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The development of geology as a scientific discipline in Iowa had an early and active history dating from pre-statehood. A high standard of geological observation mixed with pioneer ruggedness evolved from the first reconnaissance work of David Dale Owen in 1839 to the detailed, county survey work of Samuel Calvin at the turn of the century. Aspects of explorations made within this period are highlighted, particularly those with reference to the Silurian System. Strenuous journeys, rival personalities, and the influence of scientific controversy in Europe characterize the early geological explorations in Iowa.

INDEX DESCRIPTORS: Geology in Iowa, early history; Silurian System; Calvin, Samuel; Hall, James; Owen, David D.; White, Charles A.; Wilson, Andrew G.

Prior to statehood, geological research in the Territory of Iowa was initiated by the federal government to assess mineral resources and to open new agricultural lands to settlement. The impetus of investigation was sustained by associates of educational institutions and the State's Geological Survey. In 1875 and 1887, help in organizing and restructuring the Iowa Academy of Science was forthcoming from Iowa geologists. Among other disciplines, the society made its own contribution to the advancement of geology through *The Proceedings of the Iowa Academy of Science,* beginning publication in 1890 (Part 1 of Volume 1).

The intent of this paper is to highlight some aspects of early geological explorations in Iowa from the mid-1800s to the turn of the century, especially with regard to strata of the Silurian System. These strata include the Edgewood and Kankakee Formations, the Hopkinton Dolomite, and the Gower Formation. In conjunction with present studies of these formations which crop out in eastern Iowa (see Johnson, 1975; 1977), the review of previous work conducted unfolds a fascinating story of strenous journeys, rival personalities, and the far-reaching influence of scientific controversy in Europe.

## THE OWEN EXPLORATIONS, 1839-1850

On November 2, 1842 a paper entitled "On the Geology of the Western States of North America" was read before the Geological Society of London by Charles Lyell on behalf of its author, David Dale Owen, M.D., of New Harmony, Indiana. The full text, with a geological map of Illinois, Indiana, Ohio, Kentucky, Tennessee, and the Dubuque and Mineral Point districts of Iowa and Wisconsin, was later printed in *The Quarterly Journal of the Geological Society of London* (Owen, 1846). In his discussion, Owen recognized, on the basis of fossils, that the rock formations of the Iowa-Wisconsin-Illinois area were the same age as those found in Wales upon which Sir Roderick Murchison had founded the Silurian System. Although brief notices had been published earlier (1834, 1835), Murchison's major treatise, *The Silurian System,* did not appear until 1839, the same year that Owen first ventured into the Upper Mississippi River Valley. The short time it took for the system to be widely recognized was remarkable. Other articles printed in the same volume of the London Society's journal as Dr. Owen's report indicate the climate of excitement. Charles Darwin (1846) wrote on the geology of the Falkland Islands, commenting on the presence of fossils resembling Silurian and later forms (all actually Devonian in age). The coralline limestone of Silurian age on the Swedish island of Gotland was discussed by Murchison (1846). Additional discoveries were also praised in the anniversary address of the London Society's president (Horner, 1846, pp. 159-160).

> *"The clear development of the system, and lucid descriptions of the normal types of the Silurian region of Britain, dispelled the obscurity that hung over the history of these ancient beds; and now geologists are at work in all countries, making out the great features of resemblance, and registering those variations in mineral and fossil contents, dependent on geographic position and other local causes, which are found to prevail more or less in all formations."*

Such was the world into which Owen introduced the geology of Iowa.

David Dale Owen (1807-1860; Fig. 1; see Hendrickson, 1943) was 20 years old when he first came to America. His father, Robert Owen, was a wealthy industrialist of Welsh background who intended to found an utopian community in New Harmony, Indiana. Young Owen soon

Fig. 1. David Dale Owen (1807-1860), first geologist to systematically explore large parts of Iowa. From a self portrait (Owen, 1852).

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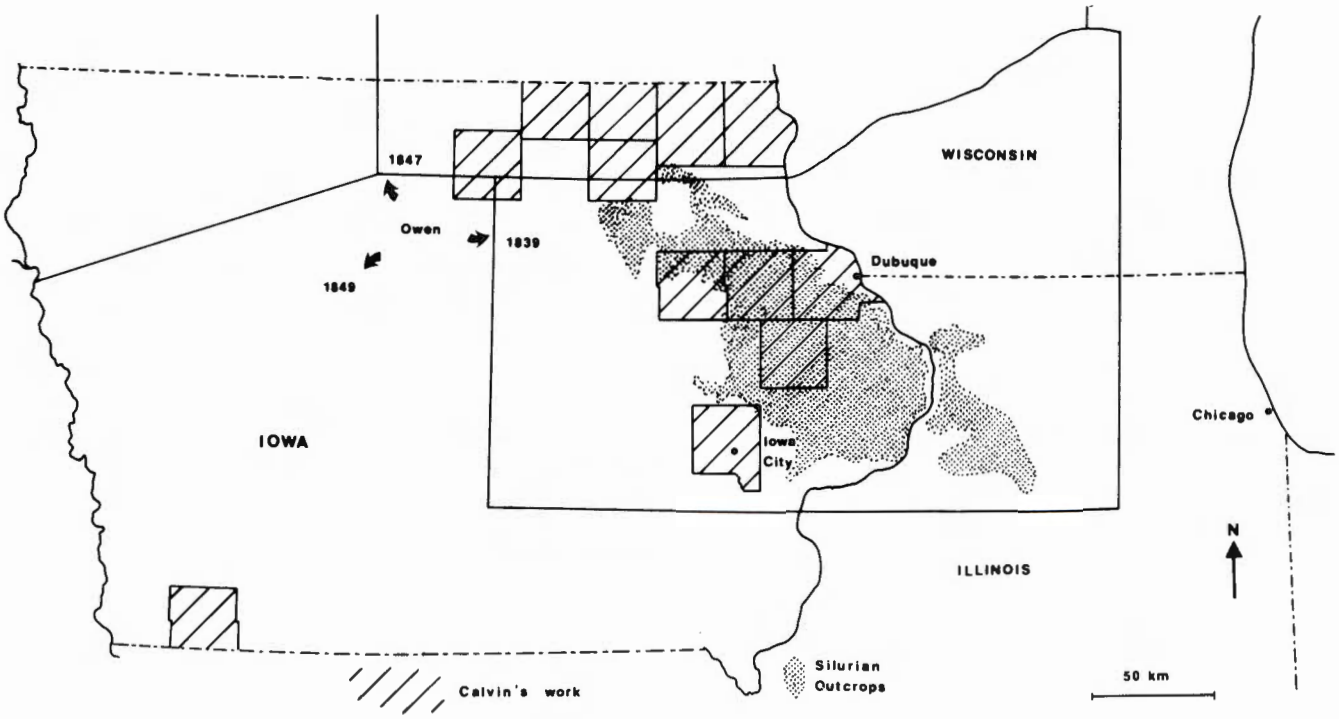


Fig. 2. Parts of Iowa and the Tri-State area explored by David Dale Owen and later by Samuel Calvin, emphasizing the outcrop pattern of Silurian rocks.

left for Europe to study chemistry at London University (Lane, 1966). Returning to this country, he acquired geological experience under Gerard Troost, State Geologist of Tennessee, and then earned a medical degree from the Ohio Medical College in Cincinnati. In 1837 at the age of 30, David Dale Owen became the first State Geologist of Indiana. Events elsewhere, however, soon led him to a position foreshadowing the establishment of the United States Geological Survey.

In 1807, Congress had approved a policy authorizing the federal government to sell public lands with agricultural potential, but only to lease lands with valuable mineral deposits. Following the Black Hawk War of 1832, settlers began to rush across the Mississippi River into newly opened lands. By the time Iowa became a territory in 1838, fraudulent registration of public lands was commonplace, particularly in the lead-rich district of Dubuque. In 1839, the General Land Office, under the Treasury Department, named Dr. Owen the Principal Agent to explore the mineral lands of the United States, and requested that the location, value, and productivity of such lands in the Iowa-Wisconsin-Illinois region be determined before the year's end. It was the plan of the Treasury Department to bring to market all lands without mineralogical value as soon as possible the next year.

Instructions reached New Harmony on the 17th of August. One month later, Owen arrived in the southern part of the 11,000 square mile area to be explored (Fig. 2) with an army of 139 assistants whom he had recruited, outfitted, and instructed in the rudiments of geology. What followed has been described by one biographer (Merrill, 1924, p. 199) as ". . . a feat of generalship which has never been equaled in American geological history." The corps was divided into 24 teams, and each supplied with skeleton maps of assigned townships. Covering nearly 8 square miles a day per group, the teams moved systematically northward while Owen repeatedly crossed the area, receiving reports at appointed stations and checking field work. By the 24th of October, work was completed in the Dubuque district, and by the 14th of November, examination of the Mineral Point district in Wisconsin was finished. Turning southward, field studies successfully came to a close at Stephenson, Illinois on the 24th of November, just as winter set in under near blizzard conditions.

Owen dispatched his full report to Washington, D.C. in April, 1840. It was printed soon after as House of Representatives Document No. 239, but lacked the maps and illustrations which had accompanied the report (see Locke, 1842). The complete report was issued in 1844 as Senate Document No. 407. Although often referred to as a reprint of the former, a significant change in opinion concerning stratigraphic position and correlation is recorded in the Senate version. Owen was familiar with *A Treatise on Geology*, by John Phillips (1837), and at least through this source was aware of Murchison's work on the Silurian System in the British Isles (Fig. 3). However, Owen's first evaluation of Iowa geology (1840, pp. 15 and 22-24) emphasized certain resemblances to the lead-bearing Scar Limestone of northern England, a sub-unit of what was then called the Mountain, or Carboniferous Limestone. Scar meant cliff and because the dolomitic bluffs along the Mississippi River seemed similar to descriptions of the Scar Limestone, Owen thought it fitting to apply the term "Magnesian Cliff Limestone" to the rocks examined in Iowa and Wisconsin. Three subdivisions were recognized: (1) the Lower or Lead-bearing Beds, (2) the Middle or Coralline Beds, and (3) the Upper or Shell Beds (Fig. 3). Sometime before submitting the results of his research to the Geological Society of London, Owen realized that the Middle and Lower Beds were equivalent to parts of Murchison's Silurian System, on the basis of fossils. Consequently, the 1844 edition of Owen's report makes proper reference to this system (pp. 17 and 28). Characteristic Silurian fossils from the Middle Beds, which were previously considered terebratulid brachiopods (1840, pp. 25 and 66), were

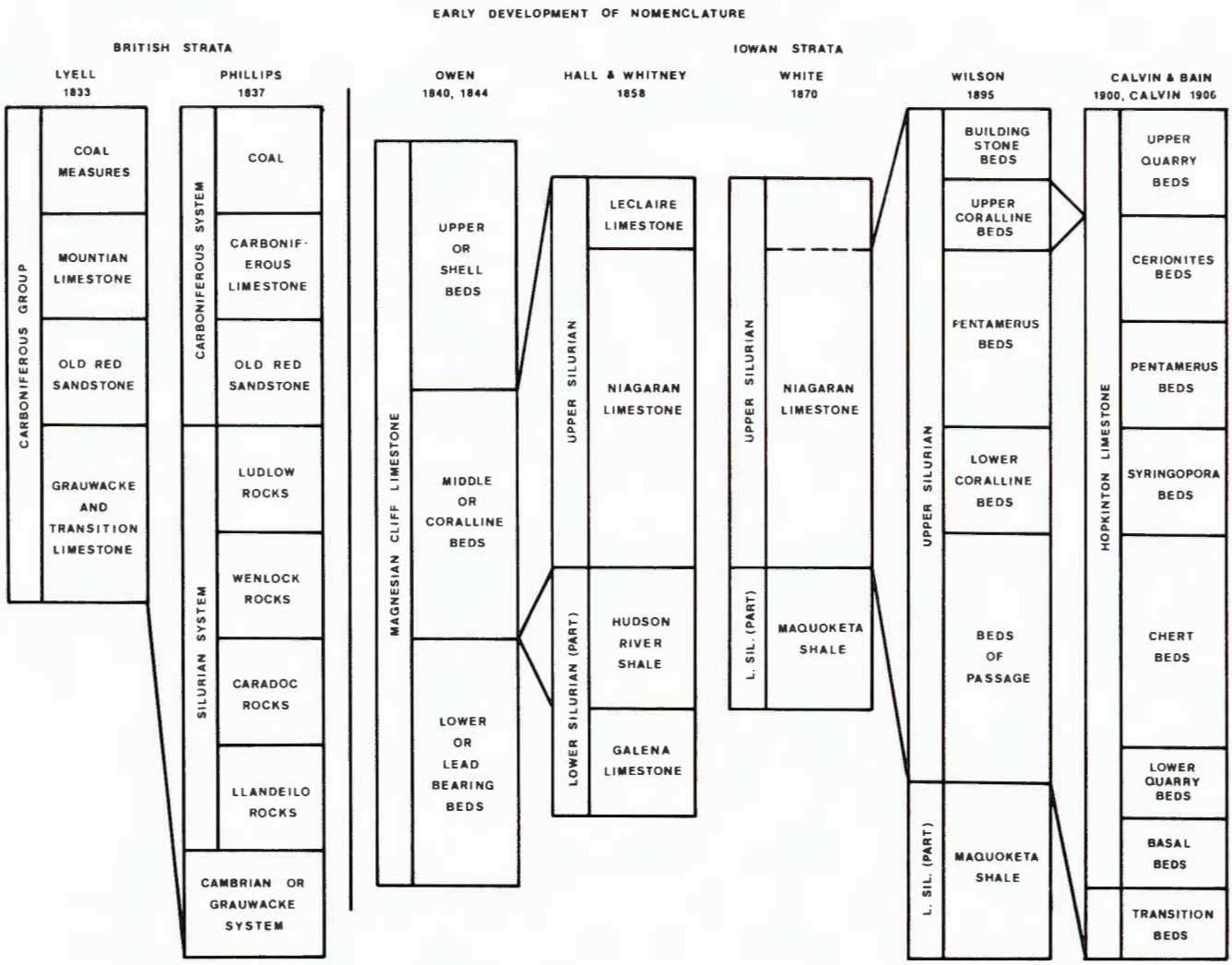


Fig. 3. Early development of nomenclature for Paleozoic strata in British Isles and Iowa, with particular reference to the Silurian. The expansion of the stratigraphic column from Lyell (1833) to Phillips (1837) shows the influence of Murchison's work on the Silurian System. The interval now referred to as the Silurian System was then called the Upper Silurian. The "Lower Silurian" of early authors is today recognized as the Ordovician. The summary of Phillips (1837) was known to Owen, who soon realized (1844) that the Coralline Beds and Lead Bearing Beds corresponded to the Silurian of Murchison (1839). Later workers, particularly Wilson (1895) and Calvin and Bain (1900), were more detailed in their work on the "Upper Silurian" of Iowa.

correctly placed in the Genus *Pentamerus* (1844, pp. 33 and 96; Plate 7, Fig. 3 and Plate 14, Fig. 10).

The change in opinion concerning the geologic age of these deposits may have contributed to Owen's remark on the difficulties of conducting studies in what was then the American West (1846, p. 447):

> *"I regret that in this remote and secluded spot, cut off from access to public libraries and cabinets, and unable at all times to keep up with the current researches and discoveries of the day, I should not have been better able to do justice to such a subject."*

Not only did Owen cope with these problems but also with hardships peculiar to field work on the prairie. At best during the 1839 exploration, his party had the benefit of the plentiful rock exposures on the Mississippi River (Fig. 4). Owen was moved to write (1840, p. 19):

> *"These mural escarpments, exhibiting every variety of form, give to the otherwise monotonous character of the landscape in Iowa a varied and picturesque appearance. Sometimes they may be seen in the distance, rising from the rolling hills of the prairie, like ruined castles, moss-grown under the hand of time."*

Later explorations took Owen and his companions further west over the top of the escarpment. In reference to Devonian strata in northern Iowa on the Shell Rock River, Owen (1852, p. 79) vividly described field conditions:

> *"The geologist who undertakes to investigate the vast prairie country of the Mississippi Valley must be provided with no common share of patience and perseverance. He must be content to travel for half a day together without seeing aught but a rich, black soil, covered, as far as the eye can reach, even down to the very edge of the small streams, with a thick and high growth of prairie grass, with perhaps a faint outline of timber cutting the distant horizon. He must be prepared to wade swamps, to ford*

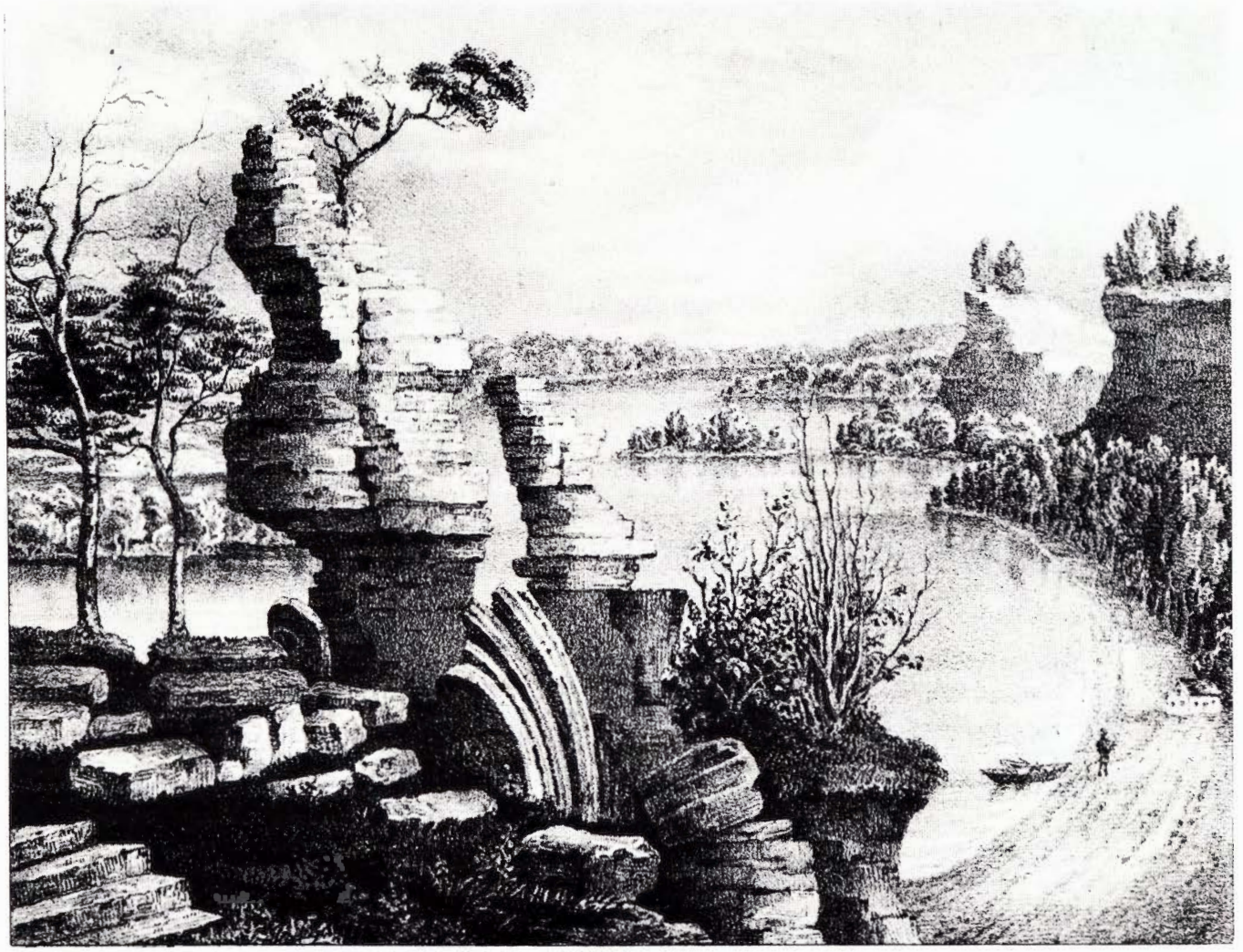

Fig. 4. Cliffs of the Lead Bearing Beds along the Mississippi River below Dubuque, Iowa. Lithography by E. Weber & Co., Baltimore, from a drawing by David Dale Owen (1844).

*streams waist deep, or, in times of freshets, to plunge in and brest the current. He must not shrink beneath a broiling sun, without even a bush to cast a faint shadow over an occasional resting-place. He must think himself fortunate if he can reach, at night, a few scattered oaks to plenish his fire, and boil his campkettle; and he may consider it a special instance of good luck, if, in return, he can catch a glimpse of a rock exposure once or twice a day.''*

Conditions were probably little different in studying the older, Silurian rocks situated more to the southeast. Despite this, Owen (1844, Plates 7, 13, and 14) was able to recover Silurian fossils from many of the major fossiliferous beds eventually described in the more detailed reports of Wilson (1895), Calvin (1896, 1898), and Calvin and Bain (1900). It was hoped that the fossil and mineralogical specimens collected by Owen would form the ''. . . nucleus of a national cabinet,'' and the material was subsequently reposited at the Patent Office in Washington, D.C. (Owen, 1844, pp. 67-68). The collection was later transferred to the Smithsonian Institution, but lost its identity due to ''various accidents, fires, and removals'' (Hendrickson, 1943, p. 51).

## THE SEDGWICK-MURCHISON CONTROVERSY

The world impact of Murchison's Silurian System is a story not complete without mention of the Reverend Adam Sedgwick, of Cambridge University. At the same time that Murchison had begun to study the upper strata of the Transition rocks in southern Wales, Sedgwick was busy investigating lower strata of the same obscure sequence in northern Wales. These lower strata Sedgwick named the Cambrian System. The two geologists initially agreed that the Silurian and Cambrian Systems divided the sequence (Sedgwick and Murchison, 1836). Before long, however, Murchison was convinced that his Lower Silurian, or Caradoc and Llandeilo rocks, corresponded to Sedgwick's Cambrian System.

As a period piece of literature, it is interesting to return to the 2nd volume of *The Quarterly Journal of the Geological Society of London,*

the same in which David Dale Owen's report to that society was published. The anniversary address of the London Society's president (Horner, 1846, pp. 160-163) mentions Murchison's assertion that the line drawn between the Lower Silurian and the Cambrian rocks beneath them, no longer had ". . . any reference to strata identified by distinguishing organic remains, for the same fossils are found in strata on each side of that demarcation." In reference to Sedgwick, however, hope was expressed that the Cambridge professor would ". . . soon gather together his scattered materials, and bring out a new edition of his work . . . and we may perhaps then indulge in a little excusable national vanity of possessing another standard with which the structure of extensive and distant regions of the earth will be compared."

In fact, a paper authored by Sedgwick (1846) appeared in the same volume. The conclusion of this article states the following (p. 130).

> *"Taking the whole view of the case therefore as far as I know it, I would divide the older palaeozoic rocks of our island into three great groups -each (in local descriptions) to be further subdivided. They would then stand thus:*
>
> *3rd, Upper group, or exclusively Upper Silurian.*
>
> *2nd, Middle group, or Lower Silurian, including Llandeilo, Caradoc, and perhaps Wenlock.*
>
> *1st group, or Cambrian.*
>
> *This arrangement does no violence to the Silurian system of Sir R. Murchison, but takes it up in its true place; and I think that it enables us to classify the old rocks in such a way as to satisfy the conditions both of fossil and physical as well as of mineralogical development."*

Thus, while Murchison now believed the former Transition rocks yielded but one system, Sedgwick had arrived at the opinion there were three. As later championed by Lapworth (1879), the Cambrian, Ordovician, and Silurian Systems in use today approximate Sedgwick's divisions.

General acceptance of the concept outlined by Sedgwick required much time. As he later predicted (Sedgwick, 1853), a great unconformity in the Caradoc rocks of the type area was found to separate the Upper from the Lower Silurian (Salter and Aveline, 1854). Sedgwick's greatest obstacle, however, was his failure to discover distinct Cambrian fossils. Meanwhile, the influence of Murchison steadily increased with the growth of his social and professional prominence. Knighted in 1846, he assumed the directorship of Britain's Geological Survey in 1854. Murchison's prestige extended to America and the terms, Upper and Lower Silurian, received wide use up to the close of the century. By present convention, the only Silurian strata known to Owen in Iowa were his Middle or Coralline Beds of the Magnesian Cliff Limestone. What he called the Lower or Lead-bearing Beds are today considered part of the Ordovician System. Interestingly, Owen was among the first geologists in North America to recover Cambrian fossils (Merrill, 1924, p. 275), although the nomenclatural distinction was not obvious to him. In neglect of Sedgwick's efforts and in accord with the consensus of the day, fossils from even the oldest strata were assigned to the Silurian System, as Owen was predisposed to do with the fossils from the Trilobite Beds of the Iowa-Wisconsin-Minnesota region (1848, p. 131 and Plate 7; 1852, Tables I and IA).

## THE OWEN-HALL RIVALRY IN THE "WEST"

The proliferation of local geological names in this country was of much concern to some geologists. Amos Eaton (1840, p. 152) warned that "unless state geologists are to abandon geology as a science, and to amuse us with local names, insulated and heteromorphous in character, they must make it their chief object to find out transatlantic equivalents, since we cannot doubt that such may be ascertained." Owen tended to follow this approach in his pioneer work on the strata of the Ohio and Upper Mississippi valleys. James Hall (1811-1898; see Clarke, 1921), who affiliated himself primarily with the New York Geological Survey, was also anxious to develop an uniform system of nomenclature. What Hall intended was conformity to the terminology applied in New York. On his first western tour through the Ohio and Upper Mississippi valleys in 1841, Hall was accompanied by David Dale Owen part of the time (Clarke, 1921, p. 94; Hendrickson, 1943, p. 60). The following year (1842) Hall's "Notes on the Geology of the Western States" was published in the *American Journal of Science*. Such swift action on the part of Hall may have come as a surprise to Owen. A thinly vailed reference to Hall can be found in a report by John Locke (1842, p. 149), who was Owen's chief assistant during the 1839 exploration of the Iowa-Wisconsin lead district.

> *"Permit me here to add as a claim of the western geologists, rather strangely overlooked by some* eastern *writers on* western *geology, that besides these all the other western rocks yet made known, have been described by western geologists."*

Although there were certain disagreements on terminology, feelings of territoriality were clearly involved as well.

## THE SURVEYS OF HALL, 1855-58, AND WHITE, 1866-69

The first state geological survey of Iowa was established in 1855, and functioned until 1858. The office of State Geologist was filled by James Hall. Clarke (1921) relates that Hall made few trips to Iowa, and managed the duties of the new appointment without seriously interrupting work in his home state. Much of the local work was entrusted to a field party. Among these, the only officially salaried assistant was J.D. Whitney, who served as chemist and mineralogist, and who co-authored the report of the survey with Hall (1858). Preparation of the report took place in New York and it was issued by Hall's publisher in Albany. In addition to their assignment with the Survey, Hall and Whitney were appointed professorships in natural history at the State University of Iowa. A course outline is extant (Clarke, 1921, pp. 281-282), but it is doubtful if either man ever lectured in Iowa City.

Re-established in 1866, the Geological Survey operated until 1869 under Charles A. White (1826-1910; see Dall, 1911). White was a graduate of the Rush Medical College of Chicago, but had also been trained in paleontology by James Hall. While still holding the post of State Geologist, he accepted a professorship in natural history at the State University of Iowa and it is likely that the first geologically oriented instruction in Iowa was offered under his direction.

Geological relationships in the eastern part of the State had been concentrated on in the report of Hall and Whitney (1858). As a result the report of White (1870; published in Des Moines) placed a greater emphasis on the western part of the State. Neither report substantially improved Owen's description of the Coralline Beds (1844). Hall referred the greater part of these strata to the Niagaran Limestone, differentiating only a unit at the top of the sequence which he called the Leclaire Limestone. White disagreed that the Leclaire Limestone could be distinguished effectively from the rest of the Niagaran Limestone (Fig. 3). Presently considered a facies of the Silurian Gower Formation, these strata succeed those of the Hopkinton Dolomite. Both surveys continued use of the terms Upper and Lower Silurian, as designated by Murchison. The direct influence of Murchison can be traced to a letter written to Hall in 1846 (Clarke, 1921, pp. 158-162) in which the New York geologist was urged to reject Sedgwick's interpretations and to retain the same terminology widely accepted in Europe.

Hall gave the name Galena Limestone to strata Owen had called the Lower or Lead-bearing Beds, and applied the term, Hudson River Shale, to a formation excluded by Owen but discovered by Hall's Survey between the Galena and Niagaran Limestones. White proposed that the formation be renamed the Maquoketa Shale. It is now recognized that an unconformity between the Maquoketa Shale and the

overlying Silurian strata occurs in Iowa at approximately the same stratigraphic position as the major unconformity found in the Caradoc rocks of Murchison's description. Modifications in Murchison's scheme provide that strata of the uppermost Ordovician System (his Lower Silurian) are assigned to the Ashgill Series, and strata of the lowermost Silurian System (his Upper Silurian) are included in the Llandovery Series.

## THE RESEARCH OF WILSON AND CALVIN IN THE 1890s

With the completion of the generalized state-wide surveys, the character of geological studies in Iowa began to change during the last decade of the 1800s. The focus of investigation was shifting toward a more thorough inventory of smaller areas and a more detailed analysis of individual rock formations. Various publications served as an outlet for such information. Reorganized in 1892, the Iowa Geological Survey initiated a series of annual reports specializing in a county-by-county study of the State. The *American Geologist,* established in Minneapolis in 1888, and the *Journal of Geology,* founded at the University of Chicago in 1893, accomodated shorter research articles. The Iowa Academy of Science published the first volume of its *Proceedings* in 1890, and maintained a strong geology section from the beginning (see Appendix).

No other individual figured so strongly in shaping the development of geology in Iowa at this time than Samuel Calvin (1840-1911; Fig 5; see Shimek, 1912). At the age of 34, Calvin resigned his position as principal in one of the Dubuque schools to take the professorship in natural history vacated by C.A. White in 1874. Previously, as a student and then instructor at Lenox College in Hopkinton, Iowa, he had taken a keen interest in natural science, and made frequent collecting trips throughout much of the State. In Iowa City, Calvin divided the natural history chair into several professorships, allowing him to devote his full attention to geology. Calvin soon involved himself with the vitalization of the Iowa Academy of Science, helped found and became the first editor of the *American Geologist* and, as State Geologist, renewed the operation of the Iowa Geological Survey, which has since continued uninterruptedly. In later years he specialized in Pleistocene geology, although numerous county reports published in the yearbooks of the Survey indicate that his capabilities were broad. Calvin's participation in scientific circles on both a national and state level are amply demonstrated by his presidency in 1908 of both the Geological Society of America and the Iowa Academy of Science.

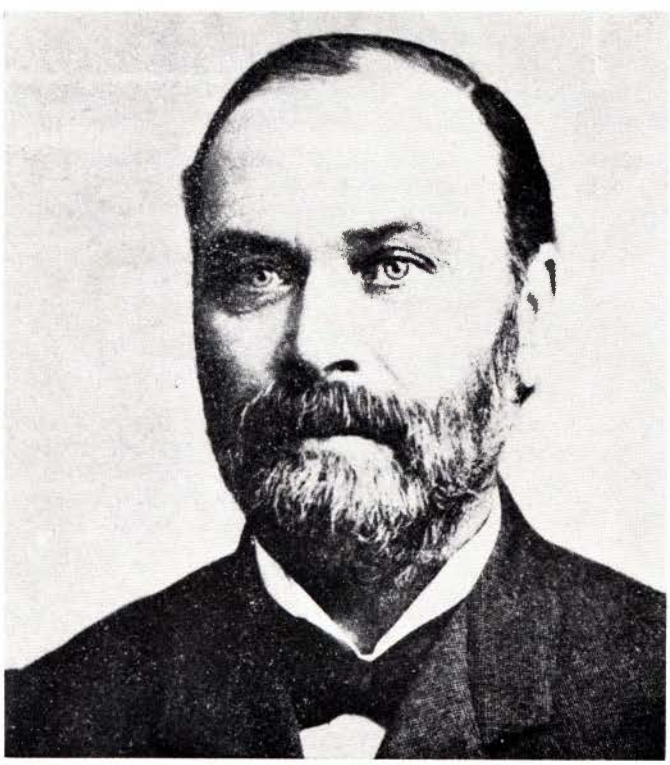

Fig. 5. Samuel Calvin (1840-1911), Professor of Geology at the State University of Iowa and State Geologist of Iowa. From MacBride, Arey, and Norton (1911).

Typical of the 1890s are the studies of Andrew G. Wilson and Samuel Calvin on strata that had previously been called the Niagaran Limestone in Iowa (Fig. 3). Work began independently at about the same time, and lasted over several years. Numerous quarry operations across the Silurian cuesta of eastern Iowa had been opened for stone and lime. These artificial exposures provided a considerable advantage over the limited prairie exposures which David Dale Owen had to contend with. Wilson, a professor of natural history at Lenox College, was the first to publish his results (1895). Not only did he subdivide a large portion of the sequence according to distinctive bedding, but he also identified cycles in the faunal and lithological characteristics of these beds. Calvin's well documented efforts (1896; 1898; and Calvin and Bain, 1900) arrived at much the same differentiation. Later when Calvin gave the name of Hopkinton Limestone to the sequence (1906), he expressed disappointment in the lack of continuity shown by some of the fossiliferous beds. The correlation of two different beds containing similar pentameran brachiopods was probably the cause of an apparent variation in successive strata (Johnson, 1975). Noteworthy of Calvin's work is his suspension of the term Lower Silurian as used by Murchison, in favor of the word Ordovician. The practice dates from his report on the geology of Allamakee County (1895), well before the U.S. Geological Survey officially adopted the term in 1903 or before usage was popularized through the textbook, *Geology,* by Chamberlain and Salisbury (1904-1906).

## CONCLUSION

Aspects of early geological explorations in Iowa have been treated within the framework of a particular stratigraphic sequence which is exposed in the eastern part of the State. My objective has been to give some impression of the physical as well as philosophical conditions under which the discipline of geology developed in Iowa from the mid-1800s to the turn of the century. Discussion included development of geology in the British Isles because, at that time, British geologists were in the forefront of a movement to establish type sections of strata as standards to which the rest of the world's strata could be compared.

These standards were arbitrarily defined, although in many ways the movement did serve a useful function in beginning to codify world nomenclature. Once Owen familarized himself with the work of Murchison, he realized that the Middle, or Coralline, Beds of the Magnesian Cliff Limestone were more comparable to Murchison's Upper Silurian than to the Scar Limestone of the Carboniferous System. Precise correlations were not immediately feasible, however. Owen thought, for example, that the Corralline Beds (also called the Pentamerus and Coralline Beds, 1852) were the American equivalent of the Wenlock rocks. Actually the beds correlate with slightly older strata of the Llandovery Series, which had not yet been carefully defined in Wales.

The first geologists to visit Iowa were faced with a dual assignment. Their task was not only to observe and describe what they found, but also to compare this new information with what was already known

about other parts of the world. Each time they returned to the same sequence, they found something not completely described before. In the British Isles, as well, geologists were retrieving more detailed information from their standard sections. While the geological sciences have developed in many different directions since, the fundamental process of interpretation and integration continues today.

## ACKNOWLEDGEMENTS

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