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Edwin James' and John Hinton's revisions of Maclure's geologic map of the United States

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Abstract. William Maclure's pioneering geologic map of the eastern United States, published first in 1809 with *Observations on the Geology of the United States*, provided a foundation for many later maps – a template from which geologists could extend their mapping westward from the Appalachians. Edwin James, botanist, geologist and surgeon for the 1819/1820 United States Army western exploring expedition under Major Stephen H. Long, published a full account of this expedition with map and geologic sections in 1822–1823. In this he extended Maclure's geology across the Mississippi Valley to the Colorado Rockies. John Howard Hinton (1791–1873) published his widely read text: *The History and Topography of the United States* in 1832, which included a compilations of Maclure's and James' work in a colored geologic map and vertical sections. All three men were to some degree confounded in their attempts to employ Wernerian rock classification in their mapping and interpretations of geologic history, a common problem in the early 19th Century prior to the demise of Neptunist theory and advent of biostratigraphic techniques of correlation. However, they provided a foundation for the later, more refined mapping and geologic interpretation of the eastern United States.

1 Introduction

Historian George Merrill (1904, p. 217) considered the year 1809 to be "*notable in the history of American geology, since it brought forth Maclure's Observations on the Geology of the United States, with a colored geological map of the region east of the Mississippi*". Maclure came to be known as "*the father of American geology and the William Smith of America*" (Merrill, 1904, p. 217). There is considerable justification for the latter assignation considering that, as with Smith (Winchester, 2001), Maclure lacked formal scientific education, was more or less self-taught, highly-motivated, field-oriented and independent in his thinking.

In this review I introduce Maclure and his map and the additions and revisions made by Edwin James and John Hinton it the quarter century following its initial publication in 1809. Of interest are the pitfalls encountered by Maclure, James and Hinton it the application of the 18th Century Wernerian classification of rocks in the study of American geology east of the Mississippi River. Although Wernerian correlation of time divisions and individual formations in America and Europe was later viewed as being forced and mistaken, the maps and geologic sections of Maclure, James and Hinton provided a foundation for the later, more refined mapping and geologic interpretation of the eastern United States. The digital format of this journal provides the opportunity to include together for, the reader's convenience, colored maps and vertical sections, which would be prohibitively expensive in traditional paper format.

2 Wernerian ("Neptunist" or "geognostic") stratigraphic framework

In the early 19th Century lithology remained the key to geologic mapping, and the unraveling of earth history. The Paleozoic and Mesozoic Eras were viewed as a succession of epochs characterized by ubiquitous deposition of the specific sediments that were common to each epoch. This approach to stratigraphic analysis harkens back to the lingering influence of the 18th Century Wernerian classification of rocks. Abraham Gottlieb Werner (1749–1817) published a summary of his "Netunistic" or "geognostic" system in his "Kurze Klassification", attempting to present a universally applicable system of rock classification that related to withdrawal of a universal ocean (Ospovat, 1969). Initially "Primitive" crystalline rocks (first granitic, then metamorphic) were precipitated from solution upon a highly uneven seafloor, which accounted for their presence at varied altitudes from the core of mountain ranges to canyon bottoms. During the later "Transition", "Flötz" (or "Secondary") and "Alluvial" (or "Tertiary") periods the seas generally receded, with some fluctuation, and deposited a variety of sedimentary rocks in widespread layers that were generally lithologically uniform, but could vary from place to place. When the level of the ocean had dropped so as to expose crystalline core rock barriers the universality of ocean deposition ended, allowing for diversity among the successions of sediments deposited in more isolated regions (Greene, 1982). Alluvial and volcanic rocks were the youngest and resulted from local conditions, thus lacking universality or near-universality (Ospovat, 1969).

Werner's rock class terminology, involving fairly common usage of the terms "Primitive", "Transition", "Secondary" and "Tertiary", was widespread by the beginning of the 1820's, when the application of faunal succession led to the definition of chronostratigraphic units (Davies, 1968; Gerstner, 1979). For several decades, however, the legacy of descriptive Wernerian terminology persisted, which led to some confusion in both mapping and the interpretation of geologic history (Berry, 1968). This may be seen in the works of Maclure, James and Hinton.

3 William Maclure

William Maclure (1763–1840; Fig. 1) was born in Scotland, had little formal education and began a mercantile career with his first voyage to the United States in 1778 (Doskey, 1988). His success in trade enabled him to retire in 1797 at the age of thirty-four and devote his life to science and public educational reform. Warren (2009, p. 4–5) notes that "*he belittled his classical education, as he did English education in general with its bias toward classical and clerical instruction which reflected the tastes of the ruling class and was directed toward the middle-class student ... [and] considered it an "original sin" that classical education was being transferred from Europe to American schools*". Maclure became a United States citizen in 1796, a friend of Thomas Jefferson and was elected to the American Philosophical Society in 1799, to which he "*subsequently donated his valuable private library and some twenty thousand dollars*" (Merrill, 1904, p. 218). He served on its council (1818–1829) and as the first president of the American Geological Society beginning 1819 (Warren, 2009).

Throughout his life Maclure traveled extensively, to Mexico, the Caribbean and throughout Europe, continually making observations on both geology and public education (Morton, 1844; Merrill, 1904; Doskey, 1988). Indeed, "*Maclure seems to have led a fugitive existence, a stateless, deracinated voyager, always on the go, visiting and residing in one country after another*" (Warren, 2009, p. 6). He deplored the rampant exploitation of workers that he believed could be alleviated via education and universal suffrage. Although called a "utopian socialist", he believed in free enterprise with a minimal intrusion of government (Warren, 2009, p. 31). With his endeavors to establish schools both in Europe (Morton, 1844) and the United States for both sexes of all classes, culminating in the founding of New Harmony Colony in Indiana, "*Maclure was among the first of the great American philanthropists*" (Warren, 2009, p. 99).

Figure 1. Portrait of William Maclure (Merrill, 1904, plate 3).

Maclure (1809, 1818a) utilized the Wernerian rock classes in his pioneering mapping of the eastern United States (Figs. 2, 3). His map was in high demand and was published in several editions, as well as in French translation, between 1809 and 1817 (White, 1977). An earlier geographic map published by C. F. Volney in 1803 served as a base for Maclure's map, and some geologic data were borrowed from Volney in Maclure's report (Volney, 1804; White, 1977). However, Maclure's was the first application of a lithostrigraphic color code to American mapping (Marcou and Marcou, 1884; Nelson, 1999). This use of Wernerian classification was perhaps more for convenience and utility of communicating his findings with scientists in Europe, inasmuch as it that was the most comprehensive, widely used system for rock unit definition at the time (Warren, 2009). Criticisms of Werner's Neptunist system by Huttonians and Vulcanists (Wyse-Jackson, 2006) "*raised doubts in his [Maclure's] mind as to the validity of the theory and he felt that certain of the proposed formations were questionable. ... [W]hile he had adopted the nomenclature of Werner, this did not mean that he concurred with the theoretical assumptions of the Neptunian system*" (Doskey, 1988, p. xxvi, xxix). In his 1824 visit to Salisbury Crags in Scotland, he observed trap [basalt]

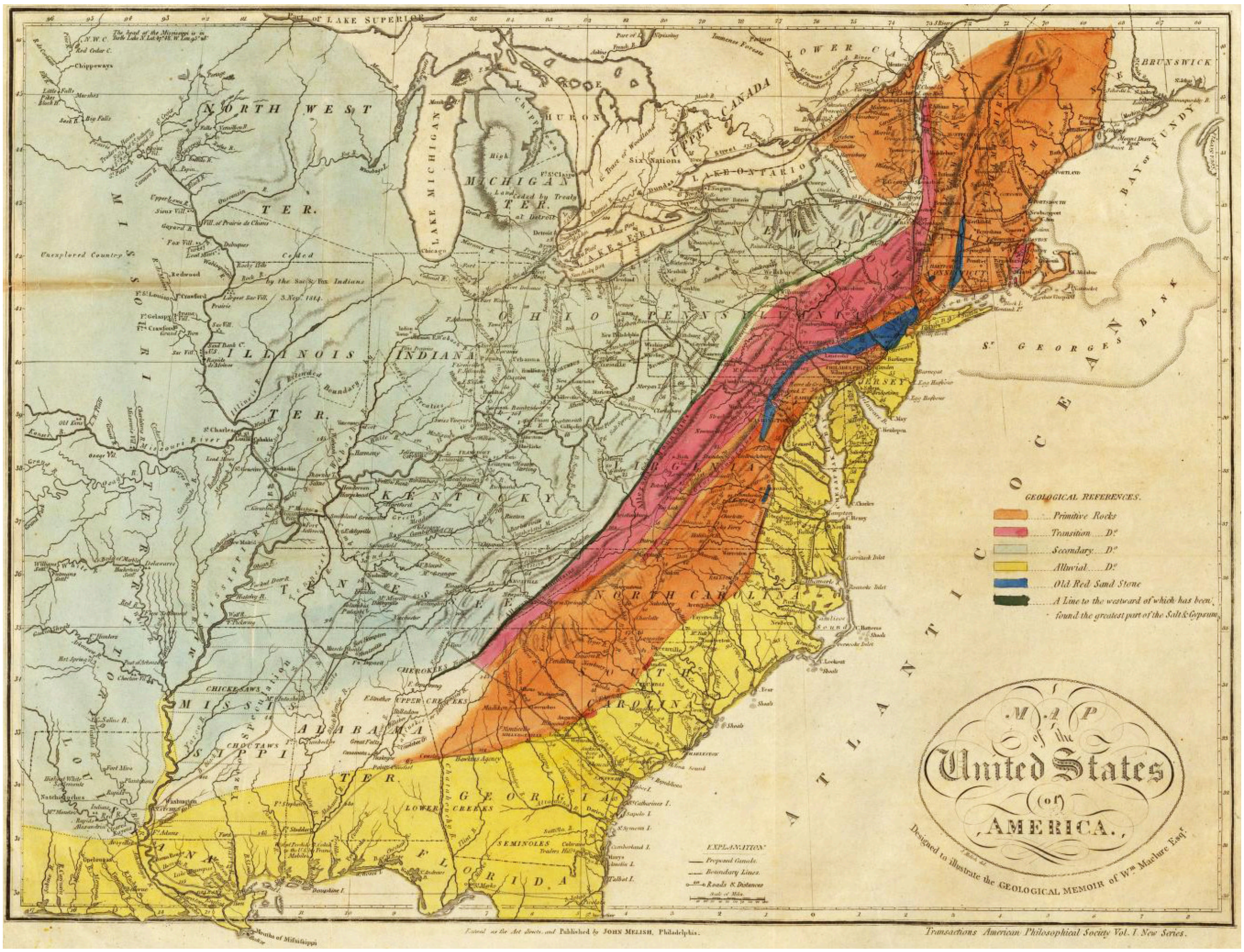

Figure 2. Maclure's (1818) geologic map of the United States. In addition to the standard Wernerian rock classes, the American equivalent of the "Old Red Sandstone" [Triassic basin-fill deposits] of the British Isles, and "a line to the westward of which has been found the greatest part of the Salt & Gypsum" are delineated.

overlying sandstone that "*has been converted to jasper for two or three inches*" and concluded that "*rational supposition would attribute it [the genesis of the trap] to be fire in the place of water*" (Doskey, 1988, p. 726).

In his *Essay on the Formation of Rocks* Maclure (1818) attempted to reconcile the opposing views of the Wernerians, vulcanists and Huttonians by offering a new rock classification scheme. Based upon lithology and field observation, Maclure (1818b, p. 266–267) speculated that:

> "*[A] natural line which will divide the rocks into two classes; the first class will contain all those whose origin, either by fire or water, as taken place under the evidence of our actual observation, or those that can be traced by positive analogy to the same origin. The second class comprising all those rocks which have no positive analogy with either, yet containing some parts which have a distant relation to both the modes of formation.*"

Maclure's (1818b, p. 269–271) "*first class includes rocks demonstrably of Neptunian origin, a "First Order" – those whose origin may be witnessed, such as sand beds, tufa, bog iron, etc. and a "Second Order" – those which by analogy to modern environments suggests a Neptunian origin, such as coal, rock salt, limestone, etc.*". His "*Second class*" includes rocks demonstrably of volcanic origin, with a "*First Order*" including the products of active volcanism, a "*Second Order*" – those associated with volcanic features and a "*Third Order*" – those with similar textures to those of the second order". Lastly, a "*Third class*" includes rocks or doubtful origin, chiefly crystalline igneous and metamorphic. Thus overlap occurred in class nomenclature whereby, for example, granite would be mapped as "*Class I – Primitive*" but placed within his "*third class*" as discussed in his treatise. Such confusion suggests his recognition that perhaps the Wernerian classification had its limitations:

> "*In adopting the nomenclature of Werner, I do not mean to enter into the origin or first creation of the different substances, or into the nature and properties of the agents which may have subsequently modified or changed the appearance and form of those substances; I am equally ignorant of the relative periods of time in which those modifications or changes may have taken place; such speculations are beyond my range, and pass the limits of my inquiries*" (Maclure, 1809, p. 427).

He noted, however, a general lack of equivalency to the European rock successions, aside from the "Old Red Sandstone", and suggested that it might have been best if other names had been adopted which might have deemphasized a prominent feature or general property of a class of rocks (Maclure, 1818b). In his personal journal of 1824 (Doskey, 1988, p. 738), Maclure disparages the use of fossils as was practiced by Georges Cuvier (1769–1832) and Alexandre Brogniart (1770–1847) in the Paris Basin "*who use the inventions of all this shell geology on which rests this diluvial deposition, which follows in the train of thought of the Bible Societies, and draws physical support from the arrangement of the rocks to support their metaphysical theories*". However, as a field geologist concerned with mapping, he nonetheless pragmatically employed Werner's lithostratigraphic nomenclature while avoiding its wider geognostic implications: "*Werner saw enough to know the difficulty of setting up exact definitions of the nomenclature of an imperfect science and gave general names rather than specific, which is perhaps one reason why more of his names have been adopted than any others*" (Maclure cited in Doskey, 1988, p. 373).

4 Edwin James' modification of Maclure's map

Following the publication of Maclure's map of the United States several attempts were made at its modification. Marcou and Marcou (1884, p. 24) noted that Parker Cleaveland's (1780–1858) geological map of the United States (Cleaveland, 1822) is "*merely a copy of Maclure's third edition*". However, they cite Edwin James' (1822a) *Map of the country drained by the Mississippi, western section* as "*[a]lthough very rough, this first sketch of the geology of the country west of the Mississippi River ... is very creditable, and entitles him to be called the first pioneer of the geology of the country between the Mississippi River and the eastern foot of the Rocky Mountains*" (Marcou and Marcou, 1884, p. 24).

Edwin James (1797–1861; Fig. 3) was raised in Vermont and graduated from Middlebury College in 1816, after which he moved to Albany, New York, to study medicine, botany under John Torrey (1796–1873) and geology under Amos Eaton (1776–1842). In 1820 he joined the 1819/1820 United States Army western exploring expedition of Major Stephen Harriman Long (1784–1864) as expedition botanist, geologist and surgeon, a combination of skills that appealed to the budget-minded major (Nichols and Halley, 1995). The expedition goal was to locate the sources of the Platte and Red Rivers, map the uncharted Louisiana Territory and locate sites for military posts (Woodman, 2010).

Figure 3. Portrait of Edwin James (Ewan, 1950).

James, with four other men, climbed Pikes Peak in 1820, the first white men to climb an American peak over 14 000 feet in elevation, from which James "*described the river valleys in all four directions [which] helped him fill in some gaps in the geographic knowledge of the area*" (Nichols and Halley, 1995, p. 133). He made the first botanical descriptions of the alpine flora of the Rocky Mountains, and with Major Long, coined the term "Great American Desert" for the portion of the United States situated west of the Mississippi River (Wheat, 1958; Carpenter, 2007). James was assigned the "*task of putting the various reports, notes, and tables into some kind of finished product*" which consequently was published under his name in 1822 (Nichols and Halley, 1995, p. 162; Thaites, 1905). The report included a geologic and geographic map (Fig. 4) and vertical sections (Fig. 5) and a full account of the expedition, including experiences with

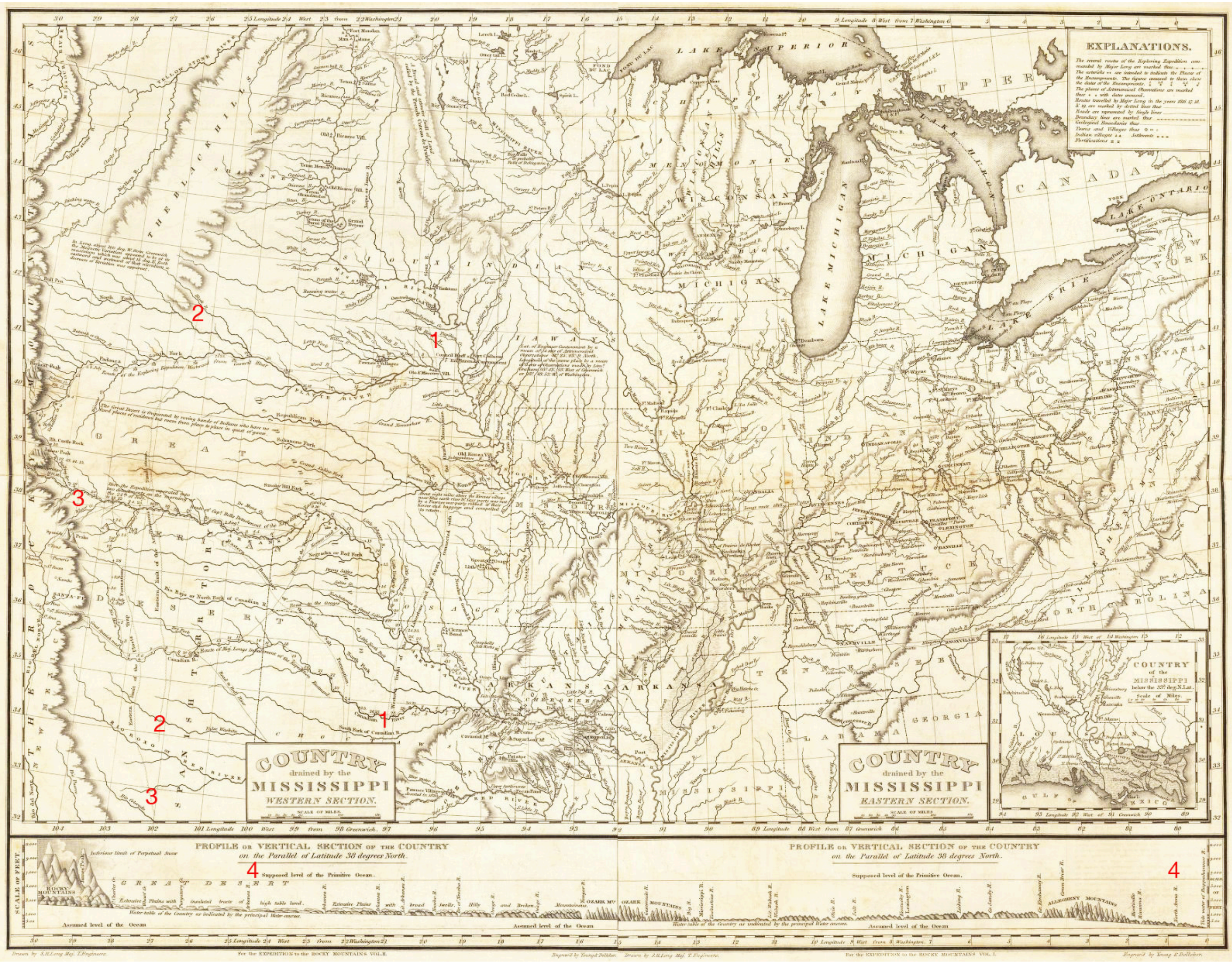

Figure 4. Country drained by the Mississippi River (James, 1822a). Text on map accompanying lines labeled: 1 – "Western limit of the Limestone and Coal strata connected with the Ozark Mountains", 2 – "Eastern limit of the Argillaceous Sandstone", 3 – "Eastern limit of the Floetz Trap [basalt] Formation", 4 – "Supposed level of the Primitive Ocean".

and customs of Native American tribes encountered (many of these having first been serialized with James as author in the *Literary Gazette*), as well as natural history (Woodman, 2010). The vertical sections were specifically intended to "*form continuations of Maclure's ... sections*" (Merrill, 1904, p. 247). In 1823 both the American and London editions of James's account were published. Although the expedition "*had accomplished less than had been anticipated*", the final product was given moderate praise (Nichols and Halley, 1995, p. 165–166). Goetzmann (1966, p. 61) suggested that Major Long realizing his failure to achieve the original expedition objectives, "*judiciously faded into the background, allowing Edwin James to be the official chronicler of their collective misadventures*."

The following six years James served as a frontier army surgeon, "*studied Indian languages, assembled several Indian spelling books, and translated the New Testament into Ojibwa*" (Carpenter, 2007). In 1830 he left the Army to undertake editorial work for the *Temperance Herald and Journal* in Albany, New York. In 1836, moved to Iowa, where he lived out his years. He died at age 64 of injuries sustained in a wood hauling accident. Of James, English naturalist John William Salter (1820–1869) wrote (cited in McKelvey, 1956, p. 247):

> "*The life of Edwin James is worthy your thorough study. He was a remarkable man in many respects – personal, scientific, historic, moral and religious – a unique character. Personally I only knew him as a mystic, a recluse, an abolitionist, a come-outer, an underground conductor for men "guilty of a skin not colored like his own", a non-resistant, in fact a "John Brown" man, but never to*

> *the extent of taking up arms, more perhaps like a Tolstoi [sic] of to-day. I could never draw him out on his past life. He would not talk about himself.*"

Of James' observations, map (Fig. 4) and report, White and Slanker (1962, p. 18) wrote:

> "*The wealth of immediately reported geologic information from the 1819 and the 1823 expeditions is in marked contrast to the paucity of such material in the reports of other great explorers. ... His concept of the vast extent and continuity of the various strata from the Rockies far eastward is much better realized from his text than from the sections he included in his report.*"

En route westward, describing effects of an earthquake at Cape Gerardeau, Louisiana, he noted that "*[t]heir great extent, and the very considerable degree of violence with which they affect not only a large portion of the valley of the Mississippi, but of the adjacent hilly and mountainous country, appear to us most clearly to indicate that they are produced by causes far more efficient and deep-seated than the decomposition of beds of lignite or wood-coal situated near the level of the river, and filled with pyrites. ... [I]t is easy to see that the combustion of a coal-bed, ... may have afforded all the foundation on which these reports [of explosions, subterranean fires, etc.] ever rested*" (James, 1823, p. 184).

Noting "*the existence of metallic ores overlaying recent marine sandstones and compact limestones [sic]*", he suggested that fluids derived from subjacent crystalline rocks and released during "*subterranean concussions and earthquakes*" might have resulted in ore emplacement. In observations in the Mississippi Valley lead district James (1827, p. 376) concluded that "*[t]he idea that these immense deposites [sic] of lead are out of place, and have been transported from distant mountains by currents of water or other causes, has been a favourite [sic] one with American Geologists, but is wholly unsupported by any of the appearances about the mines*". Rather, "*these mineral veins were filled from below, after the consolidation of the secondary rocks had commenced*" (James, 1827, p. 380). Associated with these ores were limestone beds containing what were deemed human footprints. These in most cases "*have been satisfactorily traced to the nodular, reniform, and fancifully shaped masses of flint, which often occur in the horizontal seams of the lime-stone ... and which, being easily detached, leave impressions bearing a remote resemblance to many things, and sometimes by accident to the human foot*" (James, 1827, p. 379–380).

Traveling west along the Platte River, James (1823, p. 279) observed a "*surface more or less covered with horizontal strata of sandstone and conglomerate. ... Indeed, there are many appearances indicating that a formation of this kind formerly extended down the Platte much farther than at present*". Along the Rocky Mountain Front the plains consisted "*of granitic sands, or of secondary aggregates made up of the detritus of that great chain of primitive mountains*" (James, 1823, p. 276). At the base of the mountains are "*elevated cliffs of a similar sandstone, having its strata in a highly inclined position*" (Figs. 4 and 5 – northern section; James, 1823, p. 276). The tilted sandstone beds rested directly and unconformably upon the granite rocks, with no traces existed of traces of "*those rocks distinguished by the Wernerians as rocks of the transition period*" which, according to that scheme, should be present (James, 1823, p. 280). The "*unexperienced [sic] geologist ... will search in vain for any traces of those rocks which occupy so conspicuous a place in the works of systematic geologists, denominated rocks of transition. He may also be surprised at the total absence of those primitive strata which the theory of universal formations may have taught him to look for above the granite*" (James, 1825, p. 195).

James (1823, p. 285–286) described the stratigraphic succession adjacent to the mountain front (Fig. 5 – northern section):

> "*Sandstone formation of two members, the first being the red sandstone abundant immediately subjacent to the Rocky Mountains, hardest and lightest colored at base where its associated with puddingstone, softer and darker upsection. ... [T]he second member being "argillaceous or gray sandstone" deposited upon the red sandstone member. Contacts both well-defined and gradational.*"

He envisioned that a "*sudden emerging of the granite [had] broken off, and thrown into an inclined or vertical position the margin of the horizontally stratified rocks of the plains*" (James, 1823, p. 288–289).

> "*The organized remains ... observed in secondary aggregates along the base of those [Rocky] mountains, are mostly of animals supposed to have inhabited the depths of the ocean. But if the granite of the Rocky Mountains has been forced up at a recent period, where are the traces of all those older secondary, and fletz [sic] rocks, which should have intervened between it and the horizontal sandstones?*" (James, 1823, p. 341).

East of the Rockies James (1823, p. 290) described basaltic rocks (his "Floetz Trap") that are "*referable to the two divisions called greenstone and amygdaloid*", the former most often in vegetated "*conic hills of considerable elevation* [see Fig. 5 – southern section], *scattered without order, or grouped in various directions*". These "*two kinds referable to two divisions of the class called by Werner superincumbent rocks*" (James, 1825, p. 209). James (1822b, p. 328–329) noted that "*[h]ere, as in England, Germany and many parts of Europe, these rocks [the Floetz trap] are in immediate association with the coal strata, on which they are sometimes*

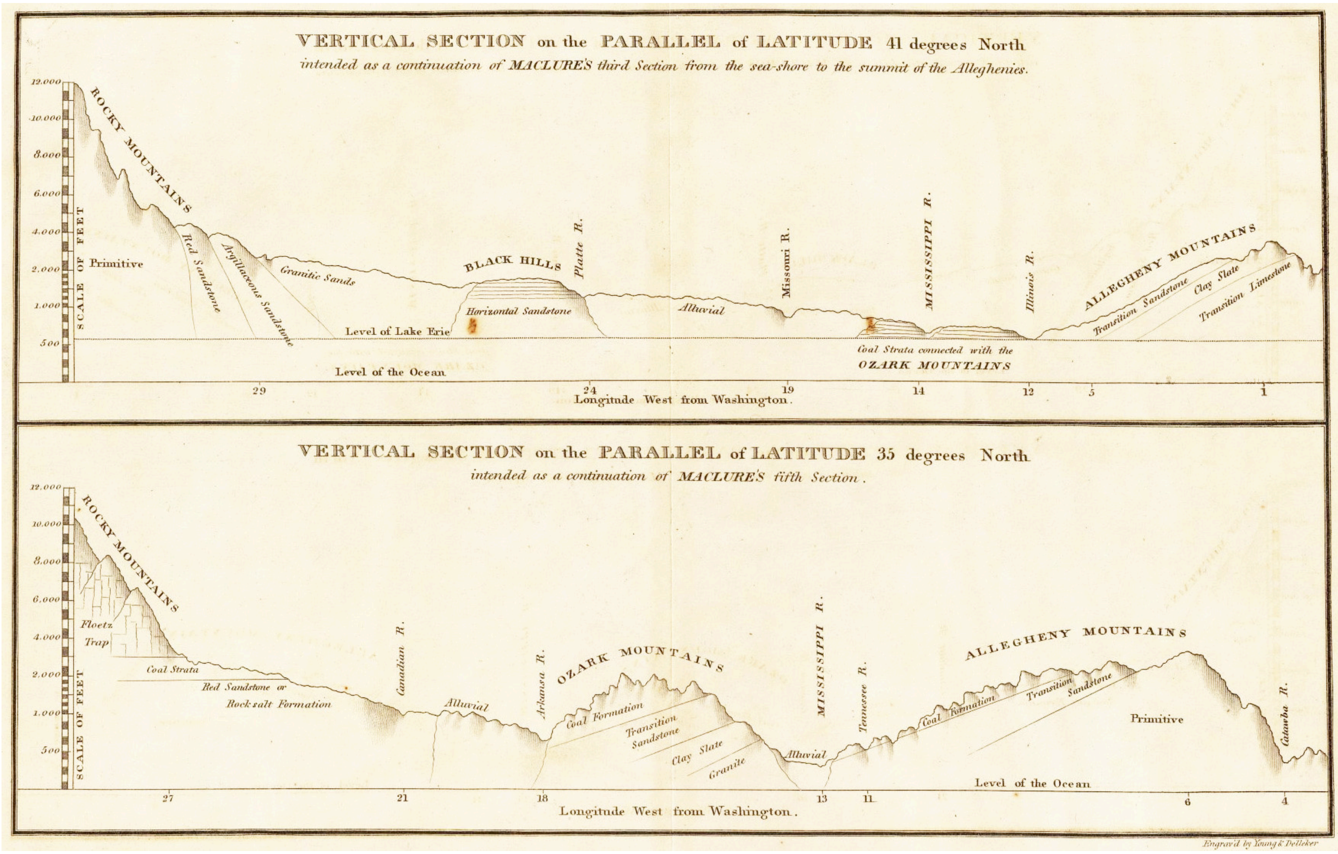

Figure 5. Vertical sections depicting James' extensions of Maclure's geology westward (James, 1823). James (1822b, p. 326) advised that the horizontal scale is inaccurate and that "*the inclination indicated by the lines between the formations is not to be considered applicable to all the strata constituting those formations*".

superimposed in immense mountain masses". Amygdaloid basalts were found in hills or as fragments scattered about the plain. Such fragments appeared light enough to be "*brought down by the rains and the currents of water*" to be distributed widely across the alluvial plain (James, 1824, p. 23).

During the past (James, 1823, p. 294) "*[s]andstones of mountain-derived detritus [were] deposited in the primeval ocean that covered the level of the great plain and flanks of the granitic mountains*". Note the "*supposed level of the Primitive Ocean*" indicated on the Fig. 4 vertical profile belies James' Wernerian education and belief in the existence of a universal ocean that precipitated crystalline rocks. Subsequently, "*[u]plift and tilting [occurred] from the action of some force beneath the primitive rocks, forcing them up to a greater elevation, ... or by the sinking down of the secondary, produced by the operation of some cause equally unknown... [followed by] the retiring of the sea, and the formation of the trap rocks.*" Subsequently, mountain-derived clastic sediments accumulated on the plains marginal to the mountain front (labeled "Granitic Sands" on Fig. 5 – northern section).

In the Ozark Mountains, James (1823, p. 274) observed the granites and more ancient rocks ("clay slate") at the lowest eastern parts (Fig. 5), "*being surmounted by those of a more recent date, the newest horizontal sandstone, and strata of compact limestone, forming the highest summits*". Of argillaceous sandstone in the Ozarks, James (1823, p. 305–306) wrote: "*The sandstones of this small group of mountains appear under almost every variety of character...*", both with and without coal. "*[W]e find a rock apparently possessing as much unity as can belong to such a subject, passing from recent secondary down, through all the intermediate grades, to the oldest transition, and thus heaping confusion upon our doctrines of the original continuity and systematic succession of strata*".

> "*[M]ay not an extensive range of granite and other primitive rocks have existed at some distant period where the Ozark mountains now are, containing the vast quantities of the ores of lead, iron, &c. now found in rocks of recent secondary origin, and even in the alluvial? and may not the operations of water during many ages, when an ocean rolled over the summits of these mountains, have worn down those primitive rocks, their detritus having been deposited horizontally upon their*

Figure 6. Hinton's (1832) geologic map of the United States. In addition to rocks classified as "Primitive", "Transition", "Secondary" and "Alluvial Formations with Tertiary Beds", Hinton delineates separately "Red Sandstone" and Argillaceous Sandstone" and "Trap Rocks" of the Chippewayan [Rocky] Mountains.

> *submarine sides and summits; so that the greater part of their surfaces are now covered by secondary aggregates. ... This supposition may derive some confirmation from the well known fact that this region is still in a remarkable degree subject to subterranean concussions and earthquakes*" (James, 1823, p. 311–312, 319–320).

He concluded that the Ozark Mountains were "*a separate system within themselves, and having no immediate connection with the Alleghanies or Rocky Mountains*" (James, 1823, p. 311).

In the Alleghany [Appalachian] Mountains James (1823, p. 323) focused on strata on the northwestern side of the range that are "*most intimately connected with the great secondary formations of the west*". The stratigraphic succession appeared as follows (James, 1823, p. 323-326):

1. "*Granular Limestone – Appears in every part of the United States, where it has hitherto been observed to be the uppermost in the series of primitive rocks ... [but] is often found to graduate, by minute and imperceptible shades of difference, into that which is decidedly secondary. ... This fact ... ought not, perhaps, to be considered as invalidating the received opinions with regard to the classification of rocks according to the doctrines of Werner. ... The series of rocks next in order to the primitive limestone ... has been very generally denominated the Transition Class. It comprehends the following strata: Metalliferous limestone, Clay-slate, Graywacke, and Graywacke-slate, and Old Red sandstone.*"

2. "*Metalliferous limestone. – It is the lowest and is considered as the most ancient of the rocks containing organized remains, which are those of cryptogamous, plants and animals without sight*" exposed along the northwestern flank of the range.

3. "*Transition Argillite. – It is believed, that throughout the range of country occupied by the several rocks here mentioned, they will be found too intimately blended, and too closely entangled with each other, to allow of their being considered as separate formations.*"

In his summary, James (1823, p. 271) concluded that his attempt to describe the geology of the region was hampered by "*the unsettled and progressive condition of geognostic science*".

> "*It must be evident to any person in the slightest degree familiarized to the examination of the rocky materials composing the earth's surface that between any two of the contiguous artificial divisions there is oftentimes no definite and discoverable boundary. Granite must consist essentially of feldspar, quartz, and mica; so must gneiss and mica-slate; and between the two former, it is often extremely difficult ... [to define] the termination of the one and the commencement of the other*" (James, 1823, p. 272).

Nelson (1999) noted that James was puzzled by the absence of transition rocks, nearly all the primitive stratified rocks, and various calcareous formations expected in the Wernerian succession:

> "*If a division is to be made of the rocks strata of the earth into primitive, transition, &c. it is, perhaps, of little importance whether the boundaries thus instituted shall traverse beds of the same substance, or separate contiguous strata composed of different materials*" (James, 1823, p. 323).

5 Hinton's modification of Maclure's map

John Howard Hinton (1791–1873), an English theologian and historian, published: *The History and Topography of the United States* in 1832, with second and third editions to follow in 1846 and 1852. Hinton emigrated to the United States in 1822. He accepted a call to the 1st Baptist Church of Richmond, Virginia, where his views against slavery made him unpopular. He therefore resigned and removed to Chicago in 1835, where he supplemented his salary by teaching. His encyclopedic work reviewed all aspects of the United States, including the political, historical, economic, geographic and geologic. His accompanying geologic map of the United States (Fig. 6) was largely a less detailed compilation of the earlier maps of Maclure and James, but nevertheless the first colored map to incorporate James' observations west of the Appalachians (White, 1977; Nelson, 1999).

Hinton (1846, p. 4) noted that the United States is naturally divided into the "Atlantic Slope" east of the Appalachians, a "great central valley" extending west from the Appalachians to the "Chippewayan Mountains", and a portion from the latter to the Pacific Ocean. The Chippewayan Mountains [Colorado Rocky Mountains] "*are of much greater altitude ... and much more distinguished by conical peaks, and marks of volcanic agency. They are not broken through by the numerous rivers which rise in them, but constitute the dividing ridge of the respective waters*" (Hinton, 1846, p. 6).

> "*The summits of this chain of mountains are formed entirely of primitive rocks, and almost exclusively, not merely of the granitic family, but of granite itself. The primitive clay-slate and limestone appear to be entirely wanting, together with mica-slate, while gneiss occurs in small quantity, and the granite passes into it by imperceptible gradations. As many members of the primitive class are here absent, the transition rocks of the Wernerians are altogether so*" (Hinton, 1846, p. 40–41).

In stratigraphic succession, siliclastic sandstone rested unconformably upon the granites (Hinton, 1846, p. 41):

> "*It consists of two members. 1. Red sandstone. – This rock, which is the lowest of the horizontal of floetz rocks, ... is very abundant ... immediately subjacent to the mountains. It occurs at intervals along their base, reposing against the primitive rocks in an erect or highly-inclined position.*"

Immediately above the red sandstone was gray or yellowish-white sandstone. Hinton (1846, p. 42) noted that as one approaches the mountains, these sandstone formations become increasingly disrupted and more steeply tilted so as to "*resemble the plats of ice often seen thrown into a vertical position ... along the banks of rivers*". Basaltic rocks overlie the sedimentary, "*sometimes they are compact. ... In other instances, black and shapeless masses of porous and amygdaloidal substances are see scattered about the plains or heaped in conical masses*". On his map (Fig. 6), these basalts are shown abutting the crystalline rocks of the Rockies and, as in James' profile, with remarkably high relief (Fig. 7). An apron of clastic debris derived from the mountains, labeled "granitic sands" (Fig. 7), mantled the ever-more-shallowly dipping sandstone formations as one moved east.

Of the Appalachians, Hinton (1846, p. 44–45) noted that "*[a] large portion of these mountains, the whole of their eastern front, is composed of primitive rocks, comprehending both the granitic family and its associated strata of clay-slate and limestone*". The width of this belt greatly varied along strike, with the highest mountains situated towards the northern and southern extremities of the range. Hinton did not include Maclure's "Old Red Sandstone" (Fig. 2) or his line delineating the extent of evaporate deposits on his map (Fig. 6), although he did depict "Transition or Old Red Sandstone" on his northern vertical section (Fig. 7). Rather, he mapped the former for the most part as "Primitive" and omitted the latter (Fig. 6). Thus he omitted pioneering mapping that delineated the Triassic rift basin deposits of eastern North America. The mid-Atlantic coastal plain, which Maclure mapped with an "Alluvial" cover, was delineated as "Alluvial Formations with Tertiary Beds". To the west, Hinton mapped a belt of variable width of "*transition strata consisting of limestone, greywacke slate and sandstone*" (Fig. 6; Hinton, 1846, p. 45).

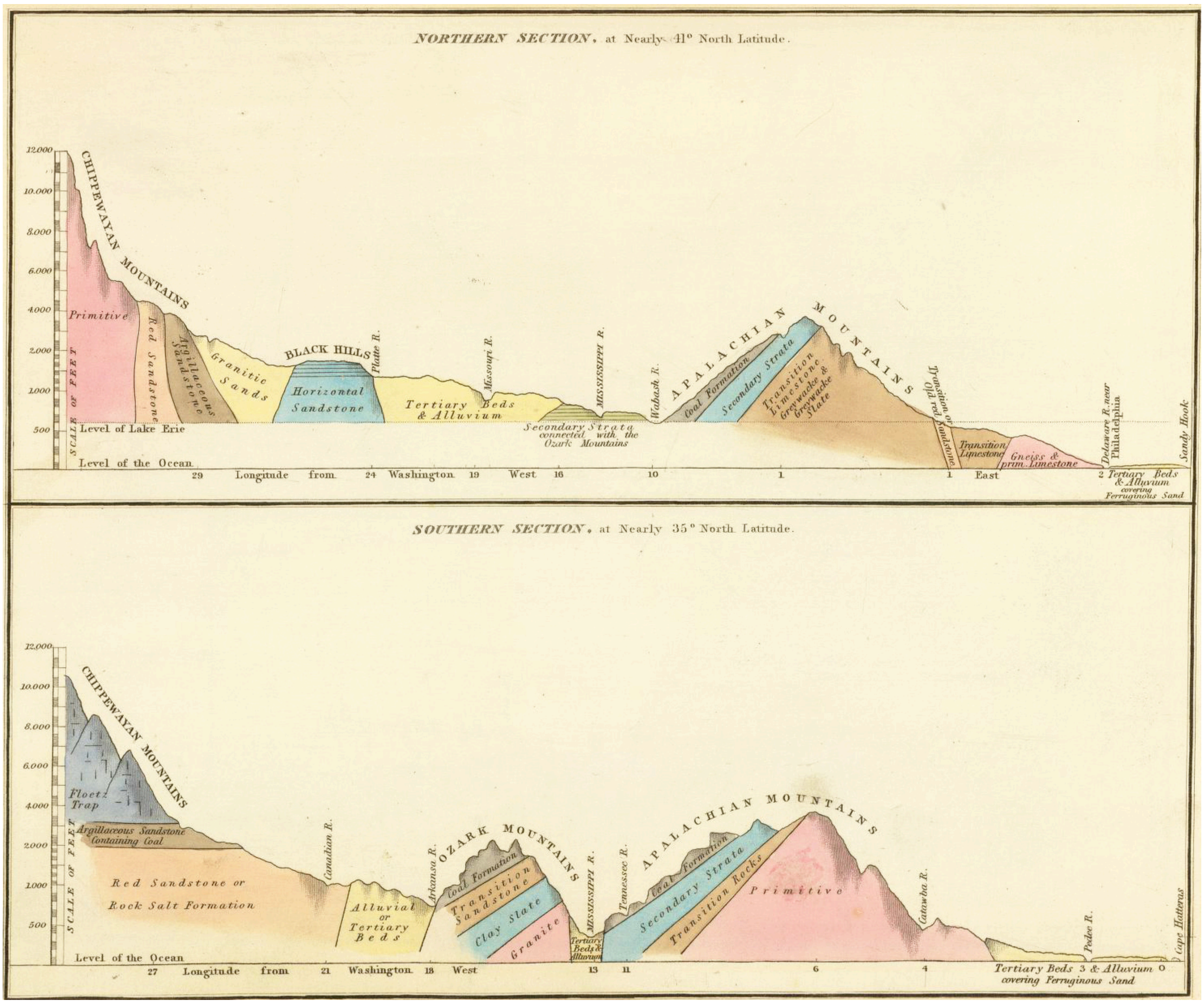

Figure 7. Hinton's vertical sections based largely upon studies by James and Maclure (Hinton, 1832).

The Ozark Mountains were mapped chiefly with "Transition" and "Secondary" rocks plus coal, although subjacent "Primitive" rocks daylight on his vertical section (Fig. 7). The Black Mountains (Black Hills) were mapped as "Secondary Sandstone" (Fig. 6), "*lying horizontally, and ... destitute of any mineral production of value*" (Hinton, 1846, p. 50).

> "*As is the case of almost all the rocks of secondary formation, there appear to have been periods during the time of its deposition when the waters of the superincumbent ocean ceased to throw down the mechanical debris of former rocks, and deposited earthy matter from a state of chemical solution, the old red sandstone contains no beds of bituminous coal, though many of anthracite, and few organized remains*" (Hinton, 1846, p. 46).

Hinton (1846, p. 51) noted that "*[g]eological researches were made with much greater facility in America than in Europe, especially in the region of the secondary strata*". He noted immense extent over which they could be traced and their relatively undisturbed condition that afforded "*valuable facilities for efforts of generalization and system*". As compared with Europe, more consistency existed along the flanks of mountain ranges. Attempts to follow the Wernerian scheme, however, were problematic (Hinton, 1846, p. 52):

> "*The order of succession from the clay salt to the granite, as well as the gradually diminishing height of the strata, from the granite through the gneiss, mica slate, and hornblende rock, down to the clay slate, is so often inverted and mixed, as to render the arrangement of any regular series impracticable. ... The primitive ... and the transition*

> *rocks of the United States, bear an almost perfect resemblance, in structure and general character, to those of Europe. They constitute the whole mass of the mountains, with the same declination, irregularity, and apparent disruption and dislocation of the strata.*"

Hinton (1846, p. 58) noted ample evidence of diluvial action in the eastern United States:

> "*Along the Connecticut [River] in the primitive region, large boulders in great numbers are commonly found, removed not many miles from the spot whence they were derived. ... Some of the highest of these boulders are found insulated on the pinnacles of the mountains. ... Above [the] hills towards Lake Erie, boulders of primitive rocks are found. That they are out of place in a region decidedly secondary and alluvial no one can doubt. They are water-worn, rounded, and smoothed. ... That they have been brought thither from the north ... [is suggested inasmuch as]: 1. they exactly resemble the primitive rocks found ... on the north side of Lake Ontario. 2. In proceeding northwardly ... they increase both in number and size.*"

Although Hinton did not contribute new field data to the Maclure map as modified by James, he was the first to incorporate James' observations in the mid-continent in a widely read publication. His modification of Maclure's "Alluvial" and James' western interior units "*reflected the growing use of mollusks and other fossils*" such was being "*developed in Britain and France, when younger colleagues used the new fossil-based stratigraphic methods to correlate American strata with the European standard*" (Nelson, 1999, p. 57). Thus the success of *The History and Topography of the United States* contributed to the dissemination of the results of William Maclure's and Edwin James' pioneering field mapping.

6 Conclusions

Maclure's mapping and geologic interpretations suffered from his lack of appreciation of the utility of biostratigraphic tools of formation correlation, as well from his fairly strict adherence to the Wernerian geognostic system, albeit with reservations. James, again with reservations concerning Wernerian classification, adhered to most of Maclure's interpretations in extending mapping of the United States across the Mississippi Valley to the Rocky Mountains. Hinton popularized their work, but in extending but generalizing their mapping, lost some detail and added little new information. Renowned mid-century mappers such as Henry Darwin Rogers (1808–1866) and William Barton Rogers (1804–1882) abandoned the Wernerian scheme and employed fossil-based stratigraphy as well as lithology in their definition of formations (Aldrich and Leviton, 1982). They viewed the correlation of time divisions and individual formations in America and Europe as being forced and a "*grave mistake*" that "*could only hinder the advance of geology in the United States*" (Gerstner, 1979, p. 176). This, however, does not diminish the significance of the early maps and geologic sections of Maclure, James and Hinton providing a foundation for the more refined mapping and geologic interpretation of the eastern United States.

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