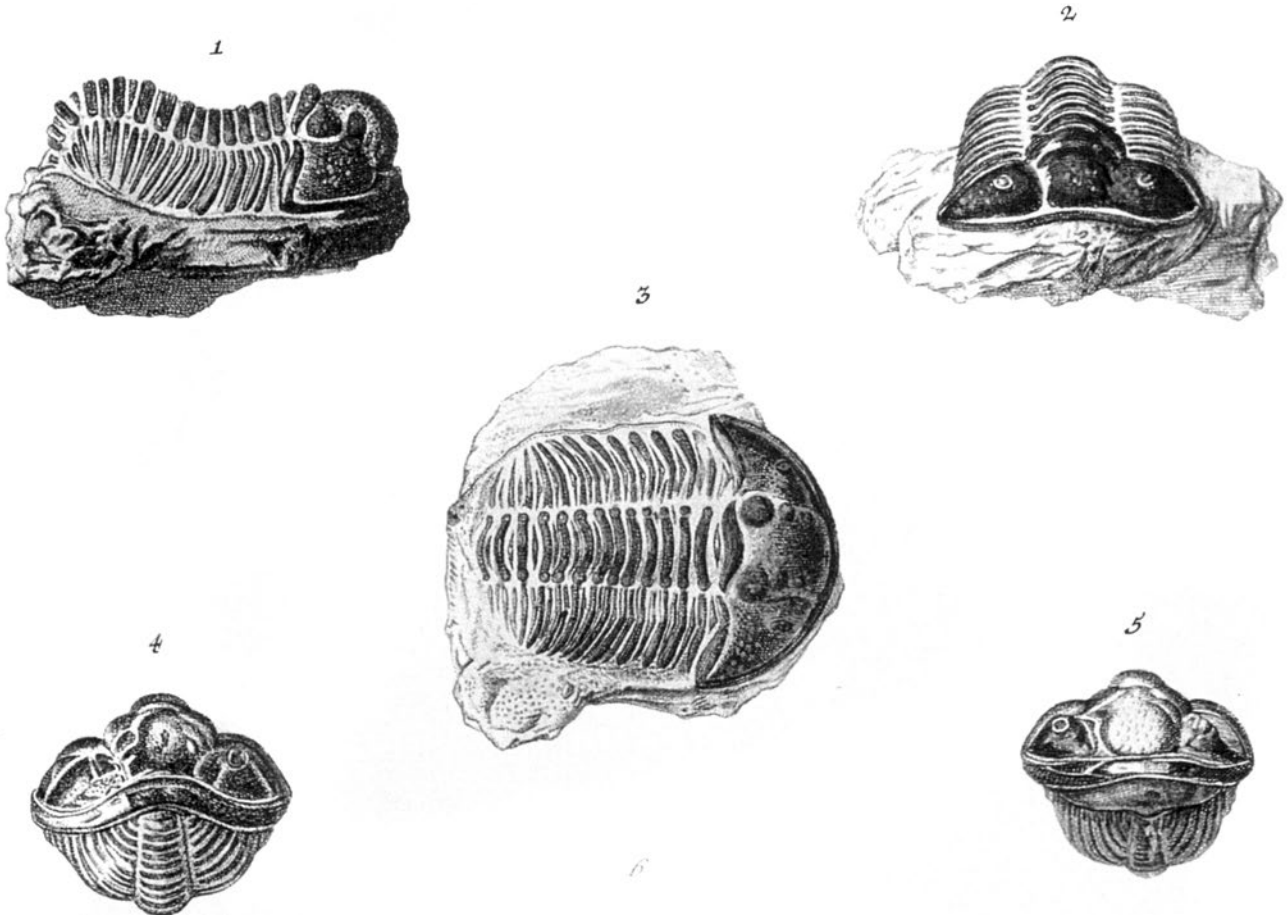


Fig. 3. Supplemental Plate IXf, figs. 1–5, of Walch (1771), with trilobites (*Calymene blumenbachii*) from Dudley in the André collection, Hannover.

important in early trilobite studies, it is noteworthy that his 1800 publication probably inspired the French scientist Alexandre Brongniart to formally name the Dudley Fossil *Calymene blumenbachii* in his honor (see Brongniart, 1822; Desmarest, 1816, 1817). This is the scientific name used today for this trilobite (see Whittington, 1983; Siveter 1985, 1996; and Whittington and Siveter, 1986, for discussions on the history of naming this species). Brongniart's paper, like that of Walch's, is considered to be one of the most important early trilobite studies. Whereas the main accomplishment of Walch's work was to establish the arthropod affinities of trilobites, Brongniart's paper marked the beginning of modern trilobite classification. He was the first author to define still-valid genera to which he assigned a number of new or previously defined species. Burmeister (1846) considered this work to be the "most perfect" and influential on trilobite workers of the time, whereas Vogdes (1893) stated that Brongniart is considered to be "the first systematic writer upon the Trilobites."

Brongniart (1822) became interested in trilobites while gathering information for a lecture on "Transition Terrain" fossils in 1812, and the Dudley Fossil apparently was critical in initiating his research on the systematics of the group, and lead to his classic 1822 paper. Recognizing that the use of Linnaeus's name *Entomolithus paradoxus* for all trilobites had created confusion, Brongniart specifically mentioned that the name had even been given to the Dudley Fossil, and indicated his perception of the uniqueness of this taxon. Ironically, it appears that Blumenbach's questionable use of the name *Entomolithus paradoxus* for the Dudley Fossil in 1800 might have initiated Brongniart's interest in the group, and resulted in his naming the fossil *Calymene blumenbachii*.

The naming and systematic description of the Dudley Fossil had a prominent role in Brongniart's paper. As Brünnich (1781), Brongniart placed the descriptions and figures of his genus *Calymene* along with its type species *blumenbachii* at the beginning of his systematic section (Fig. 5); this made *Calymene* the first and oldest genus of modern trilobite systematics. He commented that the first genus, which he named *Calymene*, included the trilobite that has been described under the name "Dudley Fossil." Although wrongly stating that it had been found over a century before (probably because of the inclusion of figures of this trilobite in the 1760 edition of Lhwyd's 1699 book), he correctly indicated the importance of these unique, common, and well-preserved fossils in determining the distinct nature of these animals.

Dudley's role in Brongniart's research was not limited to the trilobite *Calymene blumenbachii*. He also named a second species

found at Dudley, *Calymene variolaris* (known today as *Encrinurus variolaris)*, and described and illustrated Dudley specimens of *Asaphus caudatus (Dalmanites caudatus*) and an unnamed trilobite (now known as *Hemiarges bucklandi*).

Calymene blumenbachii also played an important part in the classic 1843 trilobite study by the German zoologist Herman Burmeister [see Burmeister (1846) for an English translation by T. Bell and E. Forbes]. Expanding on the work of Brongniart and others, Burmeister published a comprehensive examination of trilobites that was highlighted by a more detailed comparison between trilobites and living arthropods, as well as a proposed high-level classification of the group. He believed that previous work on these fossils had shortcomings because of the limited zoological background of most of the authors, and that his expertise in this field might allow him to resolve some of the questions raised by others. One of his new families, the Calymenidae, which represented, in part, "trilobites having the power of rolling themselves into a ball…" was, undoubtedly, inspired and based to a large degree on *Calymene blumenbachii* specimens. [This family is now credited to Milne Edwards (1840), who proposed a similar family name for a group with many of the same trilobite taxa; see Whittington (1983.)] Even though the number of trilobite taxa and specimens available to Burmeister had grown considerably since Brongniart's work, *Calymene blumenbachii* apparently was still one of the most important because of the excellent preservation and wide availability of its fossils. Burmeister specifically noted the rarity of trilobite specimens with their "real shell" preserved and that fossils of the "Dudley Trilobites" were among the few taxa in which he could "observe the external layer with its granulations in a well-preserved state." He believed this was an important feature of the group.

The historical importance of this species is acknowledged in Burmeister's (1843, 1846) discussions of previous studies of trilobites in which he mentioned the Dudley Fossil "as the Trilobites were usually called in England, from the principal locality where they were found." He also acknowledged the key role that the Dudley Fossil played in establishing the arthropod affinities of trilobites, and stated, "Their anomalous form induced a number of collectors to search for them in England, where the most beautiful and perfect specimens have always been found, and their admirable condition in that country readily caused the impression that they must be Articulata to gain ground."

In summary, the publications of Lyttelton, Mortimer, Walch, Brünnich, Brongniart, and Burmeister are among the most influential pre-1850 works on trilobites. Collectively, they demonstrate a significant progression in understanding the group based on a combination of insights, new discoveries, and cumulative knowledge. In each paper, the Dudley Fossil, *Calymene blumenbachii*, played a critical role. It was clearly the single most important trilobite taxon used in research on the group during this initial period of investigation (1750–1850) and was discussed in numerous publications. The American paleontologist James Hall (1852) stated, "Perhaps no other single species has been so generally cited in works upon this subject as the *Calymene blumenbachii*."

Following the mid-1800s, *Calymene blumenbachii* began to lose its central role in trilobite research, although it remained important as one of the first and best-known members of the group. The main reason for this decline probably was the growing discovery and description of new trilobites, some of which were based on equally well-preserved specimens (including other taxa found at Dudley). In addition, the focus of trilobite research was also changing from the original discussions on the relationships and basic characteristics of the group to more focused descriptive works on other taxa and on geographic localities and stratigraphic intervals where *Calymene blumenbachii* did not occur. As a result, scientific interest in this species shifted to more specialized research, such as its role in the composition and biostratigraphy of specific Silurian trilobite faunas. For example, the Dudley Fossil had been recognized as a characteristic fossil of

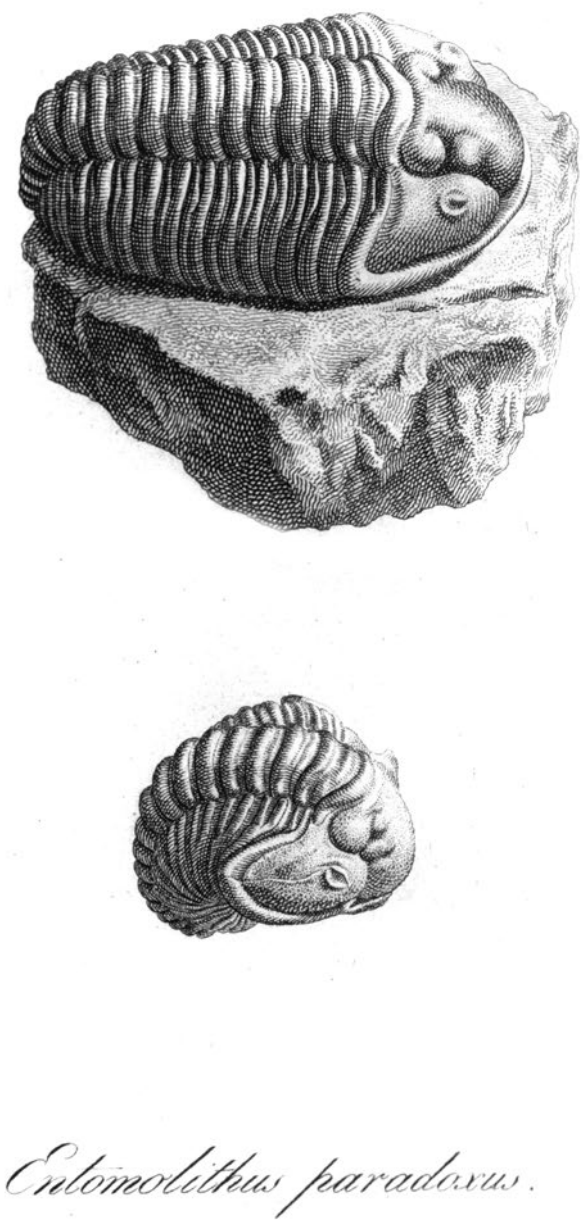


Fig. 4. Illustrations of the "Dudley-fossil" (*Entomolithus paradoxus*) reproduced from Alexandre Brongniart's personal copy of the 1803 French edition of Blumenbach's work (University of Illinois at Urbana-Champaign Library).

Fig. 5. Brongniart's (1822) Plate I, fig. 1A, B, C and D, illustrating specimens of *Calymene blumenbachii* from Dudley.

the Transition Series, then thought to represent the oldest fossiliferous rocks on Earth. With revisions of this portion of the stratigraphic column, it remained an index fossil of the more refined Silurian System (Upper Silurian), which was named by Murchison in the 1830s. The apparent abundance and widespread distribution of this species made it one of the best trilobites for this type of research. Its special importance was indicated by Salter (1859), who called it "an universal Silurian fossil."

Although losing some of its prominence in trilobite research of the mid-1800s, the Dudley Fossil had become even better known to a broader audience through its appearance in a wider variety of publications. Encyclopedias, popular works on natural history or science, and more specialized books on geology and paleontology were published with increasing frequency throughout the early nineteenth century. Many of these publications (e.g., Buckland, 1836; Mantell, 1844), especially those written for other naturalists, included discussions and illustrations of trilobites, which usually portrayed *Calymene blumenbachii* from Dudley as a primary representative. For example, Mantell (1844) included several trilobites in his discussion of the group, but highlighted *Calymene blumenbachii* with his introductory comments, "Among the numerous petrifactions which are found in the limestones in the neighborhood of Dudley, in Staffordshire, there are certain fossil bodies which, from their extraordinary form and appearance, have for more than a hundred and fifty years been objects of great interest to the naturalist, and of wonder to the general observer, and have long been provincially termed Dudley insects, or locust." This use was not confined to Great Britain, but was common throughout Europe (e.g., Vogt, 1854, 1878; Lardner, 1860; Figuier, 1864; Credner, 1883; Blanchard, 1890; Haas, 1902) and North America (e.g., Dana, 1864, 1875, 1880; LeConte, 1899). During the nineteenth century, the Dudley Fossil truly served as the "textbook" example for all trilobites. Most publications that discussed these arthropods figured outstretched and enrolled specimens of *Calymene blumenbachii*, as they were then the best-known examples that illustrated this important feature of the group. Most of these illustrations were reproduced from a limited number of older works, of which Brongniart (1822) and Burmeister (1843) were most frequently used (Fig. 6). Few publications, including books written by British authors, included figures of the Dudley Fossil from the older British works, with the exception of the poor illustrations of Parkinson (1811, 1833). Even more surprising, Walch's and Blumenbach's illustrations do not seem to have been used by anyone despite their high quality.

The number of publications that discussed and illustrated *Calymene blumenbachii* did not begin to change appreciably until the 1870s, when the first trilobite fossils were discovered with preserved appendages. At that time, illustrations of these new specimens, represented by taxa such as *Triarthrus eatoni*, began to replace *Calymene blumenbachii* as the "standard" trilobite in popular literature and textbooks. Because of its compelling popular name and historical importance, however, the Dudley Fossil remained one of the most widely cited trilobites.

THE NAMING OF A FOSSIL: A TRILOBITE BY ANY OTHER NAME

The scientific importance of *Calymene blumenbachii* is, to a large part, the result of its featured role in early trilobite research. Its long lasting notoriety, however, is due primarily to the popular and scientific names with which it has long been associated. With the exception of a few vertebrates, such as dinosaurs, rarely have other ancient organisms been identified with such a variety of widely recognized popular names as has this trilobite, and few for as long. Dating back to the 1750s, some of these names reflect the manner in which paleontology developed as a science as well as the role of *Calymene blumenbachii* in early trilobite research. Others seem to have originated with the public because of the trilobite's importance to the miners, collectors, and other inhabitants of the Dudley area. While some of them overlap in time, these names can be divided into several basic categories that relate to their origin and application. These categories include "scientific" names used in the initial studies of these fossils, formal scientific designations derived from "modern" systematic

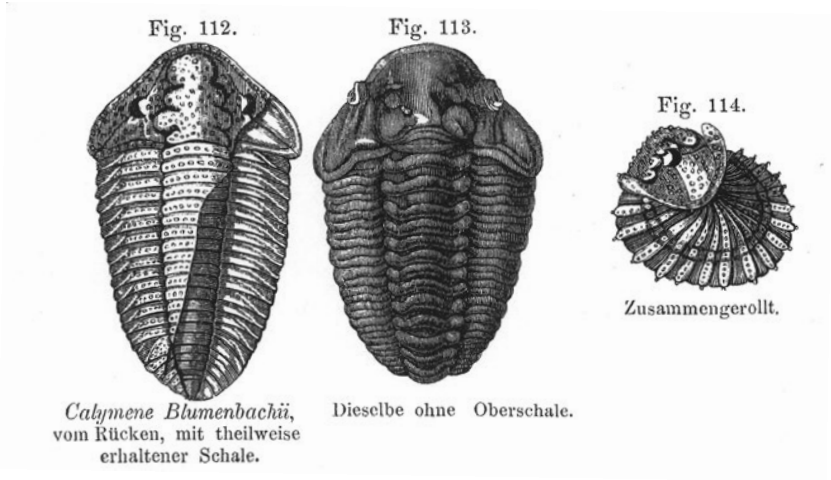


Fig. 6. Illustrations of *Calymene blumenbachii* published by Burmeister (1843, figs. 112 and 114) and Brongniart (1822, fig. 113), reproduced in Vogt (1854).

studies, and "popular" nicknames by which this trilobite has long been known. An examination of these categories demonstrates the difficulties of studying extinct organisms without close living relatives, as well as the significance of *Calymene blumenbachii* fossils to scientists and the public.

In the mid-eighteenth century, when fossils of this trilobite were first described, paleontology and biology did not really exist as scientific disciplines. Even many modern organisms were unfamiliar to the naturalists of the time, and there was no accurate classification system that could be used to establish the relationships between most living plants and animals. It is no surprise, then, that the fossils of strange forms such as trilobites were problematic to the few individuals who contemplated them, with even their organic origins having been questioned. The best approach was to find similar-appearing extant organisms that could provide clues to the nature of these fossils and identify them by the then-"scientific" terms applied to them.

As a result, during the late eighteenth century, the trilobite now known as *Calymene blumenbachii* was labeled with a variety of names. These included *Scolopendre aquatic scutate affine animal petrifaction, Pediculus marinus major trilobos, Monoculus, Onifcus, Anthropomorphite,* and *Entomolithus paradoxus monocul* (all with variations) based on a perceived resemblance to specific living or fossil arthropods. The origins of most of these names predate the beginnings of Linnaean binomial nomenclature, and, for a number of reasons, are not valid in modern systematics. They are, however, of historical interest for their role in the early study of trilobites. Initially used in scientific papers that focused only on trilobites, these names later appeared in early papers on the geology of the Dudley area (e.g., Keir, 1798; Thomson, 1816; Smith, 1836a, b; 1838). They also appeared in contemporary regional natural history volumes, tourist guides, local histories, and business directories (Nash, 1781; Payton (1794; Shaw, 1801; Booker, 1825; Bentley, 1841; Harris, 1845). The use of these old terms ended quickly in scientific circles after the publication of Brongniart's (1822) paper, which provided an accepted scientific name. In the popular press, however, these old terms, sometimes in combination with valid or invalid scientific terms along with popular local designations, remained in use until well after 1850.

Following the adoption of Linnaean binomial classification in the late eighteenth and early nineteenth centuries, *Calymene blumenbachii*, along with a few now-invalid names such as *Trilobus tuberculatus, Calymene ceratophthalama, and Calymene lata,* represented the "modern" scientific rubric for this trilobite (see Siveter, 1985). The derivation of *Calymene blumenbachii* has been discussed above. It should be noted, however, that, although that name is used for all specimens of the Dudley Fossil discussed in this paper, taxonomic studies such as those by Siveter (1985, 1996) have demonstrated that several other related trilobites (*Calymene aspera, C. fuliginata, Diacalymene allportina*) now also are known from the Silurian of Dudley. Many of the original specimens depicted in historical descriptions and illustrations of trilobite fossils from Dudley have been lost through time, therefore, it is difficult to confirm with absolute certainty that *Calymene blumenbachii* was the species those fossils represented. As these other species are generally rare compared with *Calymene blumenbachii* in museum collections, it is likely that most of this lost historical material was of the latter species.

Following the description of this species by Brongniart (1822), trilobites identified as *Calymene blumenbachii* were described or reported from many localities worldwide. Brongniart believed that fossils from distant localities in North America and Europe were of the same species. Other authors such as Burmeister (1846) stated that *C. blumenbachii* "has a very wide range, and is found in Europe, in South Africa, and North America." It now is known that many similar calymenid trilobites of different genera and species are common in Ordovician and Silurian rocks worldwide, whereas *C. blumenbachii* is restricted to the Silurian of the British Isles.

The popular names for *Calymene blumenbachii,* for which it has long been famous, are historically the most interesting. Since the eighteenth century, this trilobite has been known as the Dudley Fossil, Dudley Locust, Dudley Insect, Dudley Trilobite, or Dudley Bug. Having a widely recognized nickname for over 250 years is a feat that can be claimed by few other fossils. [The amazing record of over two thousand years goes to rocks with

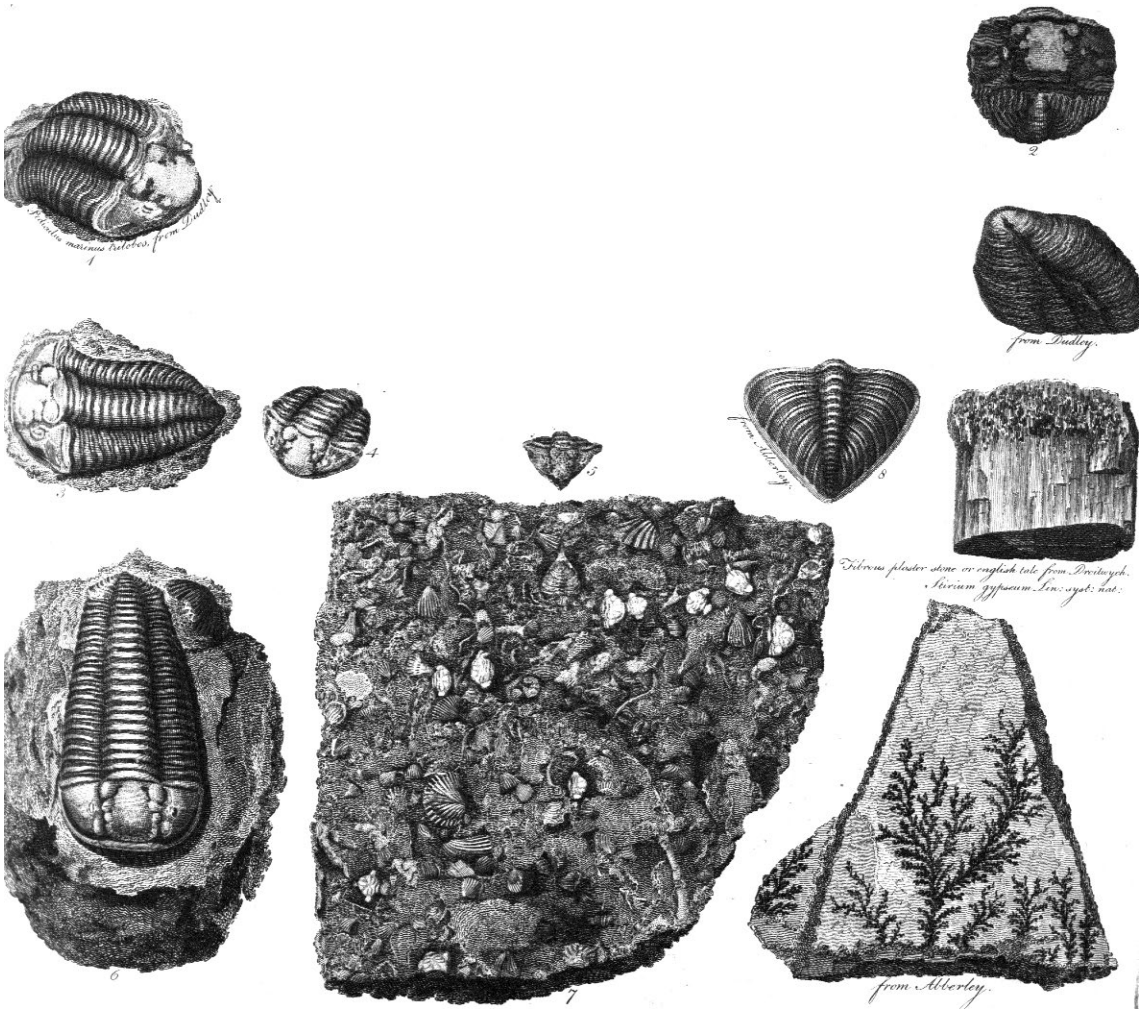


Fig. 7. Illustrations from Nash's (1781) natural history plate, with several specimens of *pediculus marinus trilobos* from Dudley (figs. 1–6) and a slab from Dudley (fig. 7), showing a variety of fossils including numerous trilobite "heads" (cephala), which may be *Acaste*.

the Chinese trilobite fossils called "batstones"; see articles by St. John and Peng, this volume.] The origin of these nicknames is unrecorded, but it is possible to establish a general history of their use by examining the extensive literature on this trilobite. These publications show clearly that the popular names fall into two categories based primarily on who used them: those used by early scientists or naturalists, usually from outside the region (i.e., Dudley Fossil, and to a lesser extent Dudley Trilobite and Dudley Insect) and those used locally by the miners (i.e., Dudley Locust and, more recently, Dudley Bug).

The first of these, Dudley Fossil, may be traced to the scientific papers of Lyttelton (1752) and Mortimer (1752). Dudley Fossil, as used by these authors, probably was not intended as a formal term, but merely reflected the locality at which these fossils were found. If it had been a locally derived name or another was then in use by Dudley residents, it wasn't noted in their reports. As the fame of these exceptional fossils spread, they generally became well known as Dudley Fossils by scientists and popular authors alike, to the exclusion of all other fossils found at Dudley. Because it was the best-preserved and most common trilobite of the time, many authors also used Dudley Fossil as a name for trilobites throughout Europe or for all trilobites from Dudley, even after Brongniart (1822) proposed the scientific name *Calymene blumenbachii*.

This usage was not limited to England, as illustrated by its prominent use in Walch (1771) and its listing as a separate subject by Defrance (1819) in the *Dictionnaire des Sciences Naturelles*. Used in a historical context or as a reference to popular usage, "Dudley Fossil" appears in many scientific and educational works into the mid-1800s (e.g., Jukes, 1829a; Sowerby, *in* Jukes, 1829a; Parkinson, 1833; Bakewell, 1833; Comstock, 1836; Murchison, 1839). Rarer variations of the name, such as "Dudley insect," (Mantell, 1844) or "Dudley trilobite" (Lyell, 1852; Owen, 1860), were also used but, eventually, all of them disappeared from scientific publications in favor of *Calymene blumenbachii*.

The most famous popular term for *Calymene blumenbachii* is "Dudley Locust." Still appearing in current publications, the continuing use of this compelling name is the primary reason for this trilobite's long-lived public renown. In contrast to the

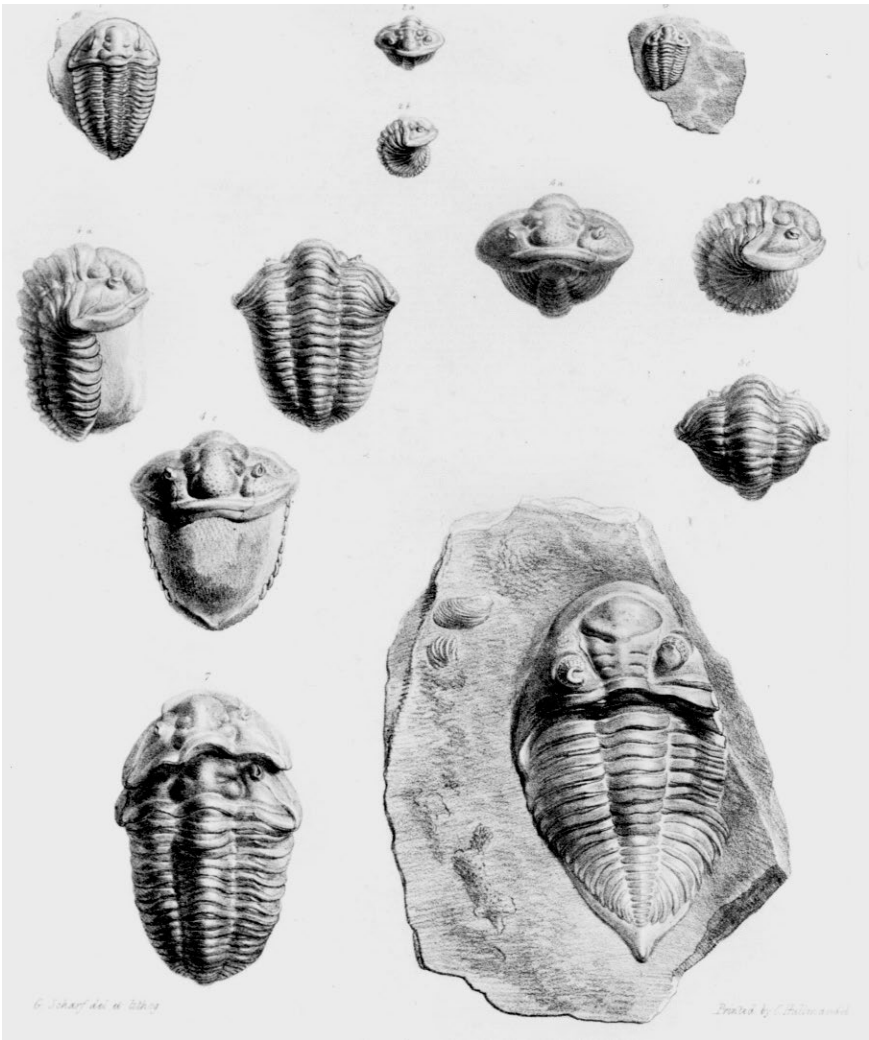


Fig. 8. Plate I from Payton (1827) showing Dudley specimens of *Calymene blumenbachii* (figs. 1–5, 7) and "*Asaphe caudatus*" (fig. 6) from his collection.

origin of "Dudley Fossil," "Dudley Locust" was not derived from the scientific work of the time, nor was it used as a name for trilobites by these investigators. Instead, it seems to have begun as a local term used by the miners and general population of Dudley. Because of this origin, the exact date when its use began and the reasons why it was chosen do not seem to be recorded.

"Dudley Locust" first appeared in print in 1781. In Brünnich's classic paper, he observed that Dudley limestone miners called these fossils [locusts] or [grasshoppers] because they thought the trilobites resembled these insects. Treadway Nash (1781) also used "Dudley Locust" in a tome titled *Collections for the History of Worcestershire*. Although generally ignored in trilobite research, this volume included several interesting observations on trilobite fossils from Dudley, and is comparable in content to some well-known contemporary works on the group. Nash began his trilobite discussion with "In lime-[s]tone quarries near this town is frequently found a kind of fo[ss]il called by the workmen the Dudley fo[ss]il or Dudley locu[s]t." He included in his discussion a brief review of the different ideas and names used in previous trilobite studies, listing some of the "[s]ynomyns of the Dudley fo[ss]il" [he apparently was unaware of Walsh's (1771) paper]. He also provided exceptionally high-quality illustrations of a number of fossils found in Worcestershire, most of which appear to be specimens of *Calymene blumenbachii* (Fig. 7). Nash recognized that there were several different trilobite species found at Dudley, and did not exclude trilobite parts from his contribution to trilobite terminology.

The next popular reference to this trilobite was supplied by Joseph Payton (1794), a businessman, author, and one-time mayor of Dudley, as well as a prominent collector of and dealer in local fossils. In 1794, Payton published a guide to Dudley Castle, in which he described a variety of interesting features of the area, including the fossils. Specifically, he observed, "In the Lime-[s]tone Quarries near this place, is found that rare fo[ss]il called by the workman, the Dudley Locu[s]t." In part, his comments may have been paraphrased from Nash, but he does include information on the other types of fossils found at Dudley absent from Nash's work. A few years later, Keir (1798)

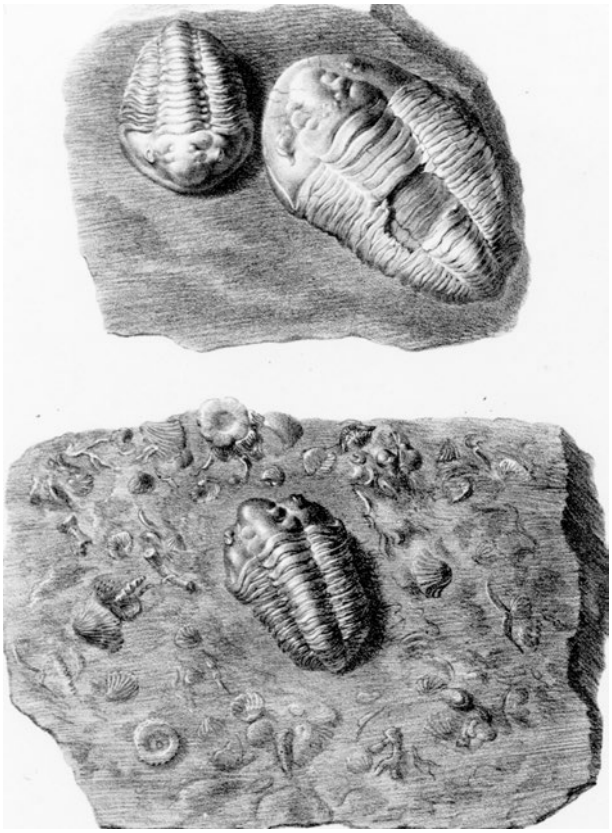


Fig. 9. Plate II from Payton (1827), showing fossiliferous slabs with specimens of *Calymene blumenbachii* from Dudley.

stated, "Among the[s]e [s]hells there is nothing [s]ingular, but one very rare fo[ss]il repre[s]entation of an animal, called by the workmen a locu[s]t, by others, the Dudley fo[ss]il, and by tho[s]e naturali[s]ts who de[s]ignate by peculiar names tho[s]e petrified [s]hells, although the [s]ame [s]pecies are not known to exi[s]t now, at lea[s]t in our climate, *Pediculus marinus trilobos* and *Anthropomorphites*." Nash (1781) stated, "[s]ome authors call it *anthropomorphites,* becau[s]e the head bears [s]ome [s]mall re[s]emblance to a man's face." Warner (1802) stated, "the rarest productions of this sort is the *pediculus marinus*, or sea-louse, the *entimolithus paradoxus monoculi deperditi* of Linnaeus, but called, in the homely naturalist's vocabulary of the place where it is found, the Dudley locust." In 1827, Payton published a short article on Dudley trilobites (Figs. 8, 9), and stated that these fossils are called "Locusts" by the miners, "a local name, of which it would be difficult to trace the origin, as no living animal at all resembling it has been yet discovered in any part of the world." Dugdale (1854?) reported that the workmen called the fossil the "Dudley locust," and added, "What is called the locust stone is the most rare and curious."

Collectively, these comments present some intriguing possibilities about the origination and use of the name "Dudley Locust." Using the earliest information from Brünnich (1781) and Nash (1781), it appears that the "workmen" were calling these fossils "locust" or "Dudley Locust" at that time (Nash also claimed they used Dudley Fossil; he is the only author to do so). Later reports, including those by such members of the local community as Payton (1794), suggest the miners used only "Dudley Locust." Other authors, such as Keir (1798), Payton (1827), Pye (1825), and Dugdale (1854?), indicate that just "locust" or even "locust stone" might have been the moniker preferred by miners.

Payton's (1827) comments should be considered the most accurate in this regard as he had long been the premier Dudley collector, and, presumably, was most familiar with the local name for this fossil. In addition, James Keir (from nearby West Bromwhich Tipton), clearly stated that the workmen called it "a locu[s]t" while the naturalist used "Dudley fossil." In any event, the likelihood that miners or other Dudley area residents coined the name "Dudley Locust" has interesting implications. Did the miners see an arthropod in their fossils before any scientists ever laid eyes on them? Was the name in use before 1781, or even before the time of Lyttelton's visit in 1749? Was it inspired by Lyttelton's use of "petrified insect" or by later scientific discussions of the arthropod affinities of trilobites? Hopefully, information might still be uncovered to answer these questions, but it is clear that the name "Locust" or "Dudley Locust" was not coined by scientists but by members of the Dudley community.

The popular appeal of the name Dudley Locust has ensured its continuous use for well over 200 years, not only by locals, but also by the world of science and the general public. As one of the few fossils with an intriguing popular name, it still is used

regularly in a wide variety of publications. Many academic works that mention *Calymene blumenbachii* also note the common name "Dudley Locust," as do publications for the general public. Although "Dudley Locust" may be more widely recognized now than ever before, in recent decades, a new name, Dudley Bug, has become increasingly popular.

ENROLLMENT, EYES AND DIVERSITY: THE SCIENTIFIC CONTRIBUTIONS OF DUDLEY TRILOBITES

Dudley trilobites were involved in a number of important contributions to the early study of this group. *Calymene blumenbachii* played a central role in establishing the basic morphological characteristics of trilobites, their ability to enroll, and their relationships to other arthropods. Over time other Dudley taxa became important in documenting additional features of the group. Noteworthy trilobite features, such as their highly developed compound eyes, were first defined by the use of Dudley species. The increasing number of new species reported from the area also provided insights into trilobite diversity. This was an important discovery in itself, as most other localities known at the time yielded only a few trilobite taxa.

Enrollment was the first and most important trilobite characteristic derived from the study of the Dudley specimens. As discussed above, the recognition that trilobites such as *Calymene blumenbachii* could enroll was a key factor in establishing the relationship between trilobites and arthropods. Because of their greater resistance to destruction, enrolled specimens of the Dudley Fossil probably were easier to collect than outstretched specimens. Therefore, it is no surprise that some of the first illustrated specimens were enrolled. Lyttelton (in the addendum to his 1752 paper) reported that he had obtained an "extended" specimen of the Dudley Fossil in addition to the enrolled specimens he collected initially. Possessing enrolled and outstretched specimens, he decided that this fossil undoubtedly represented an arthropod because of the similar construction and function of its thorax to that of modern arthropods. Arthropod enrollment is a well known feature of the group, even to many people situated far from the sea, because of the ubiquitous terrestrial isopods referred to as woodlice, pill bugs, or sow bugs. This similarity was noted by Warner (1802), "In form it resembles that common wood-louse, except that it is trilobated, and exceeds in considerable size, some specimens being nearly five inches long, and few so small as the recent insect is." Many other authors, such as Miller (1847) and LeConte (1899) commented on this conspicuous trait, and the Dudley Fossil became the main example of enrollment in trilobite research and popular discussions during the 1800s. One of the most frequently used trilobite illustrations since the nineteenth century is the combination of outstretched and enrolled specimens of *C. blumenbachii* (see Dixon, 1993; Molyneux, 1999).

Spectacular compound eyes were also discovered through the study of trilobites from Dudley. In this case, *Calymene blumenbachii* had no role. Instead, *Asaphus caudatus* (*Dalmanites caudatus*) was the important species. Although its conspicuous eyes were noted by earlier authors, William Buckland (1836) provided the first insightful and extensive commentary on their character and significance. A man of many remarkable discoveries in geology, he was very impressed with these fossils, and remarked that finding trilobite eyes "in so perfect a state of preservation, after having been buried for incalculable ages … is one of the most marvellous [sic] facts yet disclosed by geological researches." In determining the structure of trilobite eyes to be the most important point of resemblance to living crustaceans, he presented detailed comparisons of these features to show that these groups were related. Equally interesting was his observation that the similarity of the eyes of these groups indicated that modern crustaceans and ancient trilobites lived under similar conditions of light, atmosphere, and water clarity. Buckland's figure of the eye and head of a specimen of *Dalmanites caudatus* from Dudley joined those of the Dudley Fossil as repeated illustrations in numerous nineteenth-century publications. More recently, Clarkson (1966a, b; 1969) and Thomas and Lane (1984) used Dudley specimens to investigate how the character of trilobite eyes was related to their behavior.

Although the Dudley Fossil was the first and most famous trilobite taxon found at Dudley, additional taxa were discovered at the locality by the early 1800s, and further enhanced the site's importance and reputation. Parkinson (1811, 1833) figured a specimen of the Dudley Fossil along with two other trilobites (a dalmanitid and an encrinurine), which probably were found at Dudley. In addition to naming *Calymene blumenbachii*, Brongniart (1822) described three other Dudley taxa, one of which he designated as the new species *Calymene variolaris* (*Encrinurus variolaris*). Some later authors seemed to be unaware of the additional species reported in these earlier works. At least some of this confusion resulted from the rarity of articulated specimens of taxa other than *C. blumenbachii* at Dudley, and that isolated trilobite parts generally were ignored. Payton (1827) commented on this rarity, and illustrated only a single complete specimen of another trilobite, *Asaphe caudatus* (now *Dalmanites caudatus*). He remarked that, whereas parts of the former trilobite were common, complete specimens were extremely rare. He seemed unaware of some of the new taxa described in Brongniart (1822). In his paper on the famous specimen of *Bumastus barriensis* from nearby Hay Head, Jukes (1829a) stated that two trilobites were known from Dudley, "the one which is commonly called the Dudley fossil…and another…which, I believe, has not yet been particularly noticed, arising, probably, either from their scarcity, or from the imperfect condition in which they are usually found, the head and tail being generally apart." Sowerby (*in* Jukes, 1829a) identified these two trilobites as *Calymene blumenbachii* and *Asaphus caudatus,* but also believed, incorrectly, that "these are all that were known at or near Dudley."

Afterward, the number of trilobites known from this locality grew significantly, probably as the result of increased mining, collecting, and study. For example, Murchison (1839) listed thirteen different trilobite taxa from Dudley, a number that he had almost doubled to 22 in his 1859 book *Siluria* (Fig. 10). During the remainder of the nineteenth century the diversity of Dudley trilobites increased notably through a series of papers by Salter (1849, 1853, 1864a, b, 1865, 1867, 1883), Fletcher (1850a, b) and Lake (1896). Continuing work on the trilobites of Dudley further enhanced the area's reputation as one of the world's premier nineteenth-century trilobite localities. Many of the taxa described in these publications were based on articulated specimens not found elsewhere, and provided some of the best available examples of many prominent trilobite groups.

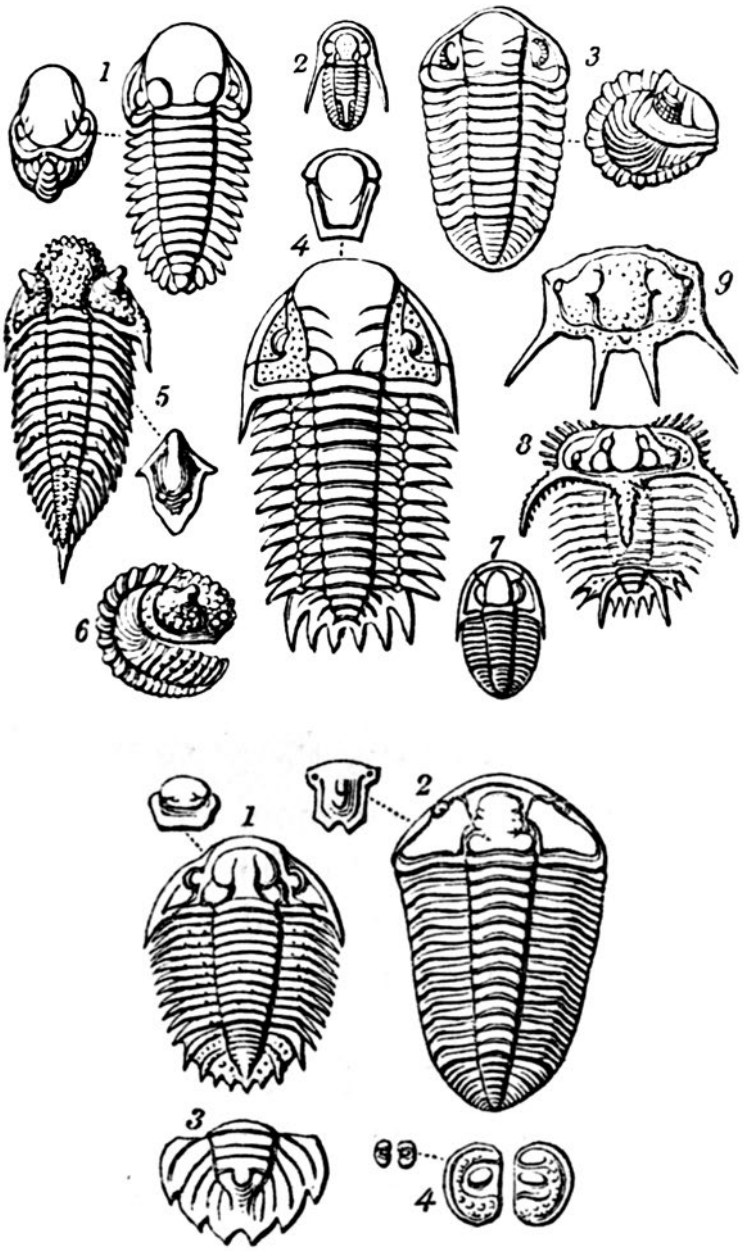


Fig. 10. Illustrations from Murchison (1859, 1872) of Wenlock trilobites, most of which are found at Dudley.

Consequently, numerous generalized publications on geology and paleontology continued to illustrate Dudley specimens as representatives of all trilobites. For example, Lyell (1866) figured a specimen of *Sphaerexochus* from Dudley on the title page of the sixth edition of his classic work *Elements of Geology*, to represent the life of the Primary [i.e., Paleozoic] Era.

After Salter's work on British trilobites was curtailed by his untimely death in the 1860s (Secord, 1985), research on trilobites from Dudley diminished, although they retained their prominence in more general and popular works. In recent decades, however, there has been an increased research interest in these fossils. Most importantly, Thomas (1978, 1981) began a study of all British Wenlock trilobites, including those from Dudley. Thomas (1979) reported at least 37 trilobite genera from the Silurian Much Wenlock Limestone Formation at Dudley, with some represented by more than one species. Some of these taxa have never been described, whereas others have not been restudied since their initial descriptions in the nineteenth century. Surprisingly, the entire Dudley trilobite biota has not yet been described fully despite its fame and over 250 years of research.

WORTH MORE THAN ITS WEIGHT IN SILVER: THE RISE OF THE TRILOBITE

A unique combination of geological and socio-economic conditions fostered the prominence of the Dudley Fossil in early trilobite research. Geologically, the Silurian rocks at Dudley contain an exceptionally diverse biota with an unusual abundance of well-preserved fossils. However, these fossils only became available for scientific research because extensive mining had developed to supply limestone for the local iron furnaces at the beginning of the Industrial Revolution. This mining provided an opportunity for discovery and collection of fossils by the miners who, along with private and commercial collectors, supplied sought-after specimens for the expanding community of professional scientists, amateur naturalists, educational institutions, and museums. During the eighteenth and early nineteenth centuries, few, if any, other sites witnessed an industry-dependent fossil collecting on as large a scale as that at Dudley. Because of this unique combination of factors, Dudley was the trilobite center of the world for almost 100 years.

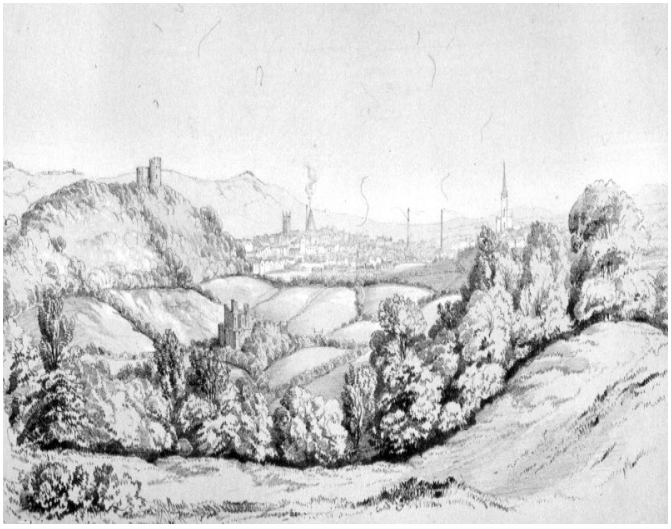


Fig. 11. Sketch of the town of Dudley and Dudley Castle Hill as seen from Wren's Nest, from Murchison (1839), as drawn by his wife.

The Geology

The characteristics of the Silurian rocks of Dudley are well known, and are described in a long series of papers (Keir, 1798; Thomson, 1816; F. Jukes, 1829a; Smith 1836a, b, 1838; Murchison, 1838, 1839; J. B. Jukes, 1859, 1866; Myers, 1866; Lapworth, 1898; Moore, 1898; Butler, 1939; Strachan, 1967; Hamblin *et al*., 1978; Oliver, 1981; Cutler *et al*., 1990; Thomas and Radcliffe, 1988; Siveter, 2000; Ray, 2001). Dudley is located in the South Staffordshire Coalfield, which lies north and northwest of Birmingham, England.

Throughout much of this area, Silurian rocks are buried by a thick sequence of Late Carboniferous coal-bearing strata. At the north edge of Dudley, however, the Silurian has been folded upward and projects through the Carboniferous in three prominent anticlinal inliers (Dudley Castle Hill, Wren's Nest Hill, and Hurst Hill) (Fig. 11). These hills consist primarily of limestone and shale strata of the Much Wenlock Limestone (Wenlock), which is underlain by shales of the Coalbrookdale Formation (Wenlock) and overlain by shales of the Elton Formation (Ludlow) (Fig. 12). The Much Wenlock Limestone here consists of a lower 16.2 m-thick Lower Quarried Limestone Member and the 8.6 m-thick Upper Quarried Limestone Member, which are separated by the 31 m-thick Nodular Member (Ray, 2001).

These rocks, especially the limestones, have long had an economic importance. Chandler and Hannah (1949) observed that the limestone was used originally for building the local castle and priory in the twelfth century, later to make lime for general building purposes, and, finally, "the easily worked limestone was exhausted through its use as flux in the blast furnaces engaged in the iron industry." Outcrops of these strata probably were extensive on all three hills originally, but are now very limited in extent, having been considerably altered and reduced by hundreds of years of mining and quarrying.

Although the limestones of the hills north of Dudley were quarried for the lime at least as early as the late seventeenth century (Plot, 1686), little information was published on their geology until the nineteenth century. Undoubtedly, miners and mining engineers understood the basic geology of the area because limestone, ironstone, and coal mining had become major local industries. During this time, an enhanced geologic knowledge of the region would have been needed in mining. Other than references to the Dudley Fossil, however, few geological observations were published about these rocks over this long period.

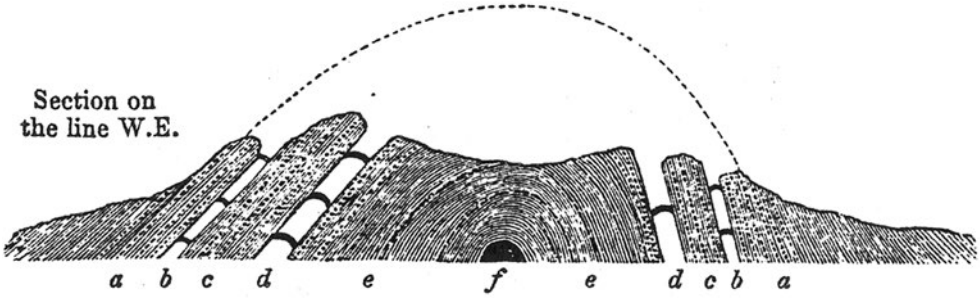


Fig. 12. Cross-section through Wren's Nest, showing the stratigraphy of Silurian rocks applied by Murchison (1839) figure: a) Elton Formation, b) Upper Quarried Limestone Member of the Much Wenlock Limestone Formation, c) Nodular Member of the Much Wenlock Limestone Formation, d) Lower Quarried Limestone Member of the Much Wenlock Limestone Formation, e and f) Coalbrookdale Formation.

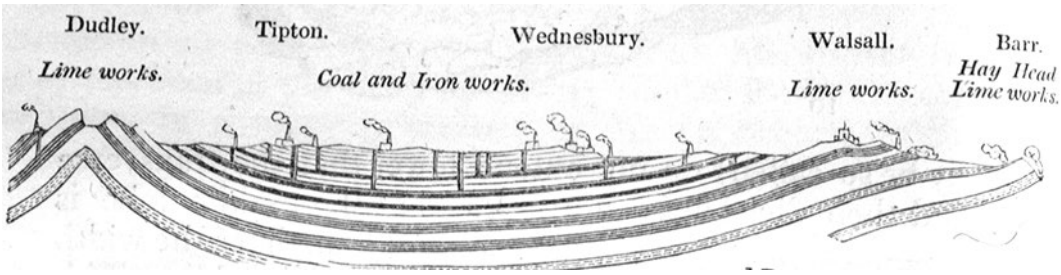


Fig. 13. Eleven-mile-long cross-section showing the presumed relationship of the Silurian limestone beds at Walsall and Barr with those at Dudley (from Jukes, 1829a).

Keir (1798) and Thomson (1816) provided the first detailed descriptions on the Silurian limestones in the Dudley area. These works have general observations about the composition, distribution, and structure of the limestone strata, and Thomson recognized that the limestone was "formed in the sea" because of its fossil content. Other geological accounts of these rocks appeared through the early 1800s, many of which were written by such local authors as Booker (1825) and Bentley (1841), in tourist guides, business directories, and other publications outside of the scientific literature. Because of their growing economic importance and scientific prominence, the Dudley limestones became the focus of increased study by a wider range of naturalists and geologists, including some of the most prominent of their day. These studies documented the local geology and paleontology, afforded early comparisons with rocks from distant localities, and helped establish a framework for understanding Lower Paleozoic rocks. The limestone beds of Dudley were recognized as part of the "Transitional Series," which in the early 1800s, was a group of poorly understood sedimentary rocks under the younger Old Red Sandstone and over a group of older, unfossiliferous, "primary" metamorphic and volcanic rocks (Thackray, 1978; Bassett, 1991). As one of the most prolific sources of what were then thought to be the oldest fossiliferous strata, the Dudley limestones provided an opportunity to study the paleontology of this ancient time.

By the 1830s, a detailed understanding of at least part of the Transitional Series of the Dudley area had been realized, as indicated in papers such as those by Jukes (1829a, b), Smith (1836a, b; 1838), and Murchison (1838). The first of these (Jukes, 1829a), although primarily a description of a new trilobite, provided a simple but accurate cross-section of the "Lime formations" from Dudley to Hay Head, a distance of about eleven miles (Fig. 13). Although he worked with discontinuous exposures in a geologically complex area, Jukes based his cross-section on observations of the distribution and dip of several limestone units, which he distinguished by their fossil content. Jukes's work is remarkably accurate, especially when viewed in comparison to the more recent cross-section by Cole (1987) based on a wealth of information including mine records and modern subsurface data. Except for identifying numerous faults in the area, Cole's cross-section is little different from Jukes's 150 years earlier. Jukes's work also inspired commentary by Sowerby (*in* F. Jukes, 1829a) who emphasized the importance of the observation that specific trilobite species "are peculiar to different beds," and could be used to identify beds or strata of the Transitional rocks "at immense distances." Murchison (1834, 1835, 1838, 1839) employed this kind of biostratigraphic approach, including the use of trilobites, to establish and subdivide his Silurian System from rocks of the old Transitional Series.

Murchison used this understanding of Dudley geology to establish his Silurian System, and made the first detailed comparisons of the rocks in this area with similar strata elsewhere. Prior to the 1830s, the fame of its fossils and industry ensured that the Dudley Limestone was a widely recognized part of the Transitional Series. However, when Murchison investigated this part of what would become his Silurian System, he used outcrops of the same strata in the vicinity of Wenlock Edge in nearby Shropshire to formally name this unit the Wenlock Limestone (now Much Wenlock Limestone Formation). Even though they were much better known, Murchison believed the limestone beds at Dudley did not show a complete enough stratigraphic section. Murchinson (1839) observed, "For these reasons therefore it is obvious, that however long known to collectors for the beauty of its organic remains, the name of Dudley limestone could not be used in stratigraphical classification, and hence I was compelled to adopt the term of Wenlock." In particular, he had found that the exposures at Wenlock Edge better demonstrated relationships with adjacent units. This new name was later the basis of the Wenlock Series, which is now recognized internationally as the term for this middle part of the Silurian—an honor lost by Dudley with the demise of the term "Dudley Limestone." However, Murchison's decision was probably correct. It should be remembered that the fame of the Dudley Locust was a primary reason that the Dudley Limestone almost became the foundation of this Silurian series.

The Fossils

The Much Wenlock Limestone beds in the Dudley area have long been known as one of the best sources of well-preserved, abundant, and diverse Silurian fossils in the world. Since the 1750s, more than 600 fossil taxa have been identified from these rocks (Cutler *et al.*, 1990), and are represented by thousands of specimens in museums worldwide. The study of these fossils has resulted in many important contributions to geology and paleontology, but has also produced a few misconceptions. Among the most notable misconceptions about trilobites are that the fossils at Dudley belong to a single biota and that articulated trilobite specimens are, or were, common in these rocks.

The idea of a single biota came about during the early development of the disciplines of geology and paleontology. When fossils from Dudley were first studied, scientists had little understanding of the ecological complexity of the modern world, much less of its ancient past. Moreover, many of their specimens were obtained from dealers, collectors, and miners who did not record the details about the environmental and stratigraphic occurrence of their discoveries. More recent research by Butler (1939), Thomas and Radcliffe (1988), and Ray (2001) has shown that the preservational nature and distribution of the fossils at Dudley vary considerably through the 70 meters of Silurian rocks locally exposed there. This variation results from temporal differences in living and burial conditions, as these rocks were deposited as sediments in a variety of marine environments and over a significant period of time (Ray, 2001). Consequently, the distribution and preservation of different taxa vary, with some being found throughout the section and others occurring only in specific intervals or environments. Similarly, some taxa may be well preserved or abundant at one horizon, and rare or fragmentary in another. This is especially noteworthy with the trilobite and crinoid fossils, as their skeletal elements are common in many beds, but only a few horizons contain significant numbers of the articulated specimens for which the locality is famous. These studies also have shown that the Dudley biota does not represent a single group of organisms living together in the same place and time, but, rather, a variety of different communities that lived at different times and under different conditions. Although not representing a single biota, Dudley remains one of the most diverse, best-known, and historically important Silurian trilobite localities in the world.

Dudley has been famous as a source of complete trilobite fossils for more than 250 years. An examination of museum collections or the scientific literature would suggest that articulated trilobite fossils, especially *Calymene blumenbachii*, were common here. In reality, this was only true relative to other localities then known in this early period of trilobite studies. At Dudley, articulated specimens were readily available in the late eighteenth and nineteenth centuries because of the large-scale industrial excavations and the financially-motivated collecting activities of the miners. Not only did the quarries and mines here produce more articulated trilobite fossils than at other contemporary sites, but these specimens were also among the best preserved. At most other localities, articulated trilobite fossils were rare, commonly compressed or distorted, and had a poorly preserved test or no test at all. In contrast, the Dudley trilobite tests typically were uncompressed, three-dimensional, and well-calcified. The availability of such Dudley specimens led to their prominence in early trilobite research.

The most numerous trilobite fossils at Dudley, however, are individual, disarticulated skeletal elements, which are plentiful in many beds. Even today, long after mining has ceased, it is not difficult to find cranidia, pygidia and other parts of the more common trilobite taxa, especially *Calymene blumenbachii*. Although noted in some of the earliest papers, these parts had little or no role in early trilobite research. The brief report by Nash (1781) was one of the few exceptions. In addition to figuring several complete specimens, he also illustrated a fossiliferous Dudley slab with common cephala of what might be *Acaste* and other trilobite parts, including a dalmanitid pygidium. Even though he did not appear to have a complete specimen of the latter taxa, Nash recognized the relationship of these parts to complete trilobites, as indicated in his comment, "where likewi[s]e is found the head without the body, as in the ma[s]s here engraved, which was found at Dudley, wherein are feveral *[s]emipediculi,* or bodies without heads, and many heads without bodies." In this regard, his creative use of the term "*femipediculi*" [semipediculi] for the headless bodies or for tails is noteworthy as it appears to have been derived from the better-known name *pediculis,* which was then used for complete specimens of *C. blumenbachii*.

In contrast with Nash's observations, some individuals did not seem to make the connection between exoskeleton parts and entire trilobite specimens. For example, Parkinson (1811, 1833) figured a *Calymene* cranidium from Dudley, which he identified as "fossil remains of some crustaceous animal, which are frequently found with the trilobite in the Dudley lime-stone" on the same plate on which he figured two articulated specimens of the same taxon labeled as "Dudley fossils." It was only after the 1830s that the use of trilobite skeletal elements became more common in research, at least for the rarer Dudley taxa for which articulated specimens had not been found.

Mining for Trilobites

Dudley became an important source of Silurian trilobites and other fossils for two basic reasons. The most obvious factor, as already discussed, was the exceptional abundance, diversity, and preservation of the fossils. The mere existence of these fossils, however, did not insure that they would be collected or available for scientific research. More important to Dudley's paleontological prominence was the early development of its local limestone industry, which provided the means for fossils to be collected and distributed on a large scale. This industry created extensive collectable excavations, and employed large numbers of miners who probably were the original source of many specimens. Dudley is one of the best examples of how early paleontological research was dependent upon industrial and engineering excavations for many of its discoveries.

The mines.—Mining played a prominent role in Dudley's history and economic development. Located in the South Staffordshire Coalfield, the community is part of the Black Country, a region named for its industrial appearance and economic prominence in Britain's nineteenth-century iron industry. Mining prospered here because of the local abundance of coal, iron ore, and limestone—the basic materials for iron smelting—and a well-developed canal system that made transportation of resources and products economical (Davies and Hyde, 1970).

Carboniferous rocks are found throughout much of the Black Country and, as a result, coal and iron ore were widespread. In contrast, Silurian limestones, used primarily to make flux for iron smelting were localized in a few outcrops near Dudley and Walsall. Although poorly documented, the quarrying of these exposures began long before the advent of the iron industry. Silurian limestones were already a source of building stone during the initial construction of Dudley Castle and Priory in the twelfth century (Chandler and Hannah, 1949; Powell, 1999). Robert Plot (1686) described late seventeenth century quarrying and burning of limestone in this area to produce lime, which was used in agriculture and as mortar in construction. One hundred years later, however, the demand for lime increased dramatically as it was needed as a flux in the growing iron industry. As

quarrying exhausted surface outcrops during the eighteenth century, extensive underground mining of these rocks began, and created the impressive caverns for which Castle Hill and Wren's Nest became famous. Limestone mining and lime burning continued as major industries during much of the nineteenth century (Warwick, 1967; Powell, 1999), with as much as 300,000 tons of stone produced in 1873 (Davies and Hyde, 1970). By 1900, however, limestone mining had diminished greatly, and finally ended in 1924. Although mining at increasingly greater depths became more difficult, it was the demise of the local iron industry, the main market for limestone, that was probably the most critical factor in the cessation of mining (Davies and Hyde, 1970).

To a large degree, the commercial excavations of these limestones controlled the availability of Silurian fossils at Dudley. Undoubtedly, natural outcrops of these rocks were much smaller than the later manmade exposures, and would have consisted predominantly of highly weathered, thick-bedded limestones, which would have made collecting highly desirable fossils, such as complete trilobites, difficult. During active mining, however, the exposures and piles of rock rubble from the industrial-scale excavations increased the availability of fossils and made them much easier to collect. (Today, the weathered exposures in old quarries and mines produce very few specimens of complete trilobites and other rare fossils.) Without intensive mining activity, it would have been impossible to collect the magnitude and quality of Dudley fossils now found in museums worldwide, and the area never would have played a major role in the scientific research of trilobites and other aspects of Silurian geology and paleontology.

The collections.—It is not surprising that the number of reports on Dudley area fossils increased with the growth of the local limestone industry. Robert Plot (1686) of the Ashmolean Museum at Oxford University was the first to comment on these fossils. As part of a study on the natural history of Staffordshire, he described and illustrated a few fossils from the limestone pits at Dudley, including a specimen given to him by the owner of the pits, Edward, Lord Ward. Most of Plot's material seems to be of the easily found brachiopods, corals and crinoids that abound in these rocks.

John Woodward (1729) listed, but did not figure, a number of fossils from Dudley that he had in his collection. Neither Plot nor Woodward described any Dudley specimens that can now be recognized as trilobites, which is surprising in view of the conspicuous nature of these fossils and the abundance of their skeletal elements. Little or nothing more was published on fossils from Dudley until Lyttelton's (1752) report. Lyttelton reported that he found his first specimen from the "Lime[s]tone Pits at Dudley" in 1749. Between the time his letter was read to the Philosophical Society in 1750 and his paper was published in 1752, several individuals had sent additional specimens to him and Mortimer for examination. This indicates that other British collectors had acquired specimens from the locality before 1752. These fossils soon found their way into other parts of Europe, as indicated by Walch's (1771) classic paper with its specimens of the Dudley Fossil from German collections.

By the early 1800s, specimens of the Dudley Fossil seemed to be commonplace, but limited information is available as to who collected this material and how it was disseminated. It is likely, however, that the scientists who studied this material were typically not the ones who found it. Many, such as Murchison and Salter, clearly indicated that much of the impressive material they were using was borrowed from private collectors. For example, Salter (1859) noted, "Indeed, the quarries of Dudley are the most famous in the world for Upper Silurian organisms. Shells, corals, encrinites of very numerous genera and species, and trilobites are all in a state of perfection such as no other locality in Britain exhibits. The well known collections of Messrs. Gray and Fletcher at Dudley, and the cabinets of nearly every public museum in Britain or elsewhere, are evidences of the great labour expended in collecting and developing these beautiful remains."

One of the few documented visits by scientifically minded individuals to collect fossils at Dudley was Hugh Miller's in 1845. Although experienced in finding fossils, his efforts on that trip were not as rewarding as he had hoped. Whereas common fossil brachiopods and corals were easy to find, he wrote disappointedly, "I will be unable, I find, to add materially to my collection here" (Miller's 1845 letter *in* Bayne, 1871). Miller bought a few complete trilobites from a fossil dealer after an unsuccessful weeklong collecting effort.

Although the more common fossils were never difficult to find in Dudley's mines and quarries, collecting rare specimens was a challenge for the casual visitor. The wealth of exceptional trilobites, crinoids, and other unusual fossils from Dudley in the world's museums is, therefore, misleading. Although for a critical period in early trilobite research, specimens of the Dudley Fossil were the most common complete trilobites available to scientists, these fossils probably were never easy to find at Dudley, and their great numbers in collections are most likely the product of an intensive effort by financially-motivated individuals to find them. As described by Lapworth (1898), "Bed for bed it is probable that these Midland Silurian rocks are no more prolific in fossils than their Shropshire representatives; but the Dudley limestones have been worked for centuries as a flux for the ironstones of the surrounding South Staffordshire Coalfield, and consequently abundant—and, indeed, unrivalled—opportunities have been afforded for the discovery and collection of the fossils … For many years—especially about the middle of the present century, when the limestone workings were open to the surface—these fossils were assiduously collected personally, or were purchased from the workmen, by local geologists and others."

Although fossils from remote locations or those that are expensive and hard to recover, such as large dinosaurs, always have tended to be collected by scientists, the majority of fossils in most older museum collections were discovered and collected by quarry workers, miners, private collectors or commercial dealers. These individuals provided the vast amount of manpower needed to explore the world and collect samples of its geology and paleontology, something that never could have been accomplished by the small number of contemporary naturalists or scientists (Mikulic, 1983). Rather than the result of planned "digs" or chance discoveries during exploration, many of the fossils used in science have been the byproduct of excavations for quarries, mines or the innumerable construction projects needed by an industrialized society. Most of these collections cannot be duplicated due to the decline in extractive industries at many classic localities, to increased mechanization of these industries, and to the diminished interest shown by the

people to invest time and money in assembling comparable collections (Mikulic, 1983). Even today, this process continues, however, with some of the most scientifically valuable specimens found at such famous localities as the Liaoning fossil beds of China (Norell, 2005) and Mazon Creek in Illinois collected by labor-intensive work by non-scientists. Without the efforts of these collectors, regardless of their motivation, we would know dramatically less about paleontology, as well as botany, archeology, and a broad range of other natural history topics.

Dudley is an important example of this collecting phenomenon. With a history extending back to the seventeenth century, it is one of the earliest sites in the paleontological literature. Its long-term scientific prominence resulted from large-scale industrial excavations and the efforts of local collectors, both of which can be tied to the rise and fall of the local iron industry. The fossil-bearing limestone, needed for flux, was undoubtedly mined at an increasing rate as iron production grew. Records on yearly production of iron and limestone in this area are incomplete, but some indication of the trends in these industries can be derived through changes in the numbers of local iron furnaces. This trend shows a dramatic increase in the number of iron furnaces from the origin of the local iron industry in the 1790s, a peak in the mid-1850s, and a dramatic decline to 1900 (Gale, 1966; Davies and Hyde, 1970). Limestone production seems to have followed the same trend. The numbers of fossils found, doubtless, was related to the amount of limestone produced. The number of fossils described from Dudley and the number of collections assembled seem to follow the same trend, with a gradual increase towards the middle of the nineteenth century and a gradual decline to 1900. After 1900, limestone mining at Dudley was limited. Although little documentation exists about the identity of the leading Dudley collectors or the conditions under which they toiled, there is enough information to establish the general roles that miners, dealers, and collectors played in acquiring these fossils and supplying them to the scientific community.

The miners.— Quarry workers and miners were the mainstay of the fossil-collecting process, and constituted a chief source of specimens at many localities worldwide in the nineteenth century (e.g., Mikulic, 1983; Mikulic and Kluessendorf, 1998), and this was also probably true at Dudley. By the mid-eighteenth century when the earliest scientific studies of the Dudley Fossil were published, Silurian limestone had been quarried at Dudley for several hundred years. Surely, Dudley quarriers and miners had long been familiar with specimens of these conspicuous fossils.

Undoubtedly, these workmen found a major portion of the rarer and larger Dudley specimens because mining was labor-intensive. During their 12-hour shift, a crew of nine or ten men would produce nine tons of stone daily, much of which they handled manually (Hemingway, 2000). With the financial incentive of supplementing their meager incomes by selling fossils, they probably became diligent collectors. Between 1837 and 1850, when complete Dudley trilobites were selling for at least ten shillings, most miners were earning only three to six shillings a day (Warwick, 1967). Because of their work, miners also would have had the advantage of knowing the best strata and localities with the rare specimens. Brünnich (1781) observed that because specimens of the Dudley locust were much desired by the English collectors, the workers also learned to appreciate the ones that were found almost complete.

Unfortunately, direct evidence about the miners' fossil collecting is scarce. A possible clue to their collecting is the name Dudley Locust. Most authors make a point of attributing this name to the miners, and indicate that they were familiar with these specific trilobite fossils. John Gray, one of the most prominent early nineteenth-century private collectors in Dudley, reportedly directed workmen in his quarry to save fossils for him, and this constituted the main source of specimens for his collection (British Museum, 1904). In addition, Gray informed Woodward (1868) that miners had been collecting trilobites from Dudley for fifty years. Woodward (1868) also mentioned a specimen at the center of a controversy that was reportedly derived from a workman. In another note, Miller (1847) implied organized collecting, and recorded that a barber in Dudley "holds a sort of fossil agency between the quarrier and the public."

The large Dudley collection (now part of the Lapworth Museum of Geology at the University of Birmingham) assembled by the wealthy Birmingham ironmaster Charles Holcroft is accompanied by a registry (Strachan, 1979). This registry lists the individuals from whom he purchased specimens, although it does not record the livelihood or other details about his sources. Between 1876 and 1897, Holcroft acquired 140 specimens of *Calymene* from the Dudley area. Of these, 104 specimens were purchased from William Woodall and 28 specimens from James Woodall. These two men also provided the vast majority of his other Dudley trilobites. Contemporary census records show that there were several individuals with these same names in the Dudley area, some of whom were limestone miners. It cannot be determined conclusively if these were the same Woodalls from whom Holcroft purchased his specimens, much less whether his sources were miners, mine foremen, fossil dealers, or worked in some other trade, or even whether they actually lived in Dudley.

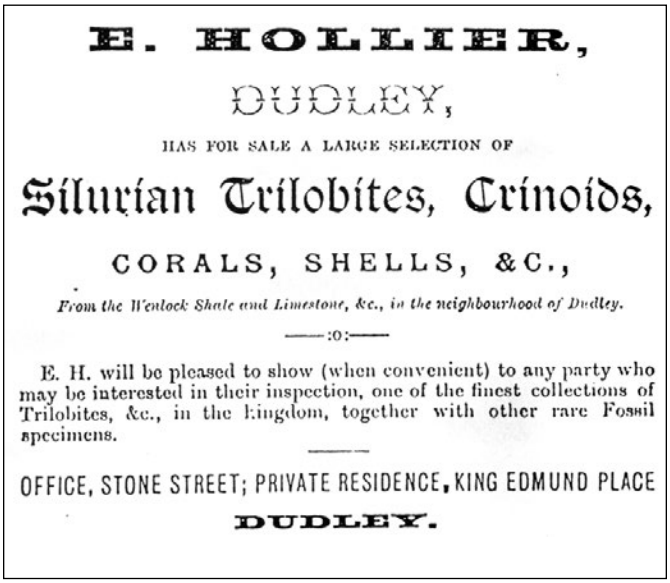
Commercial collectors and dealers.—Local commercial collectors, dealers, and private collectors are the best-documented source of fossils from Dudley in the nineteenth century. Most of the important specimens now in museums or used by scientists in research can be traced back to these individuals. Certainly, they collected some of their own material, but, most likely, they relied heavily on miners for specimens. Socially, these individuals were members of the new middle class, who had at least some leisure time and financial resources to devote to their paleontological interests. In contrast, miners have not been recorded as having personal collections and probably could collect only to earn much needed extra cash.

Although commercial collectors probably purchased most of their specimens from miners, some are known to have collected specimens on their own. For example, Blocksidge (1905) provided the following description of this pursuit, "Years ago it was a favourite resort of men who made a precarious living by finding fossils, and selling them to well-known collectors. These men were in the habit of going into the Cavern in the morning and lighting a fire, the light from which, with the aid of few candles, enabled them to proceed with their self-imposed task." This may have been an atypical example of collecting. However, according to Blocksidge's map, the cavern appears to be now known as Stores Cavern on Castle Hill, which is famous as the only location in the entire Dudley area where rare and spectacular specimens of the trilobite *Trimerus* have been found

(Hollier, 1868; Reid, 1994; Ray, 2001). As these were among the most sought-after fossils from Dudley and commanded a high price, it is likely that special efforts were made to collect them, perhaps as described by Blocksidge.

Joseph Payton may have been the one of the earliest Dudley fossil dealers. In his 1794 guide to Dudley Castle, he included a footnote to his description of the variety of fossils found there, "The Public may be [s]upplied with any of the[s]e articles, upon application to J. Payton, Dudley." Payton apparently maintained a fossil collection, published an article on trilobites (1827), served as mayor of Dudley in 1839, and was instrumental in establishing the spectacular exhibit of Dudley fossils set up for the visit by the 1839 British Association for the Advancement of Science trip to the area.

Bentley (1841) listed three fossil dealers in Dudley: Payton, who was also listed as an "auctioneer, & c.," William Roberts, also listed as a "hair-dresser," and John Tomkins, who is listed only as a fossil dealer. Having three individuals selling fossils in such a small town as Dudley indicates a great demand for these specimens. However, it is important to point out that two of the three had other sources of employment. Hugh Miller (1847) mentioned purchasing trilobites from a Dudley barber who "…had been in the way of selling Dudley fossils, he told me, for a good many years; and his father had been in the way of selling them for a good many more." Perhaps this barber was the "hair-dresser" listed by Bentley (1841). One other notable individual was Elliot J. Hollier, a Dudley chemist. Like Payton, he was a mayor of Dudley (1858) and a collector of and dealer in local fossils. In 1881, he advertised his fossil trade in a large advertisement (Fig. 14) in *The Curiosities of Dudley and the Black Country* (Clark, 1881). The only other fossil dealer in a Dudley area business directory was P. Tomkins, whose listing appeared in the 1839 directory of W. Robson and Company.


E. HOLLIER,

DUDLEY,

HAS FOR SALE A LARGE SELECTION OF

Silurian Trilobites, Crinoids,

CORALS, SHELLS, &C.,

From the Wenlock Shale and Limestone, &c., in the neighbourhood of Dudley.

—:o:—

E. H. will be pleased to show (when convenient) to any party who may be interested in their inspection, one of the finest collections of Trilobites, &c., in the Kingdom, together with other rare Fossil specimens.

OFFICE, STONE STREET; PRIVATE RESIDENCE, KING EDMUND PLACE

DUDLEY.

Fig. 14. Advertisement offering Dudley fossils for sale by Elliot Hollier (from Clark, 1881).

Private collectors.—Private collectors from Dudley and vicinity assembled the best collections of fossils. However, the earliest descriptions of Dudley trilobites were based on specimens from such individuals as Lyttelton, who lived in the region, as well as those from outside the area, such as Dr. Shaw of Oxford (Lyttelton, 1752; Mortimer, 1752). Some specimens, such as those used by Walch (1771), were borrowed from the fossil collections of private individuals, who did not specialize in Dudley fossils or even live in the region. This demonstrates that the Dudley Fossil had already found its way into distant collections as far away as Germany by the 1770s.

A shift in the source of specimens is recorded with the publication of *The Silurian System* (Murchison, 1839), which marked the first time that fossils from private Dudley area collectors were used extensively in research. Murchison used these fossils to help establish a biostratigraphic framework in order to subdivide rock units and to provide a comprehensive paleontological treatment of the taxa found in each unit. This material played a critical role in establishing the paleontological characteristics of his Upper Silurian Wenlock Limestone. In addition, this was the first attempt to describe all of the Dudley trilobites systematically. Murchison demonstrated conclusively that the old Transition beds could be subdivided based on their fossil content, and trilobites were essential to this work. Dudley trilobites were some of the best specimens available for illustration and description, and Murchison made good use of specimens from local private collectors. Ironically, Murchison was reputed to understate the amount and importance of much of the information he received from key contributors to his work (Torrens, 1990), although he did make a few references to Dudley collectors who supplied many of the spectacular trilobites from Dudley. He acknowledged the use of specimens from collectors, including Blackwell, Gray, Cartwright, Mrs. Downing, Stokes, and Morris. Murchison also commented, "The reputation of Mr. Peyton [sic], of Dudley, as a purveyor of these beautiful fossils, is widely spread." The origins of a few Dudley specimens he figured are not indicated, and this suggests that Murchison may have collected them. Clearly, most of the best trilobites he figured were borrowed from collectors.

After this time, scientific studies on Dudley trilobites came to rely on specimens from local private collectors for the best and rarest material, most of which was eventually acquired by museums. Salter (1849, 1853, 1864a, b, 1865, 1867, 1883) demonstrated this repeatedly in a series of papers in which he credited such Dudley collectors as Gray, Fletcher, Ketley, Hollier, and Mushen for loaning many of the best Dudley trilobites. Salter even solicited, in print, individuals to send him their best specimens.

The increasing number of trilobite taxa appearing in the literature over time correlates well with the rapid expansion of fossil collecting. Payton (1827), a veteran collector and dealer, reported only two taxa (although he missed a couple, such as *Encrinurus*, which already had been described). Murchison (1839) listed six. Salter's attempt to describe all British trilobites was cut short by his premature death. However, in conjunction with the papers by Fletcher (1850a, b), it is clear that many of the rarer Dudley taxa were discovered by the 1860s. By 1900, collecting dropped off significantly, and most of the Dudley collections found their way into museums. Most of these had been sold to museums by the collectors or by their heirs; however, some passed through larger commercial collectors (see sections

on Gray, Johnson, and Madley, in British Museum, 1904; and Rayska, 1994). A few collections, such as Holcroft's, were donated to local museums (Strachan, 1979). Sadly, some, such as Payton's, seem to have vanished, although some of his specimens may have been incorporated into the original Dudley Museum, which was established around the time of his death in the 1840s. Whatever the means, Dudley specimens were widely distributed and are now found in museums around the world.

Undoubtedly, the reduction in quarry and mine sites and the closing of the Dudley mines around 1900 had a negative impact on collecting. A similar situation occurred at the same time in other areas (Mikulic, 1983; Mikulic and Kluessendorf, 1998). Social changes at this time also produced fewer private collectors, while increasing mechanization in quarries and mines meant that workmen had fewer opportunities to collect specimens.

Trilobite prices.—The demand for trilobites and other Dudley fossils was probably high during the late eighteenth and early nineteenth centuries, although little documentation exists. The fact that Payton was selling them to tourists in 1794 shows that there has long been a market for these objects. Warner (1802) remarked, "Being discovered only at Dudley and another place in the kingdom, the fossil is the more valuable; a circumstance not unknown to the venders [sic] of these productions of the mines at Dudley, who charge most unconscionably for all their specimens." Booker (1825) noted that the availability and prices of trilobites changed as the limestone operations shifted underground, "Formerly, when the limestone was raised by what is termed 'open work,' this singular fossil was so frequently discovered that the finest specimens of it were purchased for a trifle; whereas now when the stone is got from much deeper measures, and immediately carried to neighboring kilns for calcination, the fossil is so seldom found, that a good specimen is worth more than its weight in silver."

The price for quality trilobites and other fossils probably remained high throughout the nineteenth century. Pye (1825) observed that "In these rocks there are numerous marine productions, and among others, one which the miners denominate a locust, for which they have been known to refuse its weight in gold; it being understood that there is only one other place in the kingdom where they are to be found." Drake (1839) mentioned that the limestone at Dudley "…is remarkably rich in fossil treasures; trilobites, or as they are vulgarly called, 'Dudley locusts,' have been found here in great variety, but from the eagerness of collectors, and the inadequate supply of these ancient creatures yielded by the rocks, they have become scarce and costly…" Bentley (1841) stated, "The price of this fossil is according to size, and can seldom be bought for its own weight in silver; in fact, very few can be purchased that are worth having at less than one sovereign each." Miller (1845, in Bayne, 1871) observed, "It is rare to find a well-preserved trilobite,—so rare that the fossil dealers charge for them from ten shillings to five pounds, and I can not afford to collect specimens at such a price." He did buy some a few days later, however (Miller, 1847). Beyond the purchase price of some specimens, collectors apparently paid to have them prepared, sometimes at high cost. The diaries of Henry Johnson, Sr., of Dudley note that he paid as much as 5£ for this service (C. Knipe, 2005, personal communication).

The fossil registry for the Charles Holcroft collection recorded the prices he paid for each specimen between 1876 and 1893 (I. Strachan, 1976, personal communication), with prices for the 666 trilobites listed ranging from as little as 3 pence to as much as 600 pence each. The most expensive were specimens of *Trimerus* from Dudley Castle Hill, followed by a few specimens of *Calymene blumenbachii* and rare trilobite taxa. Even though they were high priced, it is surprising that the spectacular large slabs of crinoids from Dudley were not as expensive as the several isolated trilobite specimens he purchased. The evidence also suggests that the price was less at Dudley than at more distant places. For example, a specimen for which Holcroft paid seven shillings in Dudley in the 1880s was worth 5£ in London, according to the prominent Dudley collector Henry Johnson (Rolfe, *et al.*, 1988). Apparently, the Dudley Locust was also prized for its aesthetic value. Oakley (1985) noted that during Georgian and Victorian times these fossils were mounted in gold and worn as brooches and tie-pins.

Dudley may have been one of the first locations to manufacture and sell fake fossils. When demand exceeded supply, the commercial fossil trade apparently resorted to this method to furnish specimens. The prominent Dudley collector John Gray (*in* Woodward, 1868) reported, "…the miners have not only collected and developed Trilobites, but even *made them* when they did not turn up in sufficient abundance…New and undescribed species are still to be purchased, composed of parts of *Calymene* and *Phacops* united together, either by accident or by the aid of a knife and a little gum." Ironically, the trilobite discussed in Woodward's (1868) paper turned out to be a specimen that a workman had enhanced. As a result, Woodward mistakenly named it a new species (Fig. 15). Debate at a meeting of the Dudley and Midland Geological Society confirmed that the "fossil in question has been mutilated" (Dudley and Midland Geological Society, 1869). Bassett (1971, 1982) and Dance (1976) have discussed faked Dudley trilobites. Museums with a large number of Dudley fossils commonly contain at least a few

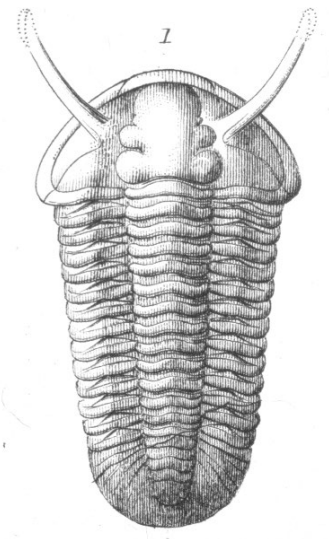
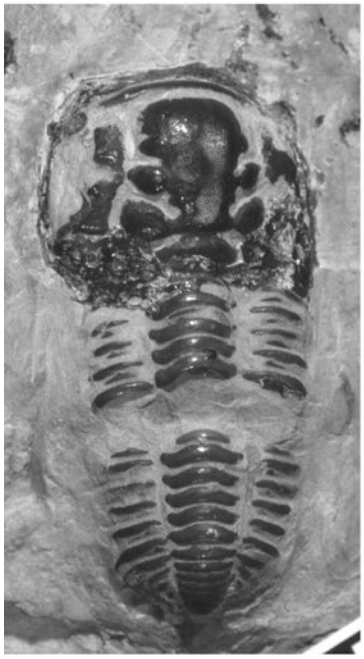


Fig. 15. Woodward's (1868) restoration of an artificially enhanced *Calymene blumenbachii* specimen, which he designated as a new species (*C. ceratophthalma*).



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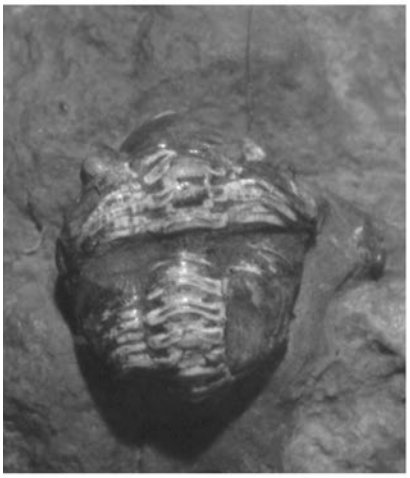

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examples of these manufactured trilobites, and reveal the variety of methods by which this fakery was accomplished (Fig. 16). The most obvious specimens, as Gray pointed out, are taxonomic mixtures of heads and tails glued together, and suggest a lack of taxonomic sophistication by the manufacturer or buyer. Fake fossils from Dudley may still be making their way into the literature. For example, Ager (1963) illustrated what he considered to be a naturally fortuitous association of a Dudley calymenid cephalon and a dalmanitid pygidium. However, the cephalon in his figure looks suspiciously like a glued-on specimen.

DUDLEY AND ITS LOCUST

The impact of mining, geology, and paleontology on Dudley has been considerable. Historically, each subject has made specific contributions to the importance and success of the community by providing economic or social opportunities as well as outside recognition. These factors were interrelated, and helped provide Dudley with an identity and fame that few other similarly sized communities could claim. For over 300 years, this fame drew numerous scientists, businessmen, and tourists to view its attractions. While some were interested only in specific subjects, others found the combination of mines, hills, fossils, canals, factories, parks, and museums both unique and impressive. No other locality could tout such a bounty of related attractions, and many people seized the opportunity to capitalize on this geological heritage.

Initially, Dudley Castle was the focus for visitors to the region. However, during the eighteenth century, industrial development added a variety of new attractions, especially for geologists and individuals interested in the technology of the local industry. If accessible, the spectacular mines in the steeply-dipping Silurian strata (Fig. 17) and their connecting tunnels to the local canal system were among the most impressive sites of the Black Country. They were described as the largest manmade underground caverns in the British Isles. Many individuals and tours visited these mines and canals. For example, in 1799, the Russian ambassador was given a canal tour that included the caverns of Dudley Castle Hill during a review of Black Country industry (Uglow, 2002). In 1844, a trip by the Duc de Bordeaux was described in the popular *London Illustrated News* (Anon., 1844).

Some of the most notable tours, however, were geologic in nature, such as those organized for the 1839 and 1849 meetings of the British Association for the Advancement of Science (BAAS) in nearby Birmingham (Anonymous, 1839, 1849). On both occasions, Lord Ward, the owner of the property, illuminated some of his Castle Hill caverns with thousands of candles for the large crowds. An estimated 15,000 people, including the French Ambassador, toured the mines during the 1849 trip (Anonymous, 1849). Among the most famous events during this trip was the subterranean lecture that Murchison gave about local Silurian geology, which was followed by his enthronement as "King of Siluria" by the Bishop of Oxford (Geikie, 1875).

Interest in the mines and geology was responsible for the formation of new institutions and organizations in Dudley. A temporary fossil exhibit mounted by Joseph Payton for the 1839 BAAS meeting inspired the town to assemble a local fossil collection, which, eventually, was housed in a municipal museum, the forerunner to the current Dudley Museum and Art Gallery. This meeting also inspired the founding of the Dudley Geological Society in 1841 (Cutler, 1981). This organization started with 150 subscribing members, including Lord Ward, who became its president, along with 30 local industrialists, geologists, and members of Parliament who became vice presidents. This Society was short-lived, but the more successful Dudley and Midland Geological Society was formed in 1862 (Cutler, 1981). This group lasted into the early 1900s, and sparked local geological research, field meetings to area geological sites, and, most importantly, re-established the Dudley museum.

Although not as economically important as mining, the Dudley Locust played a role in attracting attention to the community. For some, this trilobite was as much a symbol of Dudley as its mines, canals, and castle, and few other communities could boast of such a well-known fossil. Emmerich (1846, translation by Taylor) reflects this relationship, "The Dudley fossil bears the name of the principal place for Wenlock fossils, and has carried the name of the picturesquely-situated Dudley through the world." As early as the nineteenth century, museums worldwide had specimens of this trilobite, and a plethora of scientific publications featured it. The general public was also directed to this fossil in a wide variety of publications. During the mid-1800s, national and regional guides, such as those published for the railroad system, frequently mentioned the Dudley fossil. From 1818 to at least 1940, many directories for Worcestershire, Staffordshire, and even Birmingham in Warwickshire mentioned the Dudley Locust, even when they discussed the town only briefly. On a more specialized level, the Dudley Locust was discussed and figured in guides to the region (Payton, 1794; Booker, 1825; Bentley, 1841; Harris, 1845; and Baker, 1848), which also detailed Dudley Castle and its history, as well as local limestone mining and geology (see Powell, 1999, for other examples). Demonstrating its prominence in local culture, the Dudley Locust even graced the cover of an early book of photographs about Dudley in 1868 (Laxton, 1868).

As a result of its fame and importance, *Calymene blumenbachii* became an official symbol of the community. The Dudley Borough Seal (Fig. 18), which was adopted in 1866, featured the Dudley Locust in a prominent central position (Grazebrook, 1873; Perkins, 1905). A similar image is also featured on the Dudley Mayoral Chains. In 1957, an official coat-of-arms was

Fig. 16. (left) Trilobites from Dudley showing a variety of fakery styles in the collections of the Museum of Comparative Zoology at Harvard University, Cambridge, Massachusetts (U.S.A.): A, MCZ153342, *Calymene* cranidium glued on rock with partial thorax and partial thorax and pygidium, length 50 mm. B, MCZ153346, large partial cranidium of *Calymene* glued on rock with *Acaste* thorax and pygidium, which is also glued on rock, length 21 mm. C, MCZ153343, artificial cast of proetid glued on rock, specimen length 17 mm. D, MCZ153345, *Acaste* cephalon and partial thorax with pygidium and partial thorax, glued on rock, length 13 mm. E, MCZ153344, *Dalmanites* cephalon with *Dalmanites* pygidium glued on rock; no thorax present, specimen length 33 mm.

Fig. 17. View of a limestone mine near the entrance to the Seven Sisters Caverns in the Lower Quarried Limestone, west side of Wren's Nest (from J. Jukes, 1859).

granted to Dudley that incorporated much of the original Seal, including the Dudley Locust (Basset, 1971, 1982). In various older buildings in Dudley, such as the Town Hall, Police Department, Library, and Dudley Museum, representations of the Dudley Locust are rendered in carved stone or stained glass as part of the old Borough Seal, and, more rarely, are seen as a freestanding figure.

In recent decades, Dudley has revived its interest in promoting its industrial and scientific heritage, and the Dudley Locust continues to play a part in this legacy. Visits to the mines by the public continued until the late 1800s, when safety concerns curtailed access to most of them. Dudley Castle remained a popular attraction, particularly after the opening of the Dudley Castle Zoo in 1937. New interest in the geology and paleontology of the region began in 1956, when Wren's Nest became the first geology-based National Nature Reserve in the United Kingdom. Now visited by nearly 10,000 people a year (Connah, 1999), Wren's Nest National Nature Reserve highlights the geological, paleontological, and industrial heritage of this heavily mined area. Tourist development further expanded with the reopening of the Dudley Canal Tunnel in 1973, through the efforts of the Dudley Canal Trust, which later began canal tours to one of the limestone mines. In 1975, the Black Country Geological Society was established (Shilston, 1988). This Society has similar functions to the preceding organizations, but, in addition, helps conserve local geological features.

The Black Country Living Museum, which was opened as a cultural and industrial heritage site in 1978, now boasts a yearly attendance of 250,000. Several of the exhibits at the museum recognize the importance of geology and mining to local history. The exhibits include limekilns, a reconstructed coal mine, and a reconstruction of a fossil shop. The Dudley Locust is part of the Museum's logo. More recently, the importance of Castle Hill, Wren's Nest, and Hurst Hill to geological and industrial heritage was the impetus for a 1994 proposal to include them as part of a UNESCO World Heritage Site. Scientific groups continue to visit the area, including the 1989 field trip by The Murchison Symposium, an international meeting on the Silurian System, and the international conference on Trilobites and Their Relatives held in 2001. Thus, although the nature of scientific and industrial activities has changed dramatically over the years, they have remained an important part of Dudley's cultural heritage and, as such, provide new opportunities for the future.

CONCLUSIONS

The development of geology and paleontology as scientific disciplines were important events in the late eighteenth and early nineteenth centuries. Then, as now, progress in various aspects of these endeavors was tied to the discovery of fossils and their availability for research. Specimens of *Calymene blumenbachii* were especially important in the early development of these fields, as they were the best trilobite fossils known at the time and had a wide distribution in collections throughout Europe. The study of these specimens helped to characterize both a critical portion of geologic time (then thought to represent the oldest fossiliferous rocks) and to define trilobites as an important group of extinct animals. Because of its unique role, this trilobite became one of the best known of its group and remains so today.

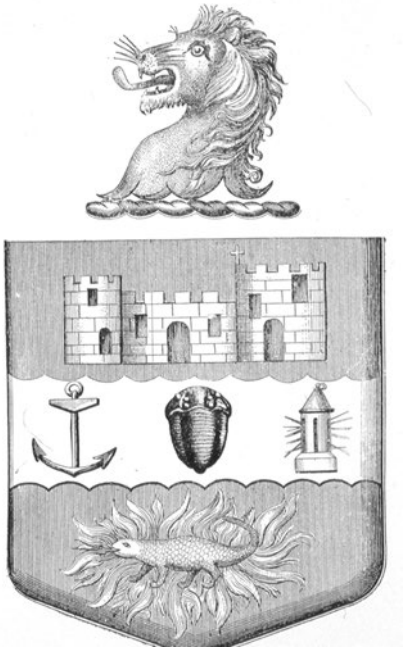

Fig. 18. Dudley Borough Seal with image of the Dudley Locust (from Perkins, 1905).

As with many other fossil taxa, the discovery and initial study of *Calymene blumenbachii* was made possible by a combination of geologic, economic, and social conditions. Exceptional fossils were present in the rocks, but the opportunity to collect these specimens would not have existed if an extensive mining industry had not developed at Dudley. Similarly, these fossils would not have been collected if miners and others did not have an economic interest. Scientists had to depend on the efforts of these individuals to secure the best research material, a situation that has changed little to the present day. The history of Dudley fossil collecting is an outstanding example of the interdependence of these factors and is one of the oldest known. Through this research, Dudley became famous to collectors and scientists as one of the best sources of trilobites and other Silurian fossils, and this had a significant social impact on the community. Tourists came to the area to see the castle, mines, and fossils, and guidebooks highlighted the Dudley Locust as one of the more interesting local features. A museum was established specifically to exhibit the fossils. Because of its fame, the Dudley Locust became a cultural icon for which the community was known internationally. Over the last 250 years, few descriptions of Dudley have failed to mention its famous fossil, while few discussions of the fossil have failed to mention the town. The Dudley Locust has been the centerpiece to the rich and related geological and industrial heritage of the region, and Dudley has promoted it to good advantage. In fact, Dudley may be the first locality to exploit geotourism, a supposedly modern concept that seeks to highlight an area's geological heritage for economic benefit. That Dudley has enjoyed the attention of both the general public and the scientific community for more than two centuries is the legacy of the "locust."

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