Geology National Historic Landmark Theme Study
(Draft 1990)

Introduction

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The Geology National Historic Landmark Theme Study represents the second phase of the National Park Service's thematic study of the history of American science. Phase one of this study, Astronomy and Astrophysics: A National Historic Landmark Theme Study was completed in l989. Subsequent phases of the science theme study will include the disciplines of biology, chemistry, mathematics, physics and other related sciences.

The Science Theme Study is being completed by the National Historic Landmarks Survey of the National Park Service in compliance with the requirements of the Historic Sites Act of l935. The Historic Sites Act established "a national policy to preserve for public use historic sites, buildings and objects of national significance for the inspiration and benefit of the American people." Under the terms of the Act, the service is required to survey, study, protect, preserve, maintain, or operate nationally significant historic buildings, sites & objects.

The National Historic Landmarks Survey of the National Park Service is charged with the responsibility of identifying America's nationally significant historic property. The survey meets this obligation through a comprehensive process involving thematic study of the facets of American History.

In recent years, the survey has completed National Historic Landmark theme studies on topics as diverse as the American space program, World War II in the Pacific, the US Constitution, recreation in the United States and architecture in the National Parks. In the years since the passage of the Historic Sites Act of l935, more than 2000 properties in a variety of themes have been identified and designated. Some of these sites are significant in the history of the Earth Sciences in the United States and are listed and discussed below. Before proceeding to this discussion it is well to define the terms Earth Science and geology to explain their relationship to each other and other scientific disciplines.

Definitions

The expression Earth Sciences includes the systematized knowledge of the solid Earth and the fluids within and around it. The three main families included within the Earth Sciences are the geological sciences, which deal with the rocky crust of the Earth and its interior; the hydrologic sciences, which are concerned with all of the waters of the Earth; and the atmospheric sciences, which encompass the physical and the chemical properties of the atmosphere as well as the air and its motions.

This theme study will focus primarily upon the science of geology and its sub- disciplines within the context of the Earth Sciences.

Geology is the group of sciences concerned with the study of the earth, including its structure, long-term history, composition, and origins. There are several sub-disciplines of Geology:[1]

Physical geology deals with the structure and composition of the earth and the forces of change affecting them. Physical geology also includes the disciplines of geodesy, geomorphology, geophysics and seismology.

Historical geology deals with the earth in past ages and the evolution of life upon it. It embraces the sciences of paleoclimatology, paleomagnatism, paleontology, and stratigraphy. Historical geology relies on the dating of events in relationship to the geological time scale.

Economic geology is concerned with the location and exploitation of the earth's natural resources and generally includes the disciplines of crystallography, mineralogy, and petrology. Its practical manifestations are prospecting and mining.

Planetary geology is concerned with the geology of the moon, planets, and other bodies of the solar system.

In addition to the above, the science of geology is also related to sciences of physics, astronomy, chemistry, biology, geography, and economics.

Background: The National Historic Landmarks Survey and the Study of the History of the Earth Sciences

In the l987 publication History and Prehistory in the National Park System and the National Historic Landmarks Program the various facets and related sites that illustrate the history of the geological sciences in the United States are listed in a variety of themes[2].

Although the existing thematic outline appears to be well represented with numerous properties in a variety of themes relating to the geological sciences, a closer examination reveals that a large number of significant properties associated with the history of the geological sciences remain to be identified and designated as National Historic Landmarks.

Previous Theme Studies

Beginning in 1957 and lasting until 1963 a total of 27 out of 40 planned theme studies were completed for the Historic Sites Survey (the original name of the National Historic Landmarks Program). Ten of these theme studies covered the area of Westward Expansion of the British Colonies and the United States from 1763 to 1898 and examined a wide variety of sites important in the history of the Earth Sciences.

For example, in 1960 the Historic Sites Survey completed a theme study titled The Lewis and Clark Expedition.[3] This study identified 7 sites of exceptional significance and 18 sites of lesser significance. By 1991 a total of l3 sites relating to the Lewis and Clark Expedition were designated as National Historic Landmarks. Four national park areas also relate to this theme.

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[1] John-David Yule. ed., Concise Encyclopedia of Science and Technology (New York: Crescent Books, 1985), pp. 253-255. For additional information concerning the geological sciences the reader should consult the following source:

Lapedes, Daniel N. ed., McGraw-Hill Encyclopedia of the Geological Sciences. New York: McGraw-Hill Co., 1975.

[2] U.S. Department of the Interior, National Park Service, History and Prehistory in the National Park System and the National Historic Landmarks Program (Washington, D. C.: National Park Service, 1987)

[3]Appleman, Roy E. ed. The Lewis and Clark Expedition. Washington, DC.: The National Survey of Historic Sites and Buildings, 1960.

The Lewis and Clark Expedition traveled from the mouth of the Missouri River, near St. Louis, in 1804 and 1805, to the Pacific Ocean at the mouth of the Columbia River. In 1806 it recrossed the country eastward. The impact of the expedition on American life and our knowledge of the lands west from the Mississippi was immense. The expedition opened up the western United States and enlarged our geographic and scientific knowledge of these lands. Among the subjects touched upon by the expedition were the fields of botany, wildlife, geology and the suitability of the land for human use.

While not all of these sites strictly relate to the study, identification or exploitation of the Earth Sciences, many of them have at least a minor component relating to the Earth Sciences and geology. No additional sites relating to the Lewis and Clark Expedition are identified in this study.

An outline of the existing theme structure with related sites in this area is given below:

Theme X: Westward Expansion of the British Colonies and the United States, 1763-1898

Subtheme A: British and United States Exploration of the West

2. Lewis and Clark Expedition, l803-l806

<u>National Parks and Affiliated Areas</u>

Fort Clatstop National Memorial, OR
Knife River Indian Villages National Historic Site, ND
Lewis and Clark National Historic Trail,
IL-MO-KS-IA-NE-SD-ND-MT-ID-WA-OR
(Affiliated Area)
Nez Perce National Historical Park, ID

<u>National Historic Landmarks</u>

Camp Disappointment, MT
Great Falls Portage, MT
Lemhi Pass, ID-MT
Lolo Trail, ID-MT
Pompey's Pillar, MT
Sergeant Floyd Monument, IA
Three Forks of the Missouri, MT
Traveler's Rest, MT
Weippe Prairie, ID

The present thematic outline also lists 6 National Historic Landmarks and 2 National Parks related to other scientific and technical surveys of the West under Theme X.

3. Scientific and Topographical Surveys

National Parks

Fort Smith National Historic Site, KS
Grand Canyon National Park, AZ

National Historic Landmarks

Desolation Canyon, UT
Expedition Island, WY
Fort Atkinson, NE
Fort Washita, OK
Pikes Peak, CO
Pikes Stockade, CO

In 1959 the Historic Sites Survey completed a theme study titled The Mining Frontier.[4] This study identified 13 sites of exceptional significance and 41 sites of lesser significance. By 1991 a total of 29 of these sites, and other sites identified by later studies, were designated as National Historic Landmarks. Three additional sites are now National Parks. This study was published by the National Park Service under the title Prospector, Cowhand and Sodbuster (National Park Service, 1967). Many of the landmarks identified under this theme (Theme X) fall into the category of economic geology (prospecting and mining):

Subtheme E: The Mining Frontier

1. California Gold Rush

National Historic Landmarks

Coloma, CA
Columbia Historic District, CA
New Almaden, CA
Old Sacramento Historic District, CA
Old United States Mint, CA
Sutter's Fort, CA
Yuma Crossing, AZ-CA

2. Northwest: Oregon, Washington, Idaho, and Western Montana

National Historic Landmarks

Assay Building, ID
Bannock Historic District, MT
Butte Historic District, MT
Fort Hall, ID
Jacksonville Historic District, Or
Virginia City Historic District, MT

3. Southwest: Arizona and New Mexico

[4] Everhart, William C. The Mining Frontier. San Francisco, California: The National Survey of Historic Sites and Buildings, 1959.

National Historic Landmarks

Jerome Historic District, AZ
Tombstone Historic District, AZ

4. Great Basin: Nevada, Utah, and Eastern California

National Historic Landmarks

Bodie Historic District, CA
Fort Douglas, UT
Virginia City Historic District, NV

5. Rockies: Colorado and Wyoming

National Historic Landmarks

Central City Historic District, CO
Cripple Creek Historic District, CO
Georgetown-Silver Plume Historic District, CO
Leadville Historic District, CO
Silverton Historic District, CO
Telluride Historic District, CO

6. Black Hills of South Dakota

National Historic Landmarks

Deadwood Historic District, SD

7. Alaskan Gold Rushes

National Parks

Iditarod National Historic Trail, AK
(Affiliated Area)
Klondike Gold Rush National Historical Park, AK-WA
Yukon-Charley Rivers National Preserve, AK

National Historic Landmarks

Cape Nome Mining District Discovery Sites, AK
Chilkoot Trail and Dyea Site, AK
Fort William H. Seward, AK
Skagway Historic District and White Pass, AK

In 1966, the Historic Sites Survey completed the Commerce and Industry Theme Study. Although this theme did not deal with the subject of the Earth Sciences directly, many sites important in the history of the mining and extractive industries (economic geology) were examined. This subject was further examined in 1976 through a contract with the American Association for State and Local history, which continued an examination of properties in the Commerce and Industry theme. This multi-year study identified numerous stores, office buildings, shops, and factories--many still in commercial use--as potential landmarks.[5] A total of 28 National Historic Landmarks and one National Historic Site represent

[5] Barry Mackintosh. The Historic Sites Survey and the National Historic Landmarks Program--A History. (Washington: D.C.: National Park Service, 1985)

this theme.

Theme XII: Business

Subtheme A: Extractive and Mining Industries

1. Iron and Ferro Alloys

National Parks

Saugus Iron Works National Historic Site, MA

National Historic Landmarks

Andrew Carnegie Mansion, NY
Cornwall Iron Works, PA
Elkins Coal & Coke Company Historic District, WV
Hull-Rust-Mahoning Open Pit Iron Mine, MN
Mountain Iron Mine, MN
Ringwood Manor, NJ
Saugus Iron Works, MA
Sloss Blast Furnaces, AL
Souden Iron Mine, MN
Stiegel-Coleman House, PA

2. Petroleum and Related Resources

Charles W. Morgan, CT
Drake Oil Well, PA
Lucas Gusher, TX
E. W. Marland Mansion, OK
Andrew Mellon Building, DC
Norman No. 1 Oil Well, KS
John D. Rockefeller Estate, NY
Harry F. Sinclair House, NY
Well No. 4, Pico Canyon Oil Field, CA

3. Other Metals and Minerals

Bingham Canyon Open Pit Copper Mine, UT
James C. Flood Mansion, CA
Jerome Historic District, AZ
Kennecott Mine, AK
Andrew Mellon Building, DC
New Almaden, CA
Phelps Dodge General Office Building, AZ
William C. Ralston House, CA
Reed Gold Mine Site, NC

The sciences of physical geography, geology, hydrology and meteorology, were examined in the 1964 theme study Inventions and Scientific Discoveries[6]. This theme study recommended 15 sites as

pp. 107-108.

[6]No listed author. Inventions and Scientific Discoveries. Washington, DC.: The National Survey of Historic Sites and Buildings, 1964.

exceptionally significant and listed 23 others sites as of lesser significance. A total of 19 sites are now listed as National Historic Landmarks for these subjects.

Theme XIII: Science

Subtheme B: Earth Science

l. Physical Geography

National Historic Landmarks

William M. Davis House, MA
Matthew Henson Residence, NY
Leffingwell Camp Site, AK
Old Naval Observatory, DC

2. Geology

National Historic Landmarks

Edward Drinker Cope Home, PA.
Reginald A. Daly House, MA.
James Dwight Dana House, CT.
William M. Davis, MA.
Leffingwell Camp Site, AK.
Old Scripps Building, CA.
David White House, DC
Robert W. Woodward House, DC
James Hall's Office, NY

3. Hydrology

National Historic Landmarks

Old Naval Observatory, DC
Old Scripps Building, CA.

4. Meteorology

National Historic Landmarks

Cleveland Abbe House, DC
Fort Meyer Historic District, VA.
Leonard Rockshelter, NV
Old Naval Observatory, DC

Subtheme C: Biological Sciences

3. Paleontology

National Parks

Agate Fossil Beds National Monument, NE
Dinosaur National Monument, CO-UT
John Day Fossil Beds National Monument, OR

National Historic Landmarks

Edward Drinker Cope Home, PA.
Othniel C. Marsh House, CT.
James Hall's Office, NY

One site listed under this theme, the Old Scripps Building, should be listed under Oceanography (a subject that is not identified in the present thematic outline).

The present thematic outline includes the subject of historical geology as a subtheme of biology. This designation should be corrected to include historical geology, including the subdisciplines of paleo-climatology, paleomagnetism, paleontology and stratigraphy, as a subtheme of geology.

The subject of education was first covered by the National Historic Landmarks Survey in 1960 with the publication of the Education Theme Study.[7] This theme study recommended 23 sites as exceptionally significant and 93 sites as lesser significance. In addition more than 100 other sites were noted in the study with no additional information. Only one site described in this theme study relates to the geological sciences--The Smithsonian Institution in Washington, DC.

In 1965 the National Historic Landmarks Survey completed a supplement to the Education Theme Study.[8] This supplement recommended 40 sites as exceptionally significant and more than 100 additional sites as of lesser significance. None of these sites had anything to do with the science of geology.

The subject of education now lists two sites of importance to the geological sciences:

Theme XXVII: Education

Subtheme G: Adjunct Educational Institutions

1. Museums, Archives, and Botanical Gardens

National Historic Landmarks

Smithsonian Building, Washington, DC
Wagner Free Institute of Science, PA

Planetary geology is not represented in the theme outline although one potential site-the Lunar Receiving Laboratory at the NASA Lyndon B. Johnson Space Center was studied in 1983, as part of the Man in Space National Historic Landmark Theme Study.

[7]No author listed. Education. Washington, DC.: The National Survey of Historic Sites and Buildings, 1960.

[8]No author listed. Education-Supplement. Washington, DC.: The National Survey of Historic Sites and Buildings, 1965.

The Geology National Historic Landmark Theme Study will primarily focus on the identification of sites in the areas of physical geology, historical geology and economic geology and secondarily in the identification of sites in the areas of planetary geology, exploration, scientific and topographical surveys.

Final note: The National Historic Landmarks Survey does not generally consider for designation property that has achieved significance within the last 50 years. Therefore, the cutoff date for the Geology Theme Study is l942. Sites that have achieved significance since l942 were not be considered within the context of this study unless they were deemed to be extraordinarily significant.

In addition to the existing list of National Historic Landmarks, the National Park Service maintains other lists of properties significant in the natural and cultural history of the United States. Many sites important to the history of American Geology can be found on this lists. These lists include both the National Registry of Natural Landmarks and the National Register of Historic Places.

National Natural Landmarks Program

Many sites important in the history of the earth sciences and geology have already been identified by the National Natural Landmarks Program[9]. These sites were selected for designation as National Natural Landmarks (NNL) because they represent the best examples of the ecological and geographical features composing the Nation's natural heritage. The National Natural Landmarks Program was established by the Secretary of the Interior in l962 to help identify and encourage the preservation of these significant areas. Since that time more than 600 sites have been designated by the Secretary of the Interior as National Natural Landmarks. Those sites that have previously been designated as National Natural Landmarks that are included in the following study list are identified with the abbreviation (NNL). The reason for including some National Natural Landmarks on the study list is to recognize the importance of these areas for their historical values as well as their already recognized natural values.

National Register of Historic Places

A few sites important in the history of science have been listed in the National Register of Historic Places. The National Register, maintained by the National Park Service, is the nation's official list of districts, sites, buildings, structures, and objects significant in American history, architecture, archeology, engineering, and culture.

Finally, many units of the National Parks were established, either wholly or in part, to protect significant geological resources. A number of these parks are included in the proposed study list so that the history associated with their important geological resources can be documented.

Those sites on the proposed study list for the Geology Theme Study that are Natural Landmarks (NNL), units of the National Park System (NP) or listed in the National Register of Historic Places (NR) are so indicated.

[9] U.S. Department of the Interior, National Park Service, Natural History in the National Park System and on the National Registry of Natural Landmarks (Washington, D.C.: National Park Service, 1990)

Emphasis on Contexts-The Role of the State Historic Preservation Officers and the State Geologists.

In a series of discussions held in Washington in late 1990, representatives from the National Conference of State Historic Preservation Officers proposed a new method of completing the Geology Theme Study to the National Park Service.

Under this approach titled "The Modest Proposal" the execution of the Geology theme Study and accompanying NHL designations would concentrate on the production of an historic context for national significance in the history of the geological sciences and a sample of completed National Historic Landmark nominations would be chosen to illustrate the most important examples of the pool of known resources, or provide examples of acceptable documentation of several property types within the theme. As much as possible the production of NHL nominations would be revised to include all aspects of a properties National Register significance and not just the area of national significance.

In order to accomplish this goal, the Geology Theme Study is intended to establish the historical context for determining the national significance of properties in the history of the geological sciences; prepare documentation for a sample of the affected resources, and suggest additional properties which appear to qualify for National Historic Landmark designations and National Register designations.

The reason for this approach is that the study of the geological sciences is large and beyond the limits of time and money available to the National Historic Landmarks Survey. Given these limits, the Geology Theme Study that follows is intended to concentrate on the history of the science of geology with illustrations of existing resources already identified with the theme. In addition the theme study contains a small sample of new nominations designed to illustrate the documentation necessary for this class of resources and suggestions for additional specific resources that may qualify for listing on the National Register of as National Historic Landmarks, pending the completion of additional nominations.

The Geology Theme Study is not intended to be a complete and final assessment of this class of resources. This theme study is merely an initial overview of this subject with recommendations for additional study and future nominations. The completion of the Geology Theme Study will come only when the State Historic Preservation Officers, concerned Federal Agencies and State Geologists assess the significance of the various sites proposed for further study and prepare further individual nominations.

The success or failure of this approach to the thematic study of the America's cultural resources will depend upon the continue cooperation of these various agencies with the National Park Service to ensure a continual flow of nominations in this theme to both the National Register and the National Historic Landmarks Survey.

Methodology

Note: Since the purpose of this theme study is to serve as a vehicle for providing a national context for the study of sites important in the history of geology the following methodology should be considered before preparing either National Register or National Historic Landmark nominations for this class of resources.

IDENTIFICATION OF HISTORIC RESOURCES FOR THE GEOLOGICAL SCIENCES[10]

The complete and final identification of historic resources relating to the history of the geological sciences will require a survey by the State Historic Preservation Officers to supplement the information pertaining to both the location and history of the various sites outlined in this theme study. The sample of nominations contained in the appendix to this study are intended to provide concrete examples for the nomination of this class of resources both to the National Register of Historic Places and eventually as National Historic Landmarks. In all cases the State Historic Preservation Officers should consult with the State Geologists, as subject matter specialists, before preparing any nominations.

Historic Contexts[11]

When beginning a survey the amount of data available can be overwhelming. In preparing this report, for example, many hundreds of sources, both primary and secondary, were consulted. Letters to all the State Historic Preservation Officers and State Geologists were mailed. In addition more that one hundred other individuals, either geologists for historians of science were consulted for suggestions. Numerous field trips to certain selected sites were also made.

The best way to handle this mass of information is to break down known data into manageable units by developing historic context. The definition of historic context is "an organizational framework that groups information about related historic properties based on a theme, geographic area, and a time period."[12] The historic context focuses the identification, evaluation, and protection efforts and forms the basis for decision-making about what to survey, what is likely to be found, how to evaluate what is found, and how to manage significant resources.

The process of developing a historic context before starting field survey activities is a way of stepping back and taking a survey of the situation in order to formulate an efficient approach to undertaking the field survey. The historic context should first identify the concept, time period, and geographic limits for the study. Contexts can be developed at any level for example, local context might be the stone industry in the Chicago-Milwaukee area from the time of settlement in the 1820s until the First World War; a state level context could be the discovery and exploitation of paleontological sites associated with the Morrison formation from discovery in the 1860s until the onset of the Second World War; a national context might be nineteen century gold rushes in the United States.

The next step is to assemble existing information about the context, which might consist of an historical overview, existing survey data, land-use plans, environmental impact statements and recommendation from geologists and historians of the Earth Sciences. The historic context should synthesize all of this information into a useable form that identifies important patterns, events, persons, and cultural values. This information is directed toward the identification of the physical resources associated with and illustrative of this history.

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[10] The information from this section of the report discussing the National Register of Historic Places was taken from the following source: U.S. Department of the Interior, Manual for State Historic Preservation Review Boards (Washington, D.C.: National Park Service, 1990), pp. 14-38. For more detailed information the reader should consult the manual directly.

[11] For information concerning the best way to develop a historic context for historic geological sites the reader should consult the following article: Ann Houston. "The Survey and Inventory of Mining Properties," in Leo R. Barker and Ann Houston. ed., Death Valley to Deadwood; Kennecott to Cripple Creek-Proceedings of the Historic Mining Conference, January 23-27, 1989, Death Valley National Monument. (San Francisco, California: National Park Service, 1990). pp 16-17. Much of the information in this section of the report regarding historic context statement for geological sites was adapted from this article.

[12] Ibid.

The next task is to identify the known property types associated with this context. In the identification process property types can include buildings, sites, structures, objects or even large geological formations, such as an extinct volcano. The property type selected would be closely linked to the historic essay that provides the context and overview. In the case when an individual or idea can be represented by two or more sites, a selection as to which is more appropriate will have to be made.

The final step is to explain where these resources are found and their current condition. Additional archival research and field survey may be necessary to fill in the gaps. The information needed should contain data on the historical and physical character of a site. The significance of the site within the context of the history of the Earth Sciences should also be addressed if the site is being nominated as a National Historic Landmark. Additional information may include how much is already known about the resource and what kind of further study might be needed in the future; the location and distribution of the geological and/or historic resources and their relationship to the history of the geological sciences. A clearly marked map showing the location and boundaries of the resource(s) is also important.

The ideal survey team should contain both a professional historian and a geologist. Other persons knowledgeable about the resources to be dealt should also be included, if possible.

Background research is an important element in locating and evaluating this class of resources. Data already known from previous surveys, and about historic patterns of land use, economic change, social interaction and technological innovation can help predict where historic sites are located, what they will look like, and what their associations will be with broad patterns of local, regional and national history. Many of our large research universities contain important repositories of information. More specialized historical background data can be gleaned by examining published histories of the geological sciences, libraries associated with the office of the State Geologists, and from the United States Geological Survey Library in Reston, Virginia. Local historical societies and especially museums with collections pertaining to the Earth Sciences will prove useful. Specialized organizations, such as the History of Earth Sciences Society, the National Academy of Sciences and the National Science Foundation should also be consulted if needed. In all cases, I have indicated a further sources of information for each of the locations identified in my preliminary survey.

Final Note

Surveys can be designed in a variety of ways. Choosing the appropriate survey depends on the kind and purpose of information sought, how quickly it is needed, the amount of money and personnel available, and the size of the region being surveyed. "The Secretary of the Interior's Standards and Guidelines" contain specific information on survey methods and types of information that should be gathered. A useful discussion of various survey approaches is included in Thomas F. King's Archeological Survey: Methods and Uses, and National Register Bulletin 24, Guidelines for Local Survey: A Basis for Preservation Planning.

A broad topic of interest inherent in the study of the history of the Earth Sciences means that it is impossible to collect all information about a property. Data collection is inherently selective, especially given constraints of time and money, and should be undertaken with a clear idea of its eventual use. The data should be sufficient to determine whether the resources in the inventory are of sufficient importance to be eligible for listing in the National Register, and as National Historic Landmarks, if they are believed to be nationally significant. Information needed to identify and evaluate the significance of resources against the standards of the National Register and National Historic Landmarks Survey should include:

1. A description of the property's physical appearance, assessment of its historic, architectural, or archeological or geological integrity.

2. A comprehensive statement of its significance.

3. A map with clearly delineated boundaries and photographs.

After the historic context for a site, or class of sites, has been established it is time to apply the National Register criteria for evaluation.

National Register Process

The National Register of Historic Places is the official list of the Nation's cultural resources worthy of preservation. Authorized under the National Historic Preservation Act of 1966, the National Register is part of a national program to coordinate and support public and private efforts to identify, evaluate, and protect our historic and archeological resources.

The National Register includes:

1. All historic areas in the National Park System

2. National Historic Landmarks which have been designated by the Secretary of the Interior for their significance to all Americans and

3. Properties significant to the Nation, State, or community which have been nominated by the States, Federal agencies and others approved by the National Park Service.

Most nominations to the National Register are made by the States through the State Historic Preservation Officers. Federal agencies are required by law to locate, inventory and nominate to the National Register historic properties in Federal ownership or control. Any individual preparing a nomination of a property identified in this theme study to the National Register should first contact the relevant State Historic Preservation Officer for further information. A list of the addresses of the State Historic Preservation Officers is included in the appendix to this study.

National Register Criteria for Evaluation

National Register criteria define, for the nation as a whole, the scope and nature of historic and archeological properties that are considered for listing in the National Register of Historic Places.

> The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:

A. that are associated with events that have made a significant contribution to the broad patterns of our history; or

B. that are associated with the lives of persons significant in our past; or

C. that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. that have yielded, or may be likely to yield, information important to prehistory or history.

Ordinarily cemeteries, birthplaces, or graves of historical figures, properties owned by religious institutions or used for religious purposes, structures that have been moved from their original locations, reconstructed historic buildings, properties primarily commemorative in nature, and properties that have achieved significance within the past 50 years shall not be considered eligible for the National Register. However, such properties will qualify if they are integral parts of districts that do meet the criteria or if they fall within the following categories:

A. a religious property deriving primary significance from architectural or artistic distinction or historical importance; or

B. a building or structure removed from its original location but which is significant primarily for architectural value, or which is the surviving structure most importantly associated with a historic person or event; or

C. a birthplace or grave of a historical figure of outstanding importance if there is no other appropriate site or building directly associated with his productive life; or

D. a cemetery that derives its primary significance from graves of persons of transcendent importance, from age, from distinctive design features, or from association with historic events; or

E. a reconstructed building when accurately executed in a suitable environment and presented in a dignified manner as part of a restoration master plan, and when no other building or structure with the same association has survived; or

F. a property primarily commemorative in intent if design, age, traditional, or symbolic value has invested it with its own historical significance; or

G. a property achieving significance within the past 50 years if it is of exceptional importance.

The National Register criteria are broad in order to provide an analytical framework that can encompass the diversity of historic resources across the nation. The physical environment that people create for themselves in various periods of history is based upon needs, technologies, attitudes, and assumptions, all of which taken together shape a community's or a State's historic character or identity. Significance is based on a property's capacity to convey some aspect of that character or identity from a specific period of our history. Whether or not a property can convey this depends upon its physical integrity. It is also important to remember that significance is not limited to properties associated with the most important figures in a State's history or the best example of a particular type of resource. A wide variety of properties, ranging from the simple to the complex, can serve as tangible evidence of a community's historic identity and can give perspective to the past.

There are many methods of classifying types and arrangements of historic resources. The National Register uses the following definitions, and nominations are to be submitted in one of these categories:

A district possesses a significant concentration, linkage, or continuity of sites, buildings, structures, or objects united historically or aesthetically by plan or physical development.

A site is the location of a significant event, a prehistoric or historic occupation or activity, or a building or structure, whether standing, ruined, or vanished, where the location itself possesses historic, cultural, or archeological value regardless of the value of any existing structures.

A building, such as a house, barn, church, hotel, or similar construction, is created principally to shelter any form of human activity. "Building" may also be used to refer to a historically or functionally related unit, such as a courthouse and jail or a house and barn.

The term structure is used to distinguish from buildings those functional constructions made usually for purposes other than creating human shelter.

The term object is used to distinguish from buildings and structures those constructions that are primarily artistic in nature or are relatively small in scale and simply constructed. Although it may be, by nature or design, movable, an object is associated with a specific setting or environment.

The National Historic Landmark Process

Before the National Park System Advisory Board reviews a National Historic Landmark Nomination, the owners, specified government officials, and the public are invited to comment and may attend the Board's meeting. Owners of private property may object to designation. The Board may recommend to the Secretary that a property be designated or not, declared eligible for designation, or deferred for further study. The Director of the National Park Service reviews the nomination and the Board's recommendations and transmits them to the Secretary along with his own recommendations and any public comments. The Secretary reviews this transmittal and acts on the recommendations.

Certain rules govern the Secretary's decision. If a private owner (or the majority of owners in a historic district) objects to designation, the Secretary may not make the designation but may, instead, declare the property eligible for designation. Places which the Secretary finds do not meet the criteria may be listed in, or determined eligible for, the National Register of Historic Places, based on their local or State importance.

In cases of endangered properties, the Secretary may designate without Board review. Notice, nomination, and owner involvement are generally the same as for studies reviewed by the Board.

The following criteria are prescribed for evaluating properties for designation as National Historic Landmarks. The National Park System Advisory Board applies them in reviewing nominations and in preparing recommendations to the Secretary. The criteria establish the qualitative framework in which comparative analysis of historic properties takes place.

National Historic Landmarks Criteria for Evaluation

The quality of national significance is ascribed to districts, sites, buildings, structures and objects that possess exceptional value or quality in illustrating or interpreting the heritage of the United States in history, architecture, archeology, engineering and culture and that possess a high degree of integrity of location, design, setting, materials, workmanship, feeling, and association, and:

(1) That are associated with events that have made a significant contribution to, and are identified with, or that outstandingly represent, the broad national patterns of United States history and from which an understanding and appreciation of those patterns may be gained; or

(2) That are associated importantly with the lives of persons nationally significant in the history of the United States; or

(3) That represent some great idea or ideal of the American people; or

(4) That embody the distinguishing characteristics of an architectural type specimen exceptionally valuable for the study of a period, style or method of construction, or that represent a significant, distinctive and exceptional entity whose components may lack individual distinction; or

(5) That are composed of integral parts of the environment not sufficiently significant by reason of historical association or artistic merit to warrant individual recognition but collectively compose an entity of exceptional historical or artistic significance, or outstandingly commemorate or illustrate a way of life or culture; or

(6) That have yielded or may be likely to yield information of major scientific importance by revealing new cultures, or by shedding light upon periods of occupation over large areas of the United States. Such sites are those which have yielded, or which may reasonably be expected to yield, data affecting theories, concepts and ideas to a major degree.

Exclusions and Exceptions to Exclusions:

Ordinarily, cemeteries, birthplaces, graves of historical figures, properties owned by religious institutions or used for religious purposes, structures that have been moved from their original locations, reconstructed historic buildings and properties that have achieved significance within the past 50 years are not eligible for designation. Such properties, however, will qualify if they fall within the following categories:

(1) A religious property deriving its primary national significance from architectural or artistic distinction or historical importance; or

(2) A building or structure removed from its original location but which is nationally significant primarily for its architectural merit, or for association with persons or events of transcendent importance in the Nation's history and the association consequential; or

(3) A site of a building or structure no longer standing but the person or event associated with it is of transcendent importance in the Nation's history and the association consequential; or

(4) A birthplace, grave, or burial if it is of a historical figure of transcendent national significance and no other appropriate site, building or structure directly associated with the productive life of that person exists; or

(5) A cemetery that derives its primary national significance from graves of persons of transcendent importance, or from an exceptionally distinctive design or from an exceptionally significant event; or

(6) A reconstructed building or ensemble of buildings of extraordinary national significance when accurately executed in a suitable environment and presented in a dignified manner as part of a restoration master plan, and when no other buildings or structures with the same association have survived; or

(7) A property primarily commemorative in intent if design, age, tradition, or symbolic value has invested it with its own national historical significance; or

(8) A property achieving national significance within the past 50 years if it is of extraordinary national importance.

Nomination Formats

Each listing in the National Register of Historic Places or the list of National Historic Landmarks fits one of the five categories or resource types described above. A category of property may be: (i) nominated and listed individually using National Register of Historic Places Documentation Form (NPS-10-900), or (ii) more than one property nominated in a multiple property format using National Register of Historic Places Multiple Property Documentation Form (NPS-10-900-b) provided that all included properties bear some significant historic or cultural relationship to each other. In either case, each district, site, building, structure, and object included in the nomination will be evaluated individually against the National Register Criteria and/or the National Historic Landmarks Criteria.

The Multiple Property Documentation Form (NPS-10-900-b) is a cover document and not a nomination in its own right; it serves as a basis for evaluating the National Register and National Historic Landmark eligibility of related properties. On it, the themes, trends, and patterns of history shared by the properties are organized into **historic contexts** and **property types** representing those contexts. It may be used to nominate a large number of related historic properties simultaneously, or to establish the registration requirements for properties not yet identified or documented, but which are expected to be nominated in the future. The nomination of each building, site, district, structure, or object within a thematic group is made on the National Register Registration Form. The name of the thematic group, denoting the historical framework of nominated properties is the **multiple property listing**. When nominated and listed in the National Register of Historic Places, the Multiple Property Documentation Form, together with the individual Registration Forms, constitute a **multiple property submission**.

Questions

The preparation of nominations for the National Historic Landmarks Survey and the National Register of Historic Places usually prompts questions concerning the mechanics of preparing the nomination forms. Some of these commonly asked questions are listed below. For further information the reader should consult the list of suggested readings attached to the end of this section.

1. How does multiple property documentation form differ from a historic district nomination?

The Multiple Property Nomination is a format for submitting groups of related properties and can include districts, sites, buildings, structures, and objects in a specific rural area, town, county, or section of a town, city, region, or State. These properties share a common association with the broad unifying themes, trends or, patterns of an area's history, such as historic events, significant persons, architectural styles, archeological types, or physical characteristics. Information common to the group of properties is documented in the multiple property documentation form.

A district, on the other hand, is itself a historic resource. It is a coherent whole, consisting of a grouping of buildings, sites, structures and/or objects that convey a sense of time and place and/or that convey significant information because of the design and relationship of component parts. There may be buildings or features in a district that do not contribute to the significance of the district. However, each resource included within the boundary of a district is part of the National Register listing, not as an individual property, but as part of the grouping or the historic environment that constitutes the district. Historic districts are documented on individual nomination forms.

2. Can properties be nominated under only one criterion or area of significance when more apply?

Yes. Any property that meets at least one of the criteria is eligible for listing, if the nomination adequately supports the property's significance under that criterion and area of significance. States are encouraged to look at all aspects of a property and to present comprehensive documentation; ideally properties should be nominated under all applicable criteria and areas of significance. However, properties will be listed in the National Register provided at least one criterion is sufficiently justified.

States may ask people preparing nominations to address more than one criterion or area of significance in the interest of gathering information and gaining a more complete understanding of the resource. When additional areas of significance are known or suspected at the time of nomination, they may be briefly described in the text as areas for further study, alerting the reader to the possibility that more research may expand current understanding of the property's significance.

3. Can a property be nominated individually if it is located within a potential historic district?

If a property is individually eligible, it may be nominated, even if it is also part of an eligible district. However, many properties are eligible only as part of a district. Individual nomination of properties in historic districts is not encouraged because this is a duplication of effort and the protection afforded the property from Federal undertakings is the same.

4. What is the definition of local significance and how is the distinction made between local, State, and national importance?

Historic significance is a measure of the intrinsic value of a property as an embodiment or expression of past events, architectural design and construction, development patterns, or folkways.

Significance is evaluated primarily in two ways:

> what the resource reflects or expresses about the period in which it was created (or the period in which it achieved significance), and how it fits into the context of prehistory or history in its own period; and,
>
> how the resource has structurally evolved over time, what physical integrity remains, and how the resource compares to other extant examples.

Local significance is determined by evaluating the resource within the context of the history of the locality - the village, town, city, or county. A property that is significant within the context of the State is one which, upon comparison with other resources and upon examination of the principal development patterns of the State, is found to be important either as an example of a type of structure or feature or for its expression of some theme or characteristic of the State's history. Judgments concerning State significance should be made by professionals who have a sound knowledge of a State's history and resources. As it grows, the State inventory will help provide perspective on the historic resources of specific communities, as well as of the State. The Secretary of the Interior and the Keeper of the National Register rely upon the SHPO, the State Review Board, and the State staff to provide judgments concerning local and State significance, and, in addition, to recommend resources which may be of national significance.

5. Are there any special considerations that should be taken into account when nominating a geological property?

The nomination of geological properties involves looking for much of the same kinds of data as any other historic property: descriptive information giving a specific analysis of the site or district and how this is known; contextual information which indicates how this site or district fits into current knowledge of a region's prehistory or history; and explicit boundaries and reasons for their delineation based on the known extent of the resource.

Like other types of historic properties, geological properties may be eligible under more than one criterion. It is important to keep this in mind when nominating geological sites, as the nomination form should refer to all aspects of the significance of the property, and provide support for each if the site is nominated for more than one criteria or area of significance. For example, in justifying the eligibility of a site or district under criterion D, the text of the nomination form should demonstrate what data are contained in the site and explain how that information is used to answer specific research questions. The importance of the information to be gained should be established by discussing the site or district in the context of current knowledge of the region's history or prehistory. For sites consisting largely of buried deposits, demonstration of potential to yield important information may involve subsurface testing. The necessity for, and scope of, subsurface testing must be decided on a property specific basis.

If a group of related geological properties have become separated due to modern construction it may be appropriate to select a discontinuous boundary. The discontinuous boundary, composed of two or more definable significant areas separated by nonsignificant areas is used when the deposits are related to each other through cultural affiliation, period of use, or site type.

6. Are there special criteria or considerations for nominating objects to the National Register?

Of the categories of resources eligible for the National Register, objects have often been the most controversial. They are a kind of resource different enough to raise questions about what types of objects are eligible and how the National Register criteria apply. Integrity of location and setting is especially important in determining what objects qualify for the Register. Objects that are part of collections are not eligible for listing on the grounds that the required "integrity of location, setting, feeling and association" is not present in a museum type of arrangement. Small objects not designed for a specific location are normally not eligible. Such works include transportable sculpture, furniture, and other decorative arts that, unlike a fixed outdoor sculpture do not possess association with a specific place. Objects currently listed in the National Register include boundary markers, monuments, statues, mileposts, and fountains.

7. How important is the integrity of the property when considering a nomination?

Integrity is the ability of a property to convey its significance. Historic properties either retain integrity, or they do not. Within the concept of integrity, the National Register criteria recognize seven aspects or qualities that, in various combinations, define integrity. Integrity is a quality that applies to location, design, setting, materials, workmanship, feeling and association. It refers to the clarity of a property's historic identity.

In terms of architectural design, integrity means that a building must still possess the attributes of mass, scale, decoration, etc., from its Period of Significance, that is from either (1) the period in which it was conceived and built, or (2) the period in which it was adapted to a later style which has validity in its own right as an expression of historical character or development. The question of whether or not a building possesses integrity is a question of degree of alteration. For a building to possess integrity, its principal features must be sufficiently intact for its historic identity to be apparent.

A building that is significant for historic association must retain sufficient physical integrity to convey that association. The building should thus substantially retain the physical character or appearance it had at the time of its association with the significant event or person. In the case of a historic site which may not possess any historic buildings (for example, battlefields, traditional cultural properties, treaty sites, fords, and so forth), the site's continuing ability to communicate its historic associations with an event or person frequently depends on the retention of the appropriate natural setting.

Severe structural deterioration can affect eligibility of a property for listing on the National Register. If there is strong justification for the property's historical integrity despite its deterioration, it may be nominated and listed with the expectation that this recognition may spur efforts to save and improve the property. It is important that evaluation of such a case address the condition of a deteriorated property and that photos used during evaluation accurately depict its condition. If the building has lost its structural integrity it may be determined that the building is beyond the point of rehabilitation and therefore beyond the point of making a lasting contribution to the community, State, or nation. In such an instance, the property would not be listed in the National Register. Even though a property may have no buildings retaining integrity, the property may have archeological remains that could make it eligible for the National Register.

In the case of districts, integrity means the physical integrity of the buildings, structures, or features that make up the district as well as the historic, spatial, and visual relationships of the components. Some buildings or features may individually have been more altered over time than others. In order to possess integrity a district must, on balance, still communicate its historic identity.

The quality of integrity in an archeological property means that the cultural material remains are relatively undisturbed, thus retaining the potential to yield important information, communicate historic associations, or exemplify artistic or construction techniques. Many factors may affect the integrity of an archeological property, including both man-made and natural disturbances such as modern construction, quarrying, cultivation, erosion, or even previous archeological investigations.

Refer to National Register Bulletin 15, How to Apply the National Register Criteria for Evaluation, for an extended discussion of integrity.

8. How important are intrusions when considering a district for nomination to the National Register? How many are too many?

There is no easy formula or standard rule concerning the number of intrusions that renders a district ineligible for National Register listing. The primary means of judging district intrusions is to determine their impact upon the area's architectural, historic, or archeological integrity. Factors to be considered in this judgment include the relative size, scale, design, and location of the questionable property, or, in the case of an archeological district, the seriousness of any ground-disturbing activities. Any proposed district must convey a sense of time and place through the collective significance of its buildings or features. In the case of a historic or architectural district, if there are too many scattered non-contributing features, or if the one or two present have a dominating visual impact and so interrupt the sense of historical period or architectural style, then the district's integrity may be lost or seriously damaged.

9. Where should boundaries be drawn?

Once the significance of a historic property has been identified, the boundaries should be carefully drawn to include all the aspects or qualities that contribute to its significance. Boundaries should not be drawn to include buffer zones, nor should they exclude features that are intrinsic to the resource. For example, all buildings/features of a historic complex should be included. Visual qualities such as integrity of setting or historic sight lines related to the significance of the property should be considered integral parts of the resource.

In addition to visual qualities and distribution of all significant features, factors that influence the selection of boundaries include historical uses and associations, property lines, integrity of site, topographic features, and research qualities. The last generally apply to archeological sites. For example, the boundaries for an archeological property should reflect the known extent and configuration of the cultural deposits. Areas of high potential may be included when justifiable, although the inclusion of large areas of uncertain potential is not acceptable. For archeological districts, boundaries should also reflect the distribution of related sites. Districts may include areas with additional site potential, but they should not include large amounts of "empty" acreage. If warranted, a discontinuous segment approach may be used to eliminate irrelevant areas. In some cases, additional survey may be needed before appropriate boundaries can be selected.

10. What qualities must be present for a property less than 50 years old to qualify for the National Register?

The National Register criteria for evaluation allow for the nomination of properties that have achieved significance within the last 50 years only if they are **exceptionally important** or if they are integral parts of districts that are eligible for National Register listing. As a general rule, properties that have achieved significance within the last 50 years are not eligible for listing because the Register is a compilation of the nation's historic resources worthy of preservation. The National Register does not include properties important solely for their contemporary use or impact. Passage of time allows perceptions to be guided by scholarly study, the judgments of previous decades, and the dispassion of distance. One is then better prepared to objectively evaluate what constitutes enduring interest and value.

The criteria do not describe "exceptional," nor should they. "Exceptional" cannot by its own definition be fully catalogued or anticipated. It may reflect the extraordinary impact of a social or political event. It may exist because an entire category of resources is so fragile that survivors of any age are unusual. It may be a function of the relative age of a community and its perceptions of old and new. It may be represented by a building whose developmental or design value is quickly recognized by the architectural profession. It may reside in a range of possibly threatened resources for which the community has an unusually strong attachment.

11. When are cemeteries or graves of notable geologists eligible for listing?

Ordinarily cemeteries are not considered eligible for the National Register. Exceptions may include cemeteries with distinctive design, association with historic events, or uncommon age. Graves of persons of transcendent importance may be listed only if there is no other appropriate site or building directly associated with their productive lives.

Unmarked graves may be defined as cemeteries according to State law and thereby protected. Such properties also may be significant as archeological sites because they provide important information about people in the past.

12. What is the role of Federal Agencies in the nomination of properties to the National Register of Historic Places?

The procedure by which Federal agencies nominate properties is outlined in National Register regulations (36 CFR Part 60.9). Federal agencies are required by law to establish a program to locate, inventory, and nominate all properties under the agency's ownership or control that appear to qualify for the National Register. Nomination forms are prepared under the supervision of the Federal Preservation Officer designated by the head of the Federal agency. Completed nominations are submitted to the appropriate SHPO for review and comment regarding the adequacy of the nomination, the significance of the property, and its eligibility for the National Register. The State is allowed 45 days to comment on the nomination.

The State Historic Preservation Officer may choose to submit the nomination to the State Review Board during this period. The Review Board then considers the nomination in the same manner that it reviews State nominations, and submit its opinion to the State Historic Preservation Officer. After reviewing the comments of the State Historic Preservation Officer and the chief elected local official, or if there has been no comment within 45 days, the Federal Preservation Officer may approve the nomination and forward it to the National Register.

Suggested Reading

The following publications are free upon request by writing Interagency Resources Division, P.O. Box 37127, Washington, D.C. 20013-7127:

National Register Bulletins

The bulletins provide guidance on a variety of topics related to the survey, evaluation, registration, and listing of historic properties in the National Register. Bulletin numbers not listed are under revision or the guidance has been incorporated into another bulletin.

Bulletin 2: Nomination of Deteriorated Buildings to the National Register. Describes instances in which the National Register will list vacant, abandoned, and deteriorated buildings. Rev. ed., 1982.

Bulletin 4: Contribution of Moved Buildings to Historic Districts. Guidelines for determining when a moved building can contribute to National Register or certified local district. Rev. ed., 1987.

Bulletin 6: Nomination of Property Significant for Association with Living Persons. Discusses when it is appropriate to nominate properties of potential historical significance whose associations are with living persons. Rev. ed., 1982.

Bulletin 7: Definition of Boundaries for Historic Units of the National Park System. Explains how National Register boundaries are defined. Rev. ed., 1982.

Bulletin 12: Definition of National Register Boundaries for Archeological Properties. Using case studies, recommends approaches for delineating boundaries for commonly encountered archeological properties. 1985.

Bulletin 14: Guidelines for Counting Contributing and Noncontributing Resources for National Register Documentation. Provides guidance for distinguishing and counting contributing and noncontributing resources comprising a documented property, regardless of size or complexity. Rev. ed., 1986.

Bulletin 15: How to Apply the National Register Criteria for Evaluation. Explains how the NPS applies the criteria used to determine the eligibility of properties for listing in the National Register of Historic Places. Rev. ed., 1991.

Bulletin 16: Guidelines for Completing National Register of Historic Places Forms. For use in completing National Register forms. Part A provides information on completing the National Register Registration Form while Part B provides information on completing the Multiple Property Documentation form. Both incorporate changes that have occurred since the 1977 printing. Rev. ed., 1990.

Bulletin 19: Policies and Procedures for Processing National Register Nominations. Explains procedures for processing nominations, and describes common documentation problems and how they are addressed. 1987.

Bulletin 21: How to Establish Boundaries for National Register Properties. Guidelines and examples of how to determine National Register boundaries. n.d.

Bulletin 22: Guidelines for Evaluating and Nominating Properties that Have Achieved Significance Within the Last Fifty Years. Guidance for evaluating the "exceptional importance" required for listing properties that have achieved significance within the last fifty years. Rev. ed., 1989.

Bulletin 23: How to Improve the Quality of Photos for National Register Nominations. Suggestions to help photographers achieve better quality photographic documentation of buildings and architectural details. 1979.

Bulletin 24: Guidelines for Local Surveys: A Basis for Preservation Planning. Guidance for undertaking surveys of historic resources. 1977. Rev. ed., 1985.

Bulletin 28: Using the UTM Grid System to Record Historic Sites. Introduces the Universal Transverse Mercator (UTM) Grid System and its application to mapping historic and archeological sites. Rev. ed., 1977.

Bulletin 29: Guidelines for Restricting Information About Historic and Prehistoric Resources. Guidance on which historic resources should be protected by restricting information on their location and character from general distribution. 1990.

Bulletin 32: Guidelines for Evaluating and Documenting Properties Associated with Significant Persons. Updated information on interpreting Criterion B. 1989.

Bulletin 33: National Register Information System Manual for State and Federal Users. Designed for State and Federal users of the National Register Information System (NRIS), the database of properties listed in, determined eligible for, or pending listing in the National Register. 1987.

Bulletin 35: National Register Casebook: Examples of Documentation. Examples of multiple property case studies, maritime nominations, and concise nominations. 1988-1989.

Bulletin 39: Researching a Historic Property. Provides basic information on methods of researching an individual building for listing in the National Register. 1990.

Bulletin 42: Evaluating and Nominating Historic Mining Sites. Provides basic information on methods of researching and nominating significant mining properties for listing in the National Register. 1992.

The following publication is sold by the American Association for State and Local History Press. Write AASLH, Order/Billings Department, 172 Second Avenue North, Suite 102, Nashville, TN 37201. Make checks payable to the AASLH.

The National Register of Historic Places 1966-1988. New comprehensive listing of the more than 49,000 properties listed in the National Register. Softcover book. $89.95 plus $3.50 postage and handling.

The following publications are free upon request by writing the Archeological Assistance Division, P.O. Box 37127, Washington, D.C., 20013-7127:

Grumet, Robert S. Technical Brief No. 3: Archeology in the National Parks Landmarks Program.

Grumet, Robert S. Technical Brief No. 9: The National Historic Landmarks Program Theme Study as a Preservation Planning Tool.

Background History of the Geological Sciences

Geology is an ancient science. The oldest known treatise on rocks and minerals is the De lapidibus of Theophrastus (c. 372-287 BC). Written early in the 3rd century, this book remained the best study of mineral substances for nearly 2,000 years.

Ancient accounts of geological incidents such as earthquakes and volcanoes provide little insight into the scientific causes of these events. Aristotle believed that volcanic explosions and earthquakes were caused by the spasmodic motions of hot winds that moved underground and occasionally burst forth in volcanic activity attended by Earth tremors. Strabo (64 BC-21 AD) believed that volcanoes act as safety vlaves to vent the explosive force of winds within the Earth. Pliny the Elder (13-79 A.D.) compiled a Natural History, an account of the entire world of nature discussing minerals, rocks, earthquakes, and other geological processes. Pliny, was to lose his life while attempting to examine the eruption of Mt. Vesuvius in 79 A.D.

In the years following the fall of the Roman Empire there were few observations recorded of the earth and its features. The most famous figure to write on geology during this time was Avicenna (980-1037), a Persian physician who translated some of the works of Aristotle and wrote his own treatise in which he described the formation of mountains and the origin of rocks the composed them.

In the 13th century the medieval German thinker Albertus Magnus wrote a treatise on rocks, minerals and mountains which summarize current thinking in Europe on an assortement of geological concepts.

The invention of printing in the 15th century and its rapid development in the 16th led to the spread of geolgical knowledge and other scientific matters in Europe. Much of this early knowledge of geology was derived from experience in the field of mining. Georgius Agricola, a German mineralogist (l494-l555), penned one of the earliest studies of geology, De Re Metallica, in which he summarized all the practical knowledge gained by Saxon miners to his time. Konrad von Gesner, a Swiss naturalist (l5l6-l565), was one of the first individuals to collect and illustrate fossils found during his excursions into the Swiss mountains.

By l650, Irish Bishop James Ussher attempted to established the first time-scale for the age of the earth based upon his study of the Bible. Ussher set the date of creation at 4004 BC and based the date of Noah's flood at 2349 BC thereby establishing a time scale of 6,000 years for the age of the earth. Nicholas Steno, a Danish anatomist and geologist (l638-l686), speculated in his writings that fossils were ancient animals which had lived normal lives and in death were petrified. This explanation for the origin of fossils reverted to the speculations of a few ancient Greeks and was in opposition to the prevailing opinion that fossils were the remains of animals drowned in Noah's flood.

In l785, James Hutton, a Scottish geologist (l726-l797), published his book Theory of the Earth, in which he explained the principle of uniformitarianism: all geological features can be explained by features now observable taking place over very long periods of time; in fact, Hutton maintained, that there is no sign of earth's beginning or prospect for its end. Since Hutton's book advanced the first general principles upon which the science of geology now depends, he is often called the father of geology.

During the Industrial Revolution, it became apparent that geology was important to commerce. The placement of canals, railways, and highways as well as the location of coal and iron deposits depended on a knowledge of geology.

Abraham Gottlob Werner (l750-l8l7), a professor of mineralogy at the Mining Academy of Freiberg, was the first to introduce systematic observation to the science of geology. Werner showed that rocks were formed layer by layer, with the oldest at the bottom and the youngest at the top. He argued that in the past, the earth's surface was covered by a muddy sea and that the earth's crust was formed by the deposition of suspended material. According to him, the crystalline rocks, such as granite or basalt, were formed by the precipitation of minerals. His theory, called the neptunist theory was opposed by the vulcanists who argued that the layers of rock in the earth's surface were formed exclusively by volcanic action and the plutonists who emphasized the importance of heat from within the earth.

William Smith (l769-l839) used the construction of canals to observe different types of strata in the soil. Smith observed that each stratum had its own characteristic form of fossils not found in any other strata. No matter how the strata was bent and crumpled this fact did not change. Smith recorded his observations and published the first geological map of England in l8l6 thereby earning for himself the title of "father of stratigraphy."

Georges Cuvier (1769-1832) was a French Naturalist who realized early in his career that the different parts of an animal's body were closely interrelated; for example, mammals with horns and hoofs were all herbivores (plant eaters) and would have the teeth of herbivores. The significance of this observation was that entire animals could be restored from the evidence of isolated bones. Cuvier also recognized that many fossils belonged to extinct species, and he devised a view of Earth history in which a succession of catastrophes exterminated earlier life forms.[13]

Sir Charles Lyell (l797-l875) studied geology and read Hutton's book and was able to take Hutton's idea of small changes taking place over long periods of time to develop specific theories that are held today. In his book, The Principles of Geology, which appeared in three volumes between l830 and l833, Lyell showed that the earth was several hundred million years old and that in accord with Hutton's theory of uniformitarianism the slow processes of heat and erosion (still proceeding today) had brought about all the changes in the history of the earth. Lyell did not contribute anything new to the theory of geology but served to popularize Hutton's views. After the publication of Lyell's book most geologists began to study the history of the crust of the earth along Hutton's lines.

Louis Agassiz (1807-1873), was a Swiss-born naturalist who immigrated to the United States where he taught natural history at Harvard University and was one of the first people to encourage an interest in paleontology. Agassiz was greatly influenced by Cuvier and his catastrophic theories. He reinterpreted some of the youngest rocks, widely believed to be deposits formed by the biblical flood, and showed them to have been deposited by glaciers during the pleistocene ice age.[14]

Geology in the United States-Early History[15]

Of all the sciences, according to historian and geologist, Cecil J. Schneer, geology is the one most closely associated with the history of the United States--a land of mountains and rivers, of glaciers and prairies, atolls, hot springs, badlands, mines, and gushers. America is the land of Mammoth Cave and the Teapot Dome, the San Andreas Fault and LaBrea Tarpits, the Delaware Water Gap and the Great Okefenokee, Niagara Falls, the Grand Canyon of the Colorado, the Homestake Mine and Texas Gulf Sulfur, the Catskill

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[13] Paul D. Taylor, Fossil (New York: Alfred A. Knopf, 1990), p. 14.

[14] Ibid., 15.

[15]For further information the reader should consult the following sources:

Adams, Frank D., The Birth and Development of the Geological Sciences. New York: Dover Publications, 1954.

Drake, Ellen T. and Jordan, William M. eds., Geologists and Ideas: A History of North American Geology. Boulder, Colorado: Geological Society of America, 1985.

Fenton, Carroll L. and Mildred A., Giants of Geology. New York: Doubleday Books, 1962.

Merrill, George P. The First 100 Years of American Geology. New Haven: Yale University Press, 1924.

Moore, Ruth, The Earth We Live On: The Story of Geological Discovery. New York: Alfred A. Knopf, 1961.

Schneer, Cecil J. ed., Two Hundred Years of Geology in America. Hanover, New Hampshire: 1979.

scarp, the Mississippi delta, the Palisades, the Great Salt Lake and Mount Rainier.[16] The entire history of the United States has been shaped by the geological resources and features of the land. The influence of geology is pervasive throughout American History.

In view of this it is ironic that in the United States relatively little attention was given to the development of science in general, and to the Earth Sciences in particular, before the l9th century. The population of the country grew because of immigration and the interests of the population were geared toward practical ventures rather than the pursuit of theoretical knowledge. A premium was placed on the development of labor-saving devices which were especially valued because of the comparatively low population density and the resulting high salaries of workers. Therefore, while the role of technological inventors and entrepreneurs in industrial development remained high, the role of theoretical science remained small.

The history of the Earth Sciences in America can be traced back to the writings of Thomas Hariot in the sixteenth century. Hariot's study of the land, which included "significant geological details," were published in his book *A Brief and True Report on the New Found Land of Virginia* (1588). As the settlements spread throughout the east coast, subsequent writings praising the beauty of the land emerged. In 1634, for example, William Wood published *New England Prospect*, which described New England's geography as well as geology. In 1672, John Lederer also published *Discoveries*, a book which described the landscape of northeast America.[17]

Nevertheless, the curiosity about the appearance of the land would soon shift in the direction of the study of natural disasters, such as earthquakes. For example, in October of 1727 and November of 1755, New England suffered two devastating earthquakes that boosted the interest of scientists into the causes of earthquakes.

One of the earliest geologists in North America was John Winthrop, III, who explained earthquakes in terms of natural causes rather than divine punishment. On November 26, l755, Winthrop read A Lecture on Earthquakes in the college chapel at Harvard in which he discussed the earthquake of November l8, l755, in New England. Winthrop also studied the destructive Lisbon earthquake of November l, l755, in which l5,000 people lost their lives.

The eighteenth century brought about an explosion in the world of science. This was especially true in Europe where industrialization had sped up scientific progress. It was out of this scientific renaissance that Earth Sciences began to be studied at great lengths, particularly in North America.

By the end of eighteenth century, individuals such as Benjamin Franklin and Thomas Jefferson, had their theories and practices in the Earth Sciences. Franklin for example, believed that the earth was not a solid body but instead believed that the outer portion of the earth was floating on fluids. These fluids he believed, had the highest degree of density known to men.[18]

Thomas Jefferson on the other hand, had an immense interest in the field of paleontology. In addition to a large collection of fossils from West Virginia and Big Bone Lake in Kentucky, Jefferson maintained a close relationship with geologists from the University of Pennsylvania, where his grandson was being taught.[19]

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[16]Schneer, pp. 5-6.

[17] Cecil Schneer, Ed., *Two Hundred Years of Geology in America.* (Hanover, New Hampshire: University Press of New England, 1979)p.291.

[18] George P. Merrill, *The First One Hundred Years of American Geologists.* (New York and London: Hafner Publishing Company, 1964) Pp.13-14.

[19] E. T. Drake and W. M. Jordan, *Geologists and Ideas: A History of North American Geology*. (Boulder, Colorado: The Geological Society of America, Inc., 1985)p.378.

Geology in the 19th Century

With the westward march of expansion the United States early in the l9th century received title to the Louisiana Territory from France. The Lewis and Clark Expedition (l804-l806), sent by President Jefferson to explore the new territory, made significant discoveries in the fields of botany, ethnology, geology, and zoology. A vast mine of geographical information and data concerning the Indians and their lands was accumulated. This tradition of federal survey's also included later geological survey's by G. W. Featherstonhaugh and William W. Mather in New York and finally David Dale Owen's massive survey of the territory of Wisconsin, Minnesota, Iowa, and part of Nebraska. This last, Owen wrote in 1852, was the most extensive in this country, covering four times the territory of New York State.[20]

Physical Geology

Physical Geology, (geodesy, geomorphology, geophysics and seismology), for example, were the first to capture the interest of educators and scientists in North America. Many questions were asked as to the formation of volcanos, the causes of earthquakes, the impact of the climate upon the terrain, and other uncertainties of the land.

In the nineteenth century the study of the Earth Sciences blossomed in North America. The person often viewed as the leader of geology and "Father of American Geology," was William Maclure, (1763-1840). Maclure was an immigrant from Ayre, Scotland, when he arrived in America in 1796. His primary goal was to draft a geological map of the North American continent. This goal however was too ambitious, and he had to content himself by drafting a map of the east coast. This draft, presented in 1817, was the first outline of the geology of a vast territory that had ever been presented anywhere in the world. The map covered the east coast from the Gulf of Mexico to Canada and extended westward from the east coast to the 94 meridian, (Kansas).[21]

William Mclure's contribution to American geology did not rest with his famous map. In 1809, he published *Observations on the Geology of the United States*, where he described his findings of the Allegheny Mountains after walking them fifty times.[22] His financial situation allowed him to help establish the Academy of National Sciences in Philadelphia, where he donated $20,000 as well as 3,300 books from his personal library.

The next year Archibald Bruce began to publish the American Mineralogical Journal, the first geological publication in the United States.

In 1819, scientists at Yale College (today University), headed by William Maclure, organized and created the American Geological Society. This was the first time an organization had been created for the sole purpose of geology. This organization lasted for nine years, providing scientists with articles about new findings in the field, as well as providing a publication where scientists could write about their theories.

In l842 the Association of American Geologists and Naturalists, the first permanent scientific organization national in scope was founded in Philadelphia. In l848 it became a general professional society renamed the American Association for the Advancement of Science.

During this time the number of scientific journals and science textbooks increased in the United States.

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[20]Ibid., pp. 7-8.

[21] George P. Merrill, *The First One Hundred Years of American Geologists.* (New York and London: Hafner Publishing Company, 1969)pp.32-35.

[22] Horace B. Woodward, *History of Geology*. New York: Arno Press, 1978. Pp.130-31. (Original edition by G.P. Putnam's sons, New York and London: Knickerborker Press, 1911).

One of the first textbooks in geology was written by James Dwight Dana, a professor of natural history at Yale who wrote a Manual of Geology (l862) and a Textbook of Geology (l864).[23]

Until the establishment of the U.S. Geological Survey Bureau in 1879, the major burden of geological research was born by the state surveys. The origins of the state geological surveys can be traced to the early nineteenth century. In 1823, the state of North Carolina established the State Geological and Mineralogical Survey, the first geological survey in the United States.[24] This survey was made by Dennison Olmstead, who performed the entire task alone. In 1830, Massachusetts authorized a survey by Edward Hitchcock and Samuel Borden. This survey classified minerals, described mountains, catalogued animals and plants. The popularity of the Massachusetts survey made the nation aware of its geological resources and the need to catalogue them. By 1841, eighteen other states had undertaken geological surveys. The New York Geological Survey, begun in 1836, included a stratigraphic record made by the paleontologist James Hall. The knowledge of the geological sciences advanced rapidly in the United States as a result of these state surveys.

Much of the findings from state geological surveys had been published by private societies as well as state agencies, but by 1879, the creation of the U.S. Geological Survery (U.S.G.S), provided a common publisher as well as geological maps and reports to geologists across North America. Despite the great influence of the U.S.G.S on American Earth Sciences, no organization can be given more credit than the Association of American Geologists.

The organization, founded in 1840, was the first permanent geologic society in North America.[25] In an effort to expand its membership among paleontologists and statigraphers, the name of the organization changed to the Association of American Geologists and Naturalists. Although the change of the society's name had worked in expanding its affiliation, by 1848 the association changed its name once again, it would now be called The American Association for the Advancement of Science (A.A.A.S). "Thus," historian Edwin B. Eckel wrote, "the foundations of the A.A.A.S., which stand today as the world's largest and most all-inclusive group of scientists, were laid by American Geologists."[26]

Soon after the (AAAS) was founded, the increase in interest as well as the rapid growth of the earth sciences, combined with the rise of publications and its readership, called for the formation of an agency that would direct all its resources to the fields of earth sciences. As a result, the Geological Society of America was founded in 1888. In addition to satisfy the interest of the growing scientific community, the purpose of the organization was for "the promotion of the science of geology by the issuance of scholarly publications, the holding of meetings, the provision of assistance to research, and other appropriate means."[27]

Additional exploration of the West in the middle of the l9th century by such men as John C. Fremont continued to make major contributions to the study of geology. Fremont's reports from his second and third expeditions contained the first accurate accounts of the crystalline rocks--granitic, metamorphic, and volcanic--at the core of the Sierra Nevada.

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[23] James Dwight Dana's house at 24 Hillhouse Avenue in New Haven, Connecticut, was designated a National Historic Landmark on January 12, 1965.

[24] Arthur A. Socolow, ed., *The State Geological Surveys: A History*. (No place of publication: American Association of State Geologists, 1988),pp.331-336.

[25] Edwin B. Eckel, *The Geological Society of America -- Life History of a Learned Society.* (Boulder, Colorado: The Geological Society of America, Inc., 1982)p.8.

[26] Ibid. p.8.

[27] Ibid. p.4.

As the l9th century progressed the pace of geological studies and research in the United States quickened. After the Civil War, Clarence Edward Dutton (l84l-l9l2), joined a government survey of the West, studying volcanic eruptions and earthquakes. Dutton developed methods for determining the depth of earthquake origin and velocity with which the earthquake waves traveled through the earth.

In latter years, Dutton maintained that the rocks under the continents were less dense than those under the ocean and that the continents were dry because they were light enough to ride high on the rocks making up the outer layers of the planet. Dutton named this theory isostasy, still used to describe how a mountain floats on denser rock.

By the late nineteenth century, American Earth Scientists had acquired a world reputation. The advance in American geology was reflected by the demand for American earth scientists abroad. Rafael Pumpelly (1837-1923) for example, was contracted by the Chinese government in 1863 to Survey the coal deposits of western Peking. Pumpelly was a geologist and archeologist, his main interest centered on the effects of prehistoric conditions upon primitive society.[28] Pumpelly was also successful in his studies on the Cooper District of Michigan. In Missouri he directed a study that yielded eight geological maps of counties as well as a 440 page study of the iron ores and coal fields of Missouri.[29]

Geologist W.W. Mather, a prominent geologist from New York, as well as an accomplished explorer of the west, worked extensively on the physical geography of the United States, including ideas about the formation of secondary rocks, as well as the elevation of islands, continents and mountainous chains. The result of his studies were published in the American Journal of Science in 1845.[30]

Toward the end of the nineteenth century the study of earthquakes became increasingly important. G.K. Gilbert was the first member of the United States Geological Survey that published a paper on earthquakes in 1884. His theory was that earthquakes were caused by slow accumulation of pressure to the mountainous regions followed by an instant yielding along boundary faults. His theory was very similar to the one presently authoritative, that is that earthquakes are cause "by the sudden release of elastic strain in the dislocation of a geological fault."[31] But perhaps Gilbert better known for his research on the causation of craters. His studies were published in 1893 in his book *The Moon's Face*.[32]

Harry Fielding Reid (1859-1944) made a significant advance in the study of earthquakes. Reid was a professor of applied mechanics at John Hopkin's University. Reid came up with the elastic rebound theory, in which he proved that geological faulting was the cause of earthquakes and not the consequence of them.[33]

J. A. Udden (1859-1936) made some outstanding contributions to the world of sedimentologists. His research of wind-blown sediments made it necessary for him to invent the Udden-Wentworth Scale, which assisted him in a particle distribution theory. Although Udden's most famous studies took place in Texas where he was the director of the Texas Bureau for Economic Geology from 1911 to 1932, Udden's work on the effects of dust and sand on the geology of North America led him to the invention of a flying

[28] Ibid. pp.416-17.

[29] George P. Merrill, *The First One Hundred Years of American Geologists*. (New York and London: Hafner Publishing Company, 1964) pp.460-462.

[30] Cecil Schneer, Ed., *Two Hundred Years of Geology in America*. (Hanover, New Hampshire: The University of New England Press, 1979)pp.137-38.

[31] Ibid. p.472.

[32] Ibid. p.65.

[33] Ellen T. Drake and William M. Jordan, Ed., *Geologists and Ideas: A History of North American Geologists*. (Boulder, Colorado: The Geological Society of America, Inc., 1985)pp.473-4.

machine - "the rotopter," (similar to today's helicopter.)[34]

Economic Geology

Early American geologists were also concerned with the potential wealth, in the form of minerals, underneath the skin of the earth. This concern led to development of economic geology.

Samuel Mitchill was one the first pioneers in this field. He was the founder of the American Mineralogical Society, in 1799. Mitchill was a doctor and a professor of chemistry and natural sciences at Columbia University, in New York. His studies were directed towards the coal deposits in the state of New York. In 1798, Mitchill published his book *A Sketch of the Mineralogical History of New York*, in which Mitchill divided the mainland of New York into areas of different composure.[35]

Mineralogist, Benjamin Silliman (1779-1864) was the founder of *The American Journal of Sciences*. Silliman was a Yale graduate and concentrated his studies in chemistry, anatomy and botany. After his education in Philadelphia, Silliman became interested in the mineralogy of the northeast. In 1810, he published his first book about mineralogy, *Sketch of the Mineralogy of the Town of New Haven*. He spent most of his career lecturing principles of geology and mineralogy around the United States.[36]

Amos Eaton (1776-1842) was a disciple of Silliman, who had been educated at Yale under the professorship of Silliman. Eaton became a great lecturer and professor of mineralogy at Williams College. His continuous lectures on the subject of mineralogy around United States, quickly advanced interest in the earth sciences, exclusively mineralogy, in the northern continent. He published several books on geology, including *Index to the Geology of the Northern States* in 1818, and *Geological Text Book* in 1830. But, perhaps he is better known for founding the **Rensselaer School**, where he emphasized the importance of laboratory work. The system of "lab-work" in conjunction with lectures became so popular that in 1825 "petitions circulated for the implementation of the Rensselaerian Plan to more schools."[37] By the end of the nineteenth century, the Rensselaer School had supplied more leaders of American geology than any other institution in North America.[38]

By 1831, G. W. Featherstonhaugh, a French born scientist, later to be appointed United States Geologist, was publishing *The Monthly American Journal of Geology and Natural Sciences*. This was a tool for geologists to publish and read new findings. Just a year later, the Geological Society of Pennsylvania was created, unfortunately though, the Society lasted for only a year or two.[39]

James Dwight Dana (1813-1895), was a Professor of natural history at Yale College. Dana wrote one of the most authoritarian books on the subject of mineralogy, *System of Mineralogy*, published in 1837. In 1863 he also published another important work on the field of mineralogy, *Manual of Geology; Treating of*

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[34] Ellen T. Drake and William M. Jordan, *Geologists and Ideas: A History of North American Geologists*. (Boulder, Colorado: The Geological Society of America, Inc., 1985)p.204.

[35] Carrol Lane Fenton and Mildred Adams Fenton, *The Story of Great Geologists*. (Freeport, New York: Books for Library Press, 1945)pp.133-35.

[36] Ibid. pp.133-35.

[37] Ibid. pp.146-48.

[38] Ellen T. Drake and William M. Jordan, Ed., *Geologists and Ideas: A History of North American Geology*. (Boulder, Colorado: The Geological Society of North America, Inc., 1985)p.157.

[39] Edwin, B. Eckel, *The Geological Society of America -- Life History of a Learned Society*. (Boulder, Colorado: The Geological Society of America, Inc., 1982)p.10.

the Principals of Science, with special reference to American geological history.[40]

Mineralogy produced a number of investigations by the United States Geological Survey. These studies brought about the discovery of the iron-ores of the Lake Superior region, reports on other metalliferous deposits around the United States, findings of coal deposits throughout the east coast and prompted the investigation of underground and surface sources of water supplies in scarce areas.

One of the most significant works in the field of iron-ores was published by J.D. Whitney (1819-1896) in 1854. His book *Metallic Wealth of the United States*, proved to be a treasure to America's literature on the topic. Whitney's study listed ore locations in America as well as in nearby foreign countries.[41]

Another great mineralogist of the latter half of the nineteenth century was Clarence King (1842-1901). King had been educated at Yale, under the tutorship of James Dana. His studies concentrated in geology and mineralogy. After his graduation in 1862, he studied glaciation under Louis Agassiz. Clarence King was influential in the development of western mines in the United States. In 1863, in an effort to create a mining industry in the west, King went out to the west to join with the Geological Survey of California. In 1867, King became the director of the United States Geological Exploration of the Fortieth Parallel. By 1870, King had compiled a report on mining that would serve as an authority in North America's industry of precious metals. In addition to his accomplishments in the field of mineralogy, while on an expedition to the volcanos of the Cascades, King recorded the first citing of glaciers known in the United States.[42]

In l859, Edward Drake drilled the world's first oil well in Titusville, Pennsylvania, striking oil on April 28. Drake's discovery started a process that would eventually fund much of the large-scale geological research in the United States in the search for more oil.[43]

By the 1880s the iron industry was booming due to the continuous expansion of the railroad. The North American railroad went from 88 thousand miles of track in the 1880, to 250 thousand miles in 1900.[44] The petroleum industry was far behind, in fact petroleum accounted only for 2.4 percent of U.S. energy consumption. Nevertheless, by 1920, with the formation of the American Association of Petroleum Geologists, the new industry sought the need for the employment of experts in that field - geologists.

During the middle third of the nineteenth century a more detailed geological study of the Western United States took place. The reports of explorers and geologists such as Joseph Nicollet, John Fremont, George Featherstonhaugh, David Owen, Randolph Marcy, Howard Stansbury, John Newberry supplied increasingly detailed maps, accurate descriptions of the strata and their fossil beds, and accounts of mineral resources. The Grand Canyon explorations of Newberry and Joseph Ives, reported in 1861, and John Wesley Powell in 1869, opened up a whole new area for study and provided a view deep into the earth's crust.[45]

Paleontology

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[40] Horace B. Woodward, *History of Geology*. (New York: Arna Press, 1978)p.110.

[41] George P. Merrill. *The First One Hundred Years of American Geology*. (New York and London: Hafner Publishing Company, 1969)pp.328-9.

[42] Ibid. p.221.

[43] Drake's Oil Well in Venango County, Pennsylvania, was designated a National Historic Landmark on November 13, 1966.

[44] Ibid. p.447.

[45] The Encyclopedia Americana-International Edition (Danbury, Connecticut: Grolier Incorporated, date?). vol. ? pp. 450-51.

Paleontology had its origins in the process of searching for ores and minerals in which resulted in geologists discovering ancient and long extinct plants and animals.

The east coast geography had something to offer to all those interested in the earth science. Paleontologist Charles Lyell, came out of Oxford in 1841 to study the Niagara Falls, the faunas in the greensands of New Jersey and the Appalachian Mountains. While in the northeast, Lyell lectured at the Lowell Institute in Boston and later in Philadelphia. After his studies of dinosaur foot prints in Massachusetts, Lyell wrote *Travels in North America* (1845).

The pace of geological studies and research in the United States continued to accelerate during the nineteenth century. After the Civil War, Clarence Edward Dutton (1841-1912), joined a government survey of the West, studying volcanic eruptions and earthquakes. Dutton developed methods for determining the depth of earthquake origin and velocity with which the earthquake waves traveled through the earth.

In 1844, Ebenezer Emmons (1799-1863) launched an expedition throughout the northeast that proved fruitful in the discovery of fossils. Some have regarded him as the "Father of American paleozoic stratigraphy."[46]

Along with new exploration, the field of paleontology was maturing in the 1840s. After C.R. Eastman recorded the earliest remains of Agnatha (fish) in the United States, many other paleontologists began to make monumental discoveries.

Joseph Leidy (1823-1891) for example, uncovered multiple remains of vertebrate, including that of a horse which proved to be a great contribution to the world of paleontology. In 1847, Leidy published a book devoted to the fossil horse.[47] In his book, Leidy demonstrated with fossil evidence, that the horse existed in North America prior to the reintroduction by the Europeans in the sixteenth century.[48] Professor H.F. Osborn also made some astonishing vertebrate findings in the soils of Kansas, Colorado, Wyoming and Utah finding fossils of saurians, birds, and large mammals. In fact, it was the discovery of animals such as the Diplodocus found in Wyoming during the 1840s (80 feet in length) that generated an interest among the non-scientific community.

One of the great paleontologists in the American history of earth sciences was Louis Agassiz. Born in Switzerland and educated in Germany and Paris, paleontologist Louis Agassiz (1807-1873), did extensive research on fossils while being a Professor of zoology and geology at Harvard College in 1847. His findings were published in his book *Recherches sur les Poissons Fossiles*. Prior to this publication, another American scientists, Dr. James Deane, pointed out in 1836 fossil foot prints on the Connecticut Valley. These foot prints were evidence of an early form of bird, to which Rev. Edward Hitchcok would dedicate part of his book *Ichnology of New England*, published in 1858.

A Rensselaer student, **James Hall** (1811-1898), while serving as the state geologist, as well as director of the Museum of Natural History at Albany, dedicated much of his life to the research of paleozoic invertebrata in the state of New York. Hall is considered the "Father of American Stratigraphy" He proved to be resourceful not only in the scientific community, but in the economic community, when he proved that New York had no deposits of coal, and thus saved money for the would be investors. His later achievements would be in Iowa, where he became the state geologist.

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[46] Horace B. Woodward, *History of Geology*. (New York: Arno Press, 1978)p.134.

[47] George P. Merrill, *The First One Hundred Years of American Geologists.* (New York and London: Hafner Publishing Company, 1964)p.337.

[48] Cecil Schneer, Ed., *Two Hundred Years of Geology in America.* (Hanover, New Hampshire: The University of New England Press, 1979)p.308.

Hall was also one of the earliest American pioneers in the field of metamorphism--the change of structure or composition of a rock due to natural agencies, as pressure and heat. Hall's work concentrated on the nature of elevations and the subsidence of the earth's crust, or mountain making, and studied metamorphism on volcanic structures. Among his accomplishments, Hall was the founding president of the Geological Society of America, as well as the president of the American Association for the Advancement of Science. Among his major contributions to American geology, Hall is most remembered by his theory on geosynclinal movement or the "portion of the earth's crust subjected to downward warping during a large fraction of geologic time." Much of his work was recorded in his book, *Natural History of New York*, published in 1858.[49]

In the years after the Civil War, interest in American paleontology reached new levels of discovery and popularization providing abundant specimens. This constant discovery also paved the way for the eventual acceptance of the radical evolutionary theories of Charles Darwin.[50]

Edward Drinker Cope (1840-1897) advanced paleontology with his study of the evolutionary history of the horse in North America. Cope was also responsible for the discovery and identification of more than a thousand species of extinct vertebrates in the rocks of North America.[51]

Charles Othniel Marsh (1831-1899) was also a pioneer in the study of paleontology and competed with Cope for Fossils in the American West. By the end of his career Marsh was responsible for the description of 80 new saurian and over 500 new fossil species. Marsh was President of the National Academy of Sciences from 1883-1895.[52]

Charles D. Walcott (1850-1927), is one of the most accomplished geologists in the history of American Geology. Walcott was the director of the USGU from 1882 to 1916, while at the same time the Chief Geologist Secretary of the Smithsonian Institute. Walcott later became the president of the American Philosophical Society and the National Academy of Sciences. He is known as the father of pre-phanerozoic paleontology in North America. Most of his research was conducted in the states of Montana, Colorado, and Arizona where he was able to discover numerous remains of prehistoric animals. Other important discoveries of Walcott included the imprints of medusae (jelly fish) in the soils of Alabama. Walcott was also the first geologist to report the first genuine body fossil ever to be described from rocks during his research in the Grand Canyon in 1883.[53] His findings were published in his monograph on *The Fauna of the Lower Cambrian or Olenellus Zone*, issued in 1891.

Geology in the Twentieth century

By the beginning of the 20th century a series of related developments in physics--the discovery of x-rays, subatomic particles, relativity, and quantum theory led to a profound revolution in how scientists view matter and energy. In the United States these developments would affect the sciences, including geology.

Most of the progress in geology during these years came from the use of earthquake waves to determine

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49 Ellen T. Drake and William M. Jordan, *Geologists and Ideas: A History of North American Geology*. (Boulder, Colorado: The Geological Society of America, Inc., 1985)pp.2-7.

50 Arthur A. Socolow, Ed,. *The State Geological Surveys: A History*. (No place of publication: American Association of State Geologists, 1988)p.9

51 **Edward Cope's house at 2102 Pine Street in Philadelphia, Pennsylvania, was designated a National Historic Landmark on May 15, 1975.**

52 **Othniel C. Marsh's house at 360 Prospect Street in New Haven, Connecticut, was designated a National Historic Landmark on January 12, 1965.**

53 Horace B. Woodward, *History of Geology*. (New York: Arno Press, 1978)p.135.

the internal structure of the earth. It was during this period of time that geologists discovered that the earth has a crust, a mantle, an outer core, and an inner core. The knowledge of radioactivity quickly led to the idea that the age of a rock could be determined from the ratio of a radioactive element to its stable decay product. This period also marked the beginning of the systematic study of volcanos.

In l888, the first seismograph in the United States was installed at the Lick Observatory in California.[54] In l904, Bertram Boltwood (l870-l927) proved that one element changes into another during radioactive decay. By l907 he realized that he could calculate the age of a rock by measuring the ratio of uranium to lead, the final decay product. In l905, American Mining Engineer, Daniel Moreau Barringer (l860-l929), proposed that the large crater in Arizona was not caused by a volcano, but was caused by a meteor. Barringer's theory was first rejected but eventually accepted and used to explain the formation of lunar craters. In l906 Harry Fielding Reid (l859-l944) in his study of the San Francisco earthquake evolved his "elastic rebound theory" that stated that faults in the earth were preexisting and were not breaks caused by earthquakes. In l9l2 Thomas A. Jagger became the first scientist to work at the newly opened Hawaiian Volcano Observatory situated on the rim of the Kilauea caldera on the island of Hawaii.

In l9l4, German-American geologist Beno Gutenberg (l889-l960), discovered a discontinuity in the behavior of earthquake waves at a depth of 3000 km; this Gutenberg discontinuity marks the boundary between the earth's mantle and outer core. In l9l7, Henry Stephens Washington (l867-l934), published his book, The Chemical Analysis of Igneous Rocks, which laid the foundations for a classification of eruptive rocks based on their chemical composition.

By 1926, interest in the field of petroleum had created its second organization, the Society of Economic Mineralogists and Paleontologists. One of its leading members was Wallace E. Pratt who discovered that "fault plane can serve as Hydrocarbon traps," which in turn produce petroleum.[55]

By the middle of the twentieth century the need for petroleum had expanded its research to the arctic parts of North America - Alaska. The **G. William Holmes Research Station** was founded in 1958. In this station 80 scientists would study not only petroleum deposits but twenty other scientific disciplines. From pleistocene, geomorphology and glaciology to meteorology, hydrology and archeology. Although the project proved fruitful in the land of tundra, alpine and glacial-lake regions, by 1970 the Congressional passage of the Alaska Native Claims Act and the National Environment Policy Act had put an end to the research.[56]

One of the most significant recent developments in the study of geology in recent years has been the acceptance of the theory of plate tectonics or "Continental Drift." For many years geologists had noted that the eastern margin of South America closely "matched" the western margin of Africa. In 1858 a Frenchman, Antonio Snider, suggested that the two continents had once been united. In 1912 a german geophysicist-Alfred Wegener (l880-l930) proposed that all the continents originally had formed a single mass (Pangaea) surrounded by a continuous ocean (Panthalassa). According to Wegner, this large granite mass broke into chunks that slowly separated, floating on a basalt ocean and, over hundreds of millions of years, took up the pattern of the fragmented continents we know today.

Arguments for and against this theory of "Continental Drift" lasted for the next fifty years until 1962 when

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[54] In 1988 the Lick Observatory Building and the Crossley 36-inch Reflector Telescope were nominated by the National Park Service for designation as a National Historic Landmarks in the first phase of the Science Theme Study. See Harry A. Butowsky, Astronomy and Astrophysics: A National Historic Landmark Theme Study (Washington, D.C.: National Park Service, 1988). pp. 37-68.

[55] Ibid. p.447.

[56] Ibid. pp. 301-09.

Robert S. Dietz and Harry Hess worked out the hypothesis of "sea-floor spreading." According to this theory the Earth's crust had spread to form the ocean basins, with the result that the continents were floating further and further apart.

Beginning in the late 1950's Ronald F. Mason and Arthur D. Raff, geophysicists from the Scripps Institute of Oceanography at La Jolla, California made systematic surveys of the intensity of the earth's magnetic field over the ocean off of the west coast of North America, and found mysterious north-south trending magnetic anomalies, along the ocean floor. Maps showing these magnetic anomalies were published in 1958 and 1961. Later surveys revealed similar magnetic anomalies along the ocean floor in other areas of the world.
At the same time other geologists, including Allan Cox, Brent Dalrymple and Richard Doell were working at the Paleomagnetics laboratory at the U.S. Geological Survey Offices in Menlo Park, California, where they dated successive reversals of the earth's magnetic field. Data generated in this study was used to determine that the earth's magnetic field had reversed polarity at least twice in the last 2.5 million years.

In 1966 at a meeting of the American Geophysical Union in Baltimore Alan Cox and other geologists presented papers showing how the successive reversals of the earth magnetic field documented on land matched the magnetic anomalies found on the ocean floors. This match confirmed the theory of sea floor spreading and eventually the theory of continental drift formulated by Wegner in 1912.

STUDY LIST FOR THE GEOLOGY THEME STUDY

INTRODUCTION

This section of the Geology Theme study contains a evaluated list of more than 200 sites that have been suggested as potential National Historic Landmarks in this theme. All of these sites have been suggested by either the State Geologists, the State Historic Preservation Officers, officials from other federal agencies including the US Geological Survey, the Bureau of Land Management, the US Forest Service, the Minerals Management Service and the Bureau of Mines. In addition other individuals knowledgeable in the history of American Geology from both the private and public sectors have made suggestions that are included on this list.

All of these sites have been screened to determine if there is at least a plausible basis for their listing on the National Register of Historic Places as National Historic Landmarks. The final determination in this matter must wait until the actual preparation of a National Register or National Historic Landmark nominations. The nominations included in this theme study have all been taken from this list and are intended to serve as examples in the preparation nominations for this type of resources.

All who use this theme study should bear in mind that the following list of potentially eligible properties is not an all inclusive list. Many other sites important in the history of Geological Sciences have surely been omitted from this list. This material is only intended as a guide for the preparation of this class of nominations and to provide a thematic context for the evaluation of resources important in the history of Geological Sciences.

PHYSICAL GEOLOGY

ALASKA

Sydney Chapman Building, Fairbanks Campus of the University of Alaska:

The Sydney Chapman Building on the Fairbanks campus of the University of Alaska was the home of the internationally renowned Geophysical Institute from 1950 to 1970. Its construction was authorized and funded in full by the Congress of the United States in the late 1940s in recognition, particularly, of the difficulties encountered by ships and aircraft in maintaining radio communication when on far northern routes during World War II (the now well-known effect of auroral particles in disturbing the ionosphere). This was the first serious recognition by the United States that the Arctic was important to the United States in science and defense. Subsequently, the Geophysical Institute set a precedent and a pattern of quality for much other research that developed at the university--in oceanography, in biology and in understanding arctic ecosystems.

Katmai National Park and Preserve (NP):

Katmai National monument was established in 1918 by President Wilson for the protection of Mt. Katmai and the Valley of Ten Thousand Smokes--the site of the first order volcanic, explosive eruption in 1912. The eruption was one of the most powerful volcanic explosions ever recorded, emitting several cubic miles of material over the first few days. Expeditions organized by the National Geographic Society to study the volcanoes and the valley shortly after the event, led to a recommendation by the Society for its eventual protection. The valley remains one of the most unique volcanic areas in recent geologic time and as such has been the focus of extensive research and interest by scientists over the years.

Bearing Land Bridge National Preserve (NP):

The northern portion of the Bearing Land Bridge National Preserve contains five rare maar ash explosion craters. This is one single crater and two sets of paired craters. These craters are unusual in a permafrost environment.

AMERICAN SAMOA

American Samoa was visited by the Wilkes Expedition in 1839. The expedition's geologist was James Dwight Dana who made numerous studies of Hawaiian volcanic features. No known site associated with this expedition in American Samoa has been identified to date. The records of the Wilkes expedition are now housed in the archives of the Smithsonian in Washington, DC.

ARIZONA

Barringer Meteor Crater, Arizona (NNL):

The Barringer Meteor Crater is the largest impact crater yet discovered in the United States. The discovery of the crater provoked a debate between geologists and astronomers concerning the nature of these types of structures on both the earth and moon.[57]

ARKANSAS

Fitton's Cave, Arkansas:

This is the longest cave in Arkansas

Blanchard Springs:

No information

CALIFORNIA

California Institute of Technology, Pasadena, California:

Charles Francis Richter (1900-85), a professor of seismology developed the Richter Scale while working here. The Richter Scale enabled seismologists to measure the strength of earthquakes based on seismograms. No specific site for Richter has been identified to date.

Lassen Volcanic National Park, California (NP):

In May of 1914 Lassen Peak erupted, beginning a seven years of sporadic volcanic outbursts. The climax of this episode came in 1915 when the peak blew an enormous mushroom cloud some seven miles into the sky. Since that time Lassen Volcano has served generations of scientists as one of the world's most outstanding natural volcanic laboratories. Its volcanic features graphically demonstrate this earth building force. The revegetation of the devastated mature forest surrounding the volcano has also been the subject

[57] The best sources for the history of the Barringer Meteor Crater were both published in 1987: Hoyt, William Graves, Coon Mountain Controversies. Tucson: University of Arizona Press, 1987.

Mark, Kathleen, Meteorite Craters. Tucson: University of Arizona Press, 1987.

Although now dated, the following source should also be consulted: Foster, George, The Meteor Crater Story. Winslow, Arizona: Meteor Crater Enterprises, Inc. 1964.

of intense study.

Ukiah Latitude Observatory, Mendocino County, California:

The Ukiah Latitude Observatory was one of six astronomical stations established in the northern hemisphere in 1899 for the purpose of making systematic latitude observations. A sister station, the Gaithersburg Latitude Observatory, was designated a National Historic Landmark in 1989.

United States Geological Survey, Menlo Park, California:

Structure B, at the United States Geological Survey in Menlo Park is significant because research completed here by Dick Doell, Allan Cox, and Brent Dalrymple confirmed the theory of plate tectonics previously postulated by other scientists. The scientific work completed here in the 1950s established and dated reversals in the Earth's magnetic field. When this information was combined with other research concerning the theory of sea-floor spreading geologists now had the fundamental framework to confirm the fundamental framework of the theory of plate tectonics which revolutionize the way geologists look at the history of the earth. The research completed at Structure B was the seed bed for the greatest revolution in the history of earth science in the 20th century.[58]

San Andreas Fault (Cienega Winery Site), San Benito County, California (NNL):
The San Andreas fault is a major tectonic feature illustrating lateral, strike-slip movement between two crustal plates and is one of the larger mapped faults in the world. It is the major fault in California and has produced the severest shock waves ever recorded there. The Cienega Winery Site illustrates the slow and gradual movement along the fault line better than any other site along the fault. Generations of scientists have visited this site to study the fault.

University of California at Berkeley, Berkely, California:

G.K. Gilbert sediment studies here documented problems related to hydraulic mining.

CONNECTICUT

Yale University, New Haven, Connecticut:

Bertram Boltwood (1870-1927) worked at Yale University as an assistant professor of physics when he started his important work in radioactivity that led to his invention of a method for the calculation of the age of uranium minerals from their lead and uranium content--a method which, with some important modifications, constitutes our best method of determining the age of the earth. No specific site associated with Boltwood's work at Yale has been identified to date.[59]

Benjamin Silliman (1779-1864) studied at Yale and obtained a law degree there in 1796. In 1802, the President of Yale College hired Silliman to head a department and offer courses in science. Before he began teaching, Silliman attended lectures in chemistry at the medical school in Philadelphia and studied natural science in Europe. By 1806 Silliman had published a sketch on the mineralogy of New Haven and in 1818 he founded The American Journal of Science. The early volumes of Silliman's Journal, as it was then known, contained a number of papers on Connecticut mineralogy and geology, many by Silliman himself. No specific site associated with Silliman's work at Yale has been identified to date.[60] Denison

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[58]Glen, William. The Road to Jaramillo: Critical Years of the Revolution in Earth Science. Stanford, California: Stanford University Press, 1982.

[59] Lawrence Badash, "The Age-of-the-Earth Debate," Scientific American, Vol. 261, No. 2, (August 1989), pp. 90-96.

[60]Altamura, Robert J. "A History of the State Geological and Natural History Survey of Connecticut," in Socolow, Arthur A. ed., The State Geological Surveys: A History (American Association of State

Olmstead and Edward Hitchcock were both students of Silliman.

HAWAII

Kilauea Crater, Hawaii Volcanoes National Park (NR):

The Kilauea Volcano is significant because of its association with the science of volcanology and its association with the scientific career of Dr. Thomas A. Jagggar.[61]

Dr. Jaggar founded the Hawaii Volcano Observatory (HVO) on the rim of Kilauea in 1912 and studied the volcano at the site until his death in 1953. Under Dr. Jaggar's leadership the HVO pioneered in seismological and other studies of volcanic processes including early experiments in measuring the temperature of liquid lava. In later years the HVO used seismograms to predict the arrival of a tsunami from a distant earthquake thereby giving warning of this destructive force to people in low-lying areas of Hawaii for the first time. As a result, Kilauea is one of the world's most studied and understood volcanoes. National and international interest in Kilauea Volcano caused it to be the principal justification for Congress to authorized Hawaii Volcanoes National Park in 1916.

The Kilauea Volcano is also significant as a traditional Hawaiian cultural site. The volcano is the home of **Pele,** the Hawaiian Goddess of Fire and Volcanoes.

Whitney Seismograph Vault, Hawaii Volcanoes National Park (NR):

The Whitney Seismograph Vault is the only extant structure associated with the original observatory building constructed by Dr. Jaggar in l912. The vault was originally the cellar of the observatory and represents the beginnings of the continuous and resident study by American scientists of the earth's volcanic and seismic activity at the Kilauea and Mauna Loa volcanoes. The Hawaiian Volcano Observatory used the vault from 1912 to 1961 when more sophisticated instrumentation made the seismometers and tiltmeters it housed obsolete.

The Old Volcano House, Hawaii Volcanoes National Park (NR):

The Old Volcano House is important because of its long association with the volcano as a hotel providing overnight quarters and food service for the many non-Hawaiian visitors who traveled to see the volcano. In 1877 the Old Volcano House was the first Western style building constructed at the volcano. In 1941 the Volcano House was moved back from the rim of the Kilauea Caldera to make room for a newer hotel. The building now houses a combination gift shop and art gallery for visitors.

Geologists, 1988), p. 48.

[61]Apple, Russell A. "Thomas A. Jaggar Jr. and the Hawaiian Volcano Observatory," Volcanism in Hawaii: U.S. Geological Survey Professional Paper No. 1930, No date.

IDAHO

Craters of the Moon National Monument, Idaho (NP):

The Craters of the Moon National Monument represents part of the largest Holocene basalt lava field in the conterminous United States. Lava flows in this area occurred on at least eight different occasions over a period from 15,000 years ago to 2000 years ago.[62]

ILLINOIS

Geode Glen, Hancock County, (City of Warsaw), Illinois (NR):

Amos A. Worthen, the second state geologist of Illinois (1858-1875), moved to the village of Warsaw, Illinois in 1836 and opened a dry goods store there. While in Warsaw, Worthen became interested in the numerous geodes that occurred in the lower part of the Keokuk Limestone near Warsaw and began to train himself in the science of geology. The area known as "Geode Glen" is now a city park in Warsaw. Geodes collected by Worthen from this site provoked his curiosity about the natural and geological history of the area. In 1972 the Warsaw Historic District was listed in the National Register.

Natural Resources Building, University of Illinois, Champaign County, Illinois:

The Natural Resources Building on the campus of the University of Illinois, headquarters building of the Illinois State Geological Survey, represents a significant record of the history of state-sponsored science in Illinois. Constructed in the classic Georgian style of the University of Illinois campus, the building is a tribute to the foresight and vision of Morris M. Leighton, a noted specialist in the geology of the continental glacial deposits of North America and Chief of the Illinois State Geological Survey from 1923 to 1954.

INDIANA

New Harmony Historic District, Posey County, Indiana:

The New Harmony Historic District was designated a National Historic Landmark on June 23, 1965 in recognition of both the religious and secular inspired utopian communities, the former of which was founder by the Rappites in 1825.

New Harmony is also significant in the history of American Geology. William Maclure (1753-1840), British-born US geologist regarded as the father of American Geology for his monumental Observations on the Geology of the United States (1809) is associated with the site. In 1825 Maclure became a partner with Robert Owen in the ownership of New Harmony.

Maclure attracted other eminent geologists to New Harmony and gave the New Harmony cultural and scientific movement a geologic flavor that was unique to the New World. Maclure was also offered inspiration to David Dale Owen, the son of Robert Owen, to study geology. David Dale Owen became the first state geologist for Indiana serving from 1837-39 and 1859-60.[63]

(Owen Hall, named after David Dale Owen, is the oldest building on the Bloomington Campus of Indiana

[62]Bonnichsen, Bill and Breckenridge, Roy ed., Cenozoic Geology of Idaho. Moscow, Idaho: Idaho Bureau of Mines and Geology, 1982.

Crawford, Vern. Craters of the Moon: Life in a Volcanic Landscape. Washington, DC: National Park Service, 1978.

[63] Patton, John B. "A History of the Indiana Geological Survey," in Socolow, Arthur A. ed., The State Geological Surveys: A History (American Association of State Geologists, 1988), pp. 117-19.

University.)

KENTUCKY

Reelfoot Lake (also Tennessee), Lake County, Kentucky (NNL):

This site was formed in the winter of 1811-12 as a result of shocks from the New Madrid Earthquake, the most severe earthquake ever recorded in the United States. The site contains domes, sunken lands, fissures, sinks, sand blows, and large landslides.

MAINE

Parker Cleveland House, Cumberland County, Maine (part of a National Register District):

Parker Cleveland was the author of the Elementary Treatise on Mineralogy and Geology (1816), the first American work on this subject. His house was built for him in 1806 and he continued to reside their until his death in 1858.

MASSACHUSETTS

Amherst College, Amherst, Massachusetts:

In 1840 Edward Hitchcock, the first state geologist of Massachusetts, saw the flood that created the great oxbow bend in the Connecticut River. Hitchcock also wrote a study of the geology of the Connecticut Valley and a study of the geology of the United States.

There are several buildings at Amherst that have link to his work: his house in which he had his study; the natural history museum which still preserves the fossil footmarks he collected and various buildings at Amherst in which geological specimens he collected are housed.

MISSISSIPPI

Vicksburg Area:

The geology of the Vicksburg area is unique and important for several reasons. First, the geological formations and typography controlled the positions of the Union and Confederate Armies during the siege of the city in 1863. Second, the famous American geologist John Wesley Powell was with the Union army during the siege of Vicksburg and collected fossils there. Third, the earliest detailed geological investigation in Mississippi, and one of the earliest in the Mississippi Valley, was at Vicksburg by the French naturalist Charles A. Lesueur. Finally, Vicksburg is the type locality of the Vicksburg Group, a sequence of rocks that is mapped at the surface and in the subsurface across the Gulf Coastal Plain. The Vicksburg Group is one of the best known Lower Oligocene marine fossiliferous units in the world.[64]

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[64]Personal letter from Michael B.E. Bograd, Geologist for the MIssissippi Bureau of Geology, to Dr. Harry A. Butowsky, dated May 18, 1990.

For further information the reader should consult the following sources:

Morse, William Clifford, "The Geologic History of the Vicksburg National Military Park," Mississippi State Geological Survey Bulletin, No. 28, (1935).

Zullo, Victor A., "A New Species of the Turtle Barnacle Chelonibia Leach, 1817, (Cirripedia, Thoracica) from the Oligocene Mint Spring and Byram Formations of the Mississippi," Mississippi Geology, Vol. 3., No. 2., (March 1982).

Waterways Experimental Station, US Army Corps of Engineers, Vicksburg, Mississippi:

This facility, headquartered in Vicksburg, Mississippi, has been responsible for innovative and historical research of the geology of the Mississippi River Valley. This facility specializes in hydrology, geology, sedimentology of the Mississippi River.

MISSOURI

C.F. Marbut House, Cassville, Missouri:

C. F. Marbut was an internationally-renowned soil scientist and geologist.

Oronogo Circle, Joplin District, Missouri:

An example of a circle deposit and related geology/ore genesis.

St. Joe State Park Geology Museum, Missouri:

The site of the development of ideas related to Mississippi Valley type mineral deposits.

Swallow Hall, University of Missouri:

Swallow Hall was named for George C. Swallow, Missouri's first state geologist.

Onondaga Cave, Leasburg, Missouri:

This was the place where J. Harlen Bretz's theories of cave origin began and the site of the 1952 GSA cave genesis field trip led by Bretz

Johnson Shut-Ins State Park, Middlebrook, Missouri:

This is a type example of Ozark shut-ins, a site where stratified, ash-fall tuffs were identified and the old concepts of "porphory" were replaced with modern ideas.

NEVADA

Pyramid Lake, Nevada:

Pyramid Lake is significant in the history of the Great Basin (discovered by Fremont in 1842) and to the history of geology. C. King and T. C. Russell in the 1870s and 1880s discovered the existence of much higher shorelines from a formerly larger lake (Lake Lahonton) during glacial times. They and later workers also described the unusual tufa mounds formed by springs discharging into the former lake. Pyramid Lake lies within the boundaries of the Pyramid Lake Indian Reservation.[65]

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[65]Fremont, J.C. Report of the exploring expedition to the Rocky Mountains in the year 1842, and to Oregon and North California in the years 1843-1844, U.S. 28th Congress, 2nd. Session, House Executive Document 166, 1845.

Gilbert, C. M. and Reynolds, M. W. "Character and chronology of basin development, western margin of the Basin and Range Province." Geological Society of America Bulletin, Vol. 84, (1973). pp. 2489-2509.

King, C. "Geological and topographical atlas." in Geological exploration of the 40th Parallel, (Washington, DC.: U.S. Government Printing Office, 1876).

--------. "Systematic Geology." in Geological exploration of the 40th Parallel, Vol. 2. (Washington, DC.: U.S. Government Printing Office, 1877).

NEW MEXICO

Stream Gauging Station, Embudo, New Mexico:

This station was the U.S. Geological Survey's first station (1889) for measuring water flows of the nation's rivers and streams. From its origins in New Mexico, the USGS water-monitoring network has grown to over 50,000 monitoring stations nationwide. These stations keep a constant watch on the quantity and quality of the Nation's ground waters.[66]

NEW YORK

Lamont-Dogerty Geological Observatory, Palisades, New York:

American Geologist Harry Hess (1906-1969) worked here after World War II when he worked out his theory of "sea floor spreading" thus providing crucial support to the new theory of plate tectonics.

NORTH CAROLINA

University of North Carolina, Chapel Hill, North Carolina:

In June 1821, Denison Olmstead, Professor of Chemistry at the University of North Carolina at Chapel Hill, wrote to the Board of Internal Improvements proposing his idea to create a State Geological and Mineralogical Survey. Although his request was at first denied Olmstead persisted and on December 31, 1823, the State Legislature passed an act to employ a person to begin geological and mineralogical survey of the state. The work authorized by the legislature of North Carolina in 1823 and carried out by Olmstead in 1824 and 1825 has been referred to as the first geological survey in the United States. In the Fall of 1825 Olmstead returned to Yale College to fill the professorship of mathematics and natural philosophy. No site associated with Olmstead at Chapel Hill has been identified to date.[67]

Morrison, R. B. "Lake Lahontan-Geology of southern Carson Desert." U.S. Geological Survey Professional Paper 401, 1964.

Russell, I. C. "Geological history of Lake Lahontan". U.S. Geological Survey Monograph #11.

[66]Frazier, Arthur H. and Heckler, Wilbur. "Embudo, New Mexico, Birthplace of Systematic Stream Gauging." in U.S. Geological Survey Professional Paper #778, (1974).

[67]Socolow, Op. cit., pp. 332-33.

OKLAHOMA

Arbuckle Mountains along Vines Branch, North of Dougherty, Oklahoma:

Here on August 9, l921, the world's first reflection seismograph geological section was measured. This geophysical method records reflected seismograph waves as they travel through the earth helping to find oil bearing formations. It has been responsible for the discovery of many of the world's largest oil and gas fields. In the years since 1921, the reflection technique has become the major method of energy exploration throughout the world.

TENNESSEE

Reelfoot Lake, Tenessee (NNL):

(See Kentucky entry)

TEXAS

Odessa Meteor Crater, Ector County, Texas (NNL):

The Odessa Meteor Crater is one of only two large meteor craters (the Barringer Meteor Crater in Arizona) known in the United States. The largest of the two meteor impact craters at the site is 550 feet in diameter. Meteorites of nickel-iron composition have been found with the craters and two square miles north and northwest of them.

WASHINGTON

Channeled Scablands, Washington:

The theory of catastrophic flooding from glacial Lake Missoula was first proposed by J. Harlan Bretz in 1923 after studying this site. Bretz published numerous papers on this subject. His concepts have stood the test of time and are now firmly established.[68]

WISCONSIN

Ice Age National Scientific Reserve, Wisconsin (Affiliated Area)

Devils Lake:

Devils Lake is part of the Ice Age National Scientific Reserve and has long been the subject of investigation by geologists seeking to understand the geological history during the last glacial event in North America.

Interlobate Moraine is part of the Ice Age National Scientific Reserve and was studied by Thomas C. Chamberlain, world-renowned glacial geologist and past president of the University of Wisconsin, began his studies in southeastern Wisconsin and was the first person to distinguish four episodes of glacial advance and retreat, thus originating the concept of multiple glaciations.

[68]The Washington State Department of Natural Resources Library (206-459-6372) contains a wealth of material on J. Harlan Bretz. Most of Bretz's scientific papers have been reprinted and are available from the library. A search of the library records on April 9, 1990, yielded 13 articles by Bretz on the Channeled Scablands and 41 articles by other authors.

Two Creeks Forest Bed:

Two Creeks Forest Bed is part of the Ice Age National Scientific Reserve and was instrumental in the development of Chamberlain's concept of multi-glaciations.

Van Hise Rock, Baraboo, Wisconsin:

The Van Hise Rock is named for C. R. Van Hise, professor and later president of the University of Wisconsin. The rock is a monolith of quartzite of the Baraboo quartzite formation. The Van Hise Rock commemorates the contributions made by a great geologist to the understanding of the precambrian geology of the Lake Superior region and of the structures such as those seen in the Baraboo Quartzite Formation.

WYOMING

Sheep Mountain Anticline, Greybull, Wyoming:

The Sheep Mountain Anticline is a textbook example of a double plunging asymmetric anticline, a colorful sequence of paleozoic, and mesozoic strata representing a variety of paleoenvironments which are well exposed along its crest and flanks. Spectacular geomorphic features record the late cenozoic erosional history of the area. Sheep Mountain has been used for years in the teaching of the science of geology in characterizing earth materials and interpreting earth history and in exploring for industrial minerals and fossil fuels. Sheep Mountain is especially significant because it presents simple, understandable geological processes seldom combined in such a small area.[69]

Yellowstone National Park, Wyoming (NP):

Yellowstone National Park is not only the nation's first national park, having been established by Congress in 1872, but is also text book for Americans for the study of geology. The park's past, present and undoubtly future history has been shaped by volcanism. The Grand Canyon of the Yellowstone River provides a rare glimpse of Earth's interior: its waterfalls highlight the boundaries of lava flows and thermal areas.

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[69] In 1963 the National Park Service completed a reconnaissance survey of Sheep Mountain (National Park Service, Preliminary Report, Proposed Sheep Mountain National Monument, Big Horn Canyon, Wyoming, September 1963) to determine its potential for designation as a National Monument. This report was presented to the Advisory Board on National Parks, Historic Sites, Buildings and Monuments (now called the National Park System Advisory Board), as a classic anticlinal structure of great geological interest and expressed its opinion that the area possessed exceptional scientific value and was qualified for National Monument status. The board recommended that further studies were needed to determine the suitability and feasibility of including the Sheep Mountain area in the National Park System. In 1966 Representative Teno Roncalo introduced H.R. 16768 into the Congress to established the Sheep Mountain Monument. No action on this bill was even taken.

Historical Geology[70]

Introduction:

During the immense span of time that has elapsed since life first emerged on the Earth 3.4 billion years ago, environmental conditions have changed and different groups of plants and animals have appeared, flourished, and disappeared. Our knowledge of this life is derived from the rocks that comprise the crust of the Earth. Over the years scientists have written the geological history of the earth by studying the composition, structure, and relationship of rocks and the fossils they contain. Geological time is divided into basic units known as eons, eras, periods, and epochs, each one characterized by different environmental conditions and by specific kinds of life that flourished.

Eons and Eras

All of geological time is divided into two eons: the Precambrian Eon, which began with the formation of the Earth and ended when fossils became abundant in the fossil record some 570 million years ago, and the Phanerozoic Eon, which began with the close of the Precambrian and has lasted until the present day. The Phanerozoic Eon, is divided into three eras, the Paleozoic, Mesozoic, and Cenozoic.

Periods

Each era is divided into periods: the Paleozoic Era is broken into the Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian periods; the Mesozoic into the Triassic, Jurassic, and Cretaceous periods; and the Cenozoic into the Tertiary and Quaternary periods.

Epochs

Each period is divided into epochs. The periods of the Paleozoic and Mesozoic are divided into "Early," "Middle," and "Late," epochs, while the epochs of the Cenozoic Period are given distinctive names. The five epochs of the Tertiary Period are called the Paleocene, Eocene, Oligocene, Miocene, and Pliocene, while the two epochs of the Quaternary are called the Pleistocene or the Recent (Holocene).

Precambrian Era

The Precambrian Era lasted from 3 billion to 600 million years ago. This time interval saw the development of algae, fungi, and soft-bodied marine plants and animals. The distribution of Precambrian rocks is worldwide, but in the United States rocks of this age are found in the Cordilleran region and the Appalachian Mountains. They also occur in the Lake Superior region and in a few localities of the southern midcontinent west of the Mississippi River.

Cambrian-Early Silurian periods

The Cambrian, Ordovician, and early Silurian periods--a time span between about 600 and 420 million years ago--were the age of primitive invertebrates. Life forms were restricted to the water and were, in time, dominated by shellfish of a bewildering variety. Trilobites, brachiopods, sponges, and corals thrived, and jawless fish representing the first vertebrates made their appearance.

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[70] The definitions of historical geological time periods were taken from the following sources:

National Park Service, Natural History in the National Park System and on the National Registry of Natural Landmarks, pp 21-22.

Ida Thompson, The Audubon Society Field Guide to North American Fossils (New York, Alfred A. Knopf, 1988), pp. 15, 33.

Late Silurian-Devonian

The Late Silurian-Devonian periods--a time span between about 420 and 350 million years ago--embraced the rise of vertebrates and the first forest. Life forms continued to exist primarily in the water, but terrestrial life began with the first land plants. During Devonian time, plant growth attained tree size; also primitive land-living creatures became more firmly established and amphibians evolved.

Mississippian-Permian periods

The Mississippian, Pennsylvanian, and Permian periods include a span approximately between 350 and 220 million years ago. Crinoids attained their culmination; ammonoids and their successors, the ammonites, developed; the earliest reptiles appeared, and fish, including over 200 species of sharks, flourished. Trilobites became extinct but coal-swamp forests supporting a wide variety of insects flourished.

Triassic-Cretaceous periods

Triassic, Jurassic, and Cretaceous periods, a time interval between 220 and 70 million years ago, have together been called the age of the reptiles. This span embraces the dominance and extinction of dinosaurs and the flourishing of sea-going and flying reptiles. Modern plant types were on the rise during this period.[71]

Paleocene-Eocene epochs

The Paleocene and Eocene epochs-between 70 and 40 million years ago--embraced the time of the emerging dominance of mammals. Mammals filled niches which had been vacated by the extinct dinosaurs. Modern marine animals and fresh water fishes were on the rise.

Oligocene-Recent epochs

The Oligocene, Miocene, Pliocene, Pleistocene, and Recent epochs--beginning about 40 million years ago and extending to the present time--have together been called the "Golden Age of Mammals." During this period modern life forms became well established. This is also the time (Pleistocene) of the large mammals of the ice age, and the development of humans and their civilizations, as well as modern forms of life.

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[71] Glut, Donald F. The Dinosaur Dictionary. New Jersey: Citadel Press, 1976.

Steel, Rodney and Harvey, Anthony. The Encyclopedia of Prehistoric Life. New York: McGraw Hill Publishing Co., 1979.

Shimer, Harvey and Shrock, Robert R. Index Fossils of North America. Cambridge, Massachusetts: M.I.T. Press, 1977.

These sources illustrate the major forms of dinosaurs known to science and are strongly recommended as reference sources for anyone preparing a National Register or National Historic Landmark nomination on this class of resources.

Technical Note: Fossil Bearing Rocks

Geologists classify rocks in three broad categories based on how they were formed. Igneous rocks, such as granite and basalt, are formed by the cooling and hardening of molten materials either deep in the earth or, in the case of lava released by volcanoes, on the surface. Sedimentary rocks are formed by the hardening of deposits of sand, silt, and other fine particles, or from substances dissolved in water that have precipitated and settled on the bottom. Finally, metamorphic rocks are formed from igneous or sedimentary rocks that have been subject to pressures deep under the Earth's surface, causing their original structure to change. Most fossils are found in sedimentary rocks.

ARIZONA

Comb Ridge, Kayenta, Arizona (NNL):

(Six miles northeast of Kayenta at the top of Comb Ridge on the northeast side of the first major canyon southwest of the first major canyon (1.5 miles) of the jeep trail pass through Comb Ridge). This is the only known locality in North America that contains articulated skeletal material of advanced therapsids or mammal-like reptiles.

Petrified Forest National Park, Arizona (NP):

The collection and study of fossils from the Petrified Forest began with the investigation of the area by the U.S. Army in the 1850s. A national monument proclaimed in 1906, was the first to specifically protect fossil resources. Scientific investigations have continued to the present day.

Nankoweap Butte, Northeastern Grand Canyon National Park. (NP):

This site is important in the history of Precambrian paleontology. C. D. Walcott collected Chuaria here and stromatolite specimens Collenia occidentale.

CALIFORNIA

Rancho La Brea, Los Angles, California (NNL):

This metropolitan park contains pits of natural asphalt tar in which Pleistocene animals became entrapped in their quests for fresh water. The pits have yielded the largest and most diverse collection of Pleistocene fossil remains found anywhere in the world today. Remains of ground sloth, saber-tooth tiger, mammoth and many others are found here. The pits have been known from the days of the earliest Spanish explorers in California.

Rainbow Basin, San Benito County, California (NNL):

Rainbow basin contains significant fossil evidence of insects, larger Miocene animals and mammal tracks, as well as deep erosion canyons with rugged rims. This site has served as an outstanding outdoor laboratory for the study of geological processes.

Sharktooth Hill, Kern County, California (NNL):

Sharktooth Hill contains one of the most abundant, diverse, and well preserved marine invertebrate fossil faunas in the world. It is also the first vertebrate paleontological site west of the Rocky Mountains that was studied by scientists.

Slate in Hell Hollow (near Mariposa), California:

Clarence King first identified fossil remains here to establish the Jurassic age in the meta sediments in the Sierra foothills. This was a significant step in western U.S. metamorphic studies.

COLORADO

General note: Most of Colorado is underlain by deposits from the Morrison Formation which is the most prolific source of dinosaur skeletons anywhere in the world. This formation was laid down during the Jurassic Period some 130 to 150 million years ago. The first discoveries of dinosaur bones in Colorado were made in this formation by Professor Arthur Lakes in 1877 near Morrison, Colorado.[72]

Canyon City, Fremont County, Colorado:

Paleozoic fish remains were identified at this site by T. W. Stanton in 1890. C. D. Walcott traveled to the site in December 1890 and dated the fossils authoritatively to the Middle Ordovician (Trentonian) by the presence of associated and overlying marine invertebrates. Fieldwork by S. W. Loper the following year, and by Walcott in 1892, added additional vertebrate specimens and verified Walcott's conclusions as to age. Walcott recognized the great antiquity of these specimens and his fossils were accepted as the oldest occurrence of vertebrates for more than 80 years.

Cope Quarry Site, Fremont County, Colorado:

(Information to be supplied later)

Dinosaur National Monument, Dinosaur Colorado (NP):

The quarry area contains the remains of several species of large dinosaurs. and is associated with the career of Earl Douglass who collected for the Carnegie Museum. This is the premier site for our knowledge of the large vertebrate community of the Morrison Formation (Upper Jurassic). The discovery of the Dinosaur Quarry in 1909 was one of the most important events in the history of vertebrate paleontology in North America.[73]

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[72] The literature pertaining to the discovery of dinosaurs skeletons in Colorado during the late 19th and early 20th centuries is especially rich. The following sources are only a few of many that can be consulted for further information.

Colbert, Edwin H. Men and Dinosaurs: The Search in Field and Laboratory, New York: E.P. Dutton & Co., 1968.

Keener, James. Dinosaur Triangle-Land of the 'Terrible Lizards',
Grand Junction: Colorado, Grand River Publishing, 1988.

Kuntz, David W., Armstrong, Harley J., and Athern, Frederic J. Faults, Fossils and Canyons-Significant Geological Features on Public Lands in Colorado, Colorado State Office: Bureau of Land Management, 1989.

Ostrom, John H. and McIntosh, John S. Marsh's Dinosaurs, New Haven: Yale University Press, 1966.

Plate, Robert. The Dinosaur Hunters: Othniel C. Marsh--Edward D. Cope, New York: David McKay Co., 1964.

Wilford, John Noble. The Riddle of the Dinosaur, New York: Vintage Books, 1987.

[73]Daniel J. Chure and John S. McIntosh, "Stranger in a Strange Land: A brief History of the Paleontological Operations at Dinosaur National Monument" Earth Sciences History, Vol. 9. No. 1. (I990),

Dinosaur Trackways, Pinon Canyon, Colorado:

(Information to be supplied later)

Dry Mesa Quarry:

(Information to be supplied later)

Florrisant Fossil Beds National Monument, Florrisant Colorado (NP):

The discovery of the Florissant fossil bearing shales is credited to Dr. A.C. Peale of the U.S. Geological Survey in 1874. Peale did his work as part of the Hayden expedition. Dr. Samuel J. Scudder was the earliest scientist to make a major expedition to Florrisant in 1877. He returned again in 1879 and in the two expeditions removed 18,000 museum quality fossil specimens-both insect and plant. The fossil insects, seeds and leaves from Florissant provide an exact record of the ecosystem around prehistoric Lake Florrisant in the Oligocene Period (35 million years ago).

Garden Park Fossil Area, Freemont County, Garden City Colorado (NNL):

One of the oldest and richest sites containing dinosaur, fish, crocodile, turtle, and mammal fossils in the United States. Garden Park is the site that triggered the first interest in 'gigantic saurian bones' with the discovery by Arthur Lakes in April 1877.

Indian Springs Trace Fossil Locality, Fremont, Colorado (5 miles north of Florence), (NR 1975),(NNL 1979):

Associated with the career of Charles D. Walcott who discovered fossil vertebrate remains from this site in 1892. Recommended by the Colorado SHPO office.

Morrison Fossil Area (Dinosaur Ridge), Jefferson County, Colorado (NNL):

The Morrison Fossil Area is considered to be comparable with Garden Park. Historically, it was this site, with Garden Park, that first produced gigantic fossil bones and thus triggered the great "dinosaur rush" in the late 19th century. It subsequently produced specimens of a number of dinosaurs including Apatosaurus, Diplodocus, Allosaurus and Stegasaurus.

Rabbit Valley, Mesa County, Colorado:

Rabbit Valley contains a large section of a Camarasaurus axial skeleton in channel sandstone and has also produced elements of Iguanodon, Allosaurus, Camarasaurus, Diplodocus, Apatosaurus, crocodilians, and turtles from four horizons.

Riggs Hill, Grand Junction, Colorado:

Site of Quarry No. 13, where in July 1900 Elmer S. Riggs, excavated 19 fossil bones of a large dinosaur that Riggs named Brachiosaurus. Riggs' discovery drew attention as "the largest land animal that ever lived."

CONNECTICUT[74]

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pp. 34-40.

[74] See the following articles by Robert J. Altamura, a geologist with the Connecticut Geological and Natural History Survey for further information.

Charles O. Wolcott Quarry, Manchester, Connecticut:

This is the discovery site of three Late Triassic dinosaurs, Yalesaurus, Ammonsaurus and Anchisaurus, and is the only know site in New England that has produced more than one specimen. The Wolcott Quarry has produced most of our knowledge about Late Triassic dinosaurs of the Northeastern United States.[75]

Dinosaur State Park, Rocky Hill, Connecticut (NNL):

The tracks at Dinosaur State Park were discovered on August 23, 1966 by an equipment operator while excavating a foundation for the Connecticut State Department of Transportation Highway Testing Laboratory. The tracts date from the Early Jurassic Period (185,000,000 years ago) and were designated a Natural Landmark in 1968. These tracks represent one of the largest exposures of dinosaur footprints in the world.

Portland Quarry, Portland, Connecticut:

One of the major sites of dinosaur footprint discoveries during the latter part of the last century and the early part of this century. Much of the brownstone for New York City came from this quarry.

DELAWARE

Chesapeake and Delaware Canal, Delaware:

The Chesapeake and Delaware Canal was visited by many prominent geologists soon after its completion in the 1820s, thus playing an important role in understanding Cretaceous stratigraphy in the Atlantic Coastal Plain.[76]

Robert J. Altamura, "Historic Geological Sites in Connecticut," Connecticut Environment, Vol. 17, No. 10 (June, 1990), pp. 10-13.

__________________, "Connecticut's Historic Geological Sites," Connecticut Environment, Vol, 17, No. 11 (July-August, 1990), pp. 15-17.

The second of these two article's contains an extensive bibliographic listing of sources illustrating the geological and historic significance of these sites.

Lull, Richard Swann, "Triassic Life of the Connecticut Valley," State Geological and Natural History Survey of Connecticut Bulletin, Vol. 81, (1924).

[75] R.S. Lull, "Triassic Life of the Connecticut Valley," Bulletin of the Connecticut Geological and Natural History Survey, Vol. 81, pp. 1-336.

[76]Thomas E. Pickett, "Upper Cretaceous and Quaternary stratigraphy of the Chesapeake and Delaware Canal," in Geological Society of America Centennial Field Book--Northeastern Section. 1987. pp. 23-4.

FLORIDA

Devil's Millhopper, Florida:

This large, deep sinkhole is located on the outskirts of the City of Gainsville, in north peninsular Florida. The Miocene age sediments exposed here were first described by William H. Dall in the late 19th century.

IDAHO

Hagerman Fossil Beds National Monument, Twin Falls County, Idaho (NP):

The Hagerman Fossil Beds National Monument is world famous, containing the best known variety, quality and quantity of upper pliocene fossils. Since the first 3.5 million year old bones were discovered, researchers have pieced together remains of saber-toothed cats, zebra-like horses, ground sloths, mastodons, camels, beavers and turtles.

Berlin Icythosaur Site State Park, Idaho:

(No infortmation to date)

Sand Point, Idaho:

(No information to date)

ILLINOIS

Bridgeport Quarry, Cook County, Illinois:

The Bridgeport Quarry had a long and important history as a source of stone and lime for the City of Chicago beginning with federal government construction of the Chicago Harbor in 1833. The quarry was also a prolific source of Silurian reef fossils described by James Hall, A. Winchell, W. Marcy, C. Sheperd, S. Miller, and A. Worthen.

Farm Creek/Farmdale Exposures, Tazewell County, Illinois:

The Farm Creek/Farmdale exposures are significant because they reveal a complete stratigraphic record of late Ice Age events in the Midwest. The site is important in the history of geology in the United States for the key role it played in the development of theories of Pleistocene continental glaciation, which for the most part, were formulated in North America. In particular, this geological exposure figured prominently in the interpretation of multiple glaciations, the cyclicity of glacial and interglacial climatic stages, the occurrence of interstadial climatic changes, the origin of loess, and the identification of fossil or buried soils. The exposure was first discovered in 1897 by Frank Leverett, one of America's formost glacial geologists, who pictured and described it in his classic monograph on Illinois Quaternary geology, The Illinois Glacial Lobe.[77] This site is recommended for designation as a National Historic Landmark in this theme study.

Stony Island, Cook County, Illinois:

Stony Island figured prominently in debates by professional geologists over depositional verses tectonic origin of reef structures. The site was used as a primary outdoor classroom by the University of Chicago to teach geology in the 1920's and 1930's. The site figured importantly in Great Lakes Quaternary studies by W. C. Alden, S. Miller, and A. Worthen. This site has been developed into a residential area and no

[77]Leverett, Frank, The Illinois Glacial Lobe. Washington, DC.: US Geological Survey Monograph 38, 1899.

longer possesses sufficient integrity to be considered for National Historic Landmark designation.

Thornton Reef, Cook County, Illinois:

The Thornton Reef is one of the largest commercial stone quarries in the world. In addition, the quarry is the best exposed Silurian reef in North America. Important geologists including H. A. Lowenstam, J. Harlan Bretz, H. B. William and others have all used the Thornton Quarry to formulate modern theories of reef definition and development. In a letter dated April 15. 1991, from Mr. Louis Levy, Vice-President and Assistant to the Chairman of the Material Services Corporation (the owner of the Thornton Quarry) to Harry Butowsky, the Material Services Corporation declined to give permission for the study and possible the designation of this site as a National Historic Landmark.

Mazon Creek-Pit 11, (Will & Kankakee Counties), Illinois:

The Mazon Creek-Pit 11 sites are generally considered to be one of the five most important sources of exceptional fossil preservation in the world. The sites are a prolific source of Pennsylvanian Era fossil plants, invertebrates and vertebrates. The Pit 11 site is the only source in the world for Tullimonstrum gregarium, the State fossil of Illinois.[78] In May 1991, Commonwealth Edison requested declined to give permission for the study and possible designation of the Pit 11 site as a National Historic Landmark. The Mazon Creek site is recommended for designation as a National Historic Landmark in this theme study.

IOWA

Decorah Ice Cave, Afton, Union County, Iowa (NR):

The Decorah Ice Cave is the largest know glaciere in North America, east of the Black Hills. It was the subject of much international speculation during the late 19th century. In 1860, only 12 years after the first white settlers arrived in the area, a note was published in the Scientific American commenting on the formation of ice within the cave. Over the next 40 years a long series of articles in scientific publications speculated on the possible mechanisms of ice formation and brought international recognition to the cave. The series culminated in an article in 1898 in the Scientific American Supplement by Alois Kovarik, who proposed a theory that was accepted by the leading authorities of the day and which is still accepted.[79] The Decorah Ice Cave is recommended for designation as a National Historic Landmark in this theme study.

Loess Hills, Harrison and Monon Counties, Iowa:

The Loess Hills is the site of definitive field work by Bohumil Shimek in which he established the eolian origin of loess and the geologic origins of one of the most common glacial-age materials.[80]

Loveland Loess Type Section, Pottawattamie County, Iowa:

This is the standard reference section for one of the most widely correlated Pleistocene units of the mid-continent.[81]

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[78] Nitecki, Matthew H. Mazon Creek Fossils, New York: Academic Press, 1979.

[79] Kovarik, Alois, "Decorah Ice Cave and its Explanation," Scientific American Supplement Vol. 1195 (1898). pp. 19158-19159.

[80] Shimek, Bohumil., "Geology of Harrison and Monoa counties." Iowa Geological Survey Annual Report, Vol. 20, (1910), pp. 271-485.

Prior, Jean C., "Loess Hills: A National Natural Landmark." Iowa Geology, Vol. 12, (1987), pp. 16-19.

[81] Daniels, R. B. and Handy, R. L., "Suggested new type section for the Loveland loess in western

Cretaceous Exposures along the Big Sioux River valley north of Sioux City, Plymouth County, Iowa:

It was from this area that Meek and Hayden, in 1862, originally named the Dakota Group, the basal subdivision of Cretaceous rocks as used throughout much of the United States.[82]

Devonian-age Lime Creek Formation, Floyd County, Iowa:

(Rockford Brick and Tile Pit with historic kilns is the largest collection site) This site has been known since the 1850's and is famous internationally for some of the best fossil collecting in the Midwest.[83]

Mississippian System Type Locality, Burlington Area, Des Moines County, Iowa:

This site established the foundation for the Mississippian system, one of the basic divisions of geological time recognized throughout the world. The Burlington area crinoid fossils from this site have been known for well over a century and renowned internationally for their abundance, diversity, and excellence of preservation.[84]

Upper Ordovician Maquoketa Formation, Dubuque County, Iowa:

The shale-dominated interval at Graf was first recognized by James Hall in 1858 and was named the maquoketa Shale recognized by Charles White in 1870 from these exposures along the Little Maquoketa River. This site also has important paleontological significance for the great abundance of straight-shelled nautiloid cephalopods. Beautiful specimens from this site are seen in museums throughout the world.[85]

Iowa," Journal of Geology, Vol. 67, No. 1, (1959), pp. 114-19.

Bettis, E. Arthur III, "Holocene alluvial stratigraphy and selected aspects of the Quaternary history of western Iowa,"
Midwest Friends of the Pleistocene 37th Field Conference, May 12-13, 1990, (1990).

[82]Witzke, Brian J. and Ludvigson, Greg A., "Cretaceous exposures, Big Sioux River valley north of Sioux City, Iowa,"
in Biggs, D.L. ed., Geological Society of North America Centennial Field Guide: North Central Section, Vol. 3 (1987), pp. 97-102.

[83]Anderson, Wayne I. and Furnish, William M. "The Lime Creek Formation of north-central Iowa", in Biggs, D. L. ed., Geological Field Guide: North Central Section, Vol. 3, pp. 89-92.

[84]Williams, Henry S., "The Lower Carboniferous or Mississippian series: the development of the nomenclature and classification of the Lower Carboniferous of the Mississippian province." U.S. Geological Survey Bulletin, Vol. 80, (1891), pp. 135-172.

Glenister, Brian et al., "Starrs Cave park, Burlington area, Des Moines County, southeastern Iowa." in Biggs, D.L., Vol. 3, Geological Society of America Centennial Field Guide: North-Central Section, Vol. 3, (1987), pp. 125-132.

[85]Calvin, Samuel and Bain, H.F., "Geology of Dubuque County." Iowa Geological Survey Annual Report, vol. 10., (1900), pp. 379-622.

Witzke, Brian J. and Glenister, Brian F., "Upper Ordovician Maquoketa Formation in the Graf area, eastern Iowa." in Biggs, D.L. ed., Geological Society of America Centennial Field Guide: North Central Section, Vol. 3., (1987), pp. 103-108.

KANSAS[86]

Junction City, Kansas:

First discovery of fossils from the Permian strata.

Monument Rocks Natural Area, Grove County, Kansas (NNL):

This area includes pinnacles, small buttes, and spires of chalk of the Niobrara formation, erosional remnants of sediments deposited in the ancient Kansas sea of Cretaceous time, and is a rich source of fossils of Cretaceous Marine animals.[87]

Castle Rock, Kansas:

This site was a landmark in the late 1800s when paleontologists began the exploration and discovery of vertebrate fossils from the Niobrara Chalk area. Associated with O.C. Marsh, E. D. Cope and S.W. Williston.[88]

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[86]Peterson, John M. "Science in Kansas: The Early Years, 1804-1875." Kansas History: A Journal of the Central Plains, Autumn 1987, pp. 201-40.

John Peterson's article covers the early history of science in Kansas from the years 1904 to 1875 and is especially rich in information pertaining to the advancement of geology in Kansas science.

For additional information concerning the history of geological survey's and science in Kansas the following publication should be consulted.

Kansas Geological Survey. Catalogue of Publications of the Kansas Geological Survey. Lawrence, Kansas: Kansas Geological Survey, 1988.

[87]Hattin, Don. "Stratigraphy and Depositional Environment of Smoky Hill Chalk Member, Niobrara Chalk (Upper Cretaceous), of the Type Area, Western Kansas," Kansas Geological Survey Bulletin 225, (1982).

Hattin, Don and Siemers, C.T. "Guidebook to Upper Cretaceous Stratigraphy and Depositional Environments of Western Kansas," Kansas Geological Survey Guidebook 3, (1978).

[88]Skelton, Lawrence. "Kansas Skirmishes in the Cope/Marsh War." Earth Science History Journal Vol. 3, No. 2., (1984), pp. 117-22.

Point of Rocks, Morton County, Kansas:

(Found in the Cimmarron National Grasslands) This an outcrop of the Ogallala Formation, underlain by rocks that are now thought to be Triassic, probably in the Dockum Group. As such, Point of Rocks is the only outcrop of the Triassic in Kansas. Site was also landmark for the Santa Fe Train.

KENTUCKY

Big Bone Lick, Boone County, Kentucky (NR):

This world famous fossil locality dates back to 1739 when the site was first discovered by French explorers. It was the first widely known collecting locality for vertebrate paleontology in North America, and the expedition sent by President Thomas Jefferson and headed by William Clark in the early 1800's was the first organized, government sponsored "dig" in the New World.[89] This site is recommended for designation as a National Historic Landmark in this theme study.

MASSACHUSETTS

Moody Corner, South Hadley, Massachusetts:

(At the intersection of Pearl Street, Barnett Street and Amherst Road-State Highway 116, 2 miles north-northeast of the Mount Holyoke campus) In this vicinity the first dinosaur footprint to be discovered was found by Pliny Moody in 1800 or 180l. Moody called this footprint "Noah's Raven" and believed it to be that of a bird. The exact location may not be known.

Horse Race, Turner's Falls, Massachusetts:

(North and south banks of the Connecticut River, 1 to 2 miles east of the town of Turner's Falls, Franklin County) This is a major locale that produced large numbers of specimens of vertebrate footprints, especially during the latter part of the last century.

Lily Pond, Turners Falls, Massachusetts:

The Lily pond is one of the most prolific localities in all of New England for dinosaurian and other reptilian footprints. Hundreds of specimens have been collected here during the last 100 years representing 31 genera and 57 species.

MISSSOURI

Kimmswick Bone Bed, Mastodon State Park, Jefferson County (NR):

Mastodon State Park contains one of the most important archeological sites in Missouri--the site where archaeologists first discovered a man-made weapon with the bones of American mastodons. This was the first solid evidence of the coexistence of men and mastodons in eastern North America. In 1980 the Kimmswick Bone Bed was listed on the National Register of Historic Places with a recommendation of national significance.[90] This site is recommended for designation as a National Historic Landmark in this

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[89] Gunderson, Harvey L., "Big Bone Lick, Kentucky." University of Nebraska News--Museum Notes, No. 33, (March 1967).

[90] Graham, Russell W. "National Register of Historic Places Inventory-Nomination Form-The Kimmswick Bone Bed." Springfield, Illinois: Illinois State Museum, 1980.

For additional information please consult the following sources.

Adams, R. M. "Archeological Investigations in Jefferson County, Missouri." The Missouri Archeologist, Vol.

theme study.

MONTANA

Mouth of Deep Creek Canyon, Big Belt Mountains, Montana:

This site is located on a roadcut along an unpaved county road just off U.S. highway 12 at the mouth of the Deep Canyon. The roadcut is 150 meters long and ranges from 2 to 5 meters high, and is steeply inclined.

C. D. Walcott discovered his famous magafossil Grypania spiralis, at this site. The site continues to yield hundreds of specimens of Grypania spiralis and other magafossils in this same outcrop.

Bridger Fossil Area, Carbon County, Montana (NNL):

This site includes several quarries that have produced numerous partial skeletons from the Lower Cretaceous, including remains of armored, ornithipod, and carnivorous dinosaurs. Most of these remains are those of several specimens of an unusual small carnivore, Deinonychus.

Bug Creek Fossil Area, McCone County, Montana (NNL):

Bug Creek is found east northeast of the Hell Creek Fossil area. The site contains numerous small mammal fossils. Both sites taken together span the decline of the dinosaurs and the beginning of mammalian dominance.

Cloverly Formation Site, Big Horn County, Montana (NNL):

This site has produced a large number of partial and nearly complete dinosaurian skeletons of the early Cretaceous age. It is the single most productive region in all of North America for early Cretaceous vertebrates. Terrestrial sediments of this age are not common in North America and terrestrial faunas are consequently scarce.

11, (1949), pp. 1-72.

Graham, Russell W. "The Kimmswick Bone Beds: A Historical Perspective," The Living Museum, Vol. 42, Nos. 2,3.

----------------. "Clovis Peoples in the Midwest: The Importance of the Kimmswick Site," The Living Museum, Vol. 44, No. 2.

McMillian, R. Bruce. "Objects of Curiosity: Albert Koch's 1840 St. Louis Museum." The Living Museum, Vol. 42, Nos. 2, 3.

Hell Creek Fossil Area, Garfield County, Montana (NNL):

This area has produced numerous partial skulls and skeletons of ceratopsian dinosaurs, chiefly Triceratops.

NEBRASKA

Agate Fossil Beds National Monument, Gearing, Nebraska (NP):

In 1885, James H. Cook, a trail driver, cavalry scout and cattleman, discovered fossil bones in the hills near his home, the Agate Springs Ranch. His discovery of these Miocene mammal fossils, dating from 19 million years ago, brought collectors and scientists from all over the United States and the world to this site.[91]

NEVADA

King, Hague and Emmons, in central Nevada:

The correct identification of Cambrian strata here led to the general acceptance of the term "Cambrian" and its first use in the United States. The commonly used term before this event was Lower Silurian or Primordial.

NEW JERSEY

Hadrosaurous Foulkii Site, West Haddonfield, New Jersey:

(0.4 mile North of Hopkins Pond, on the north bank of the small stream flowing through Pennypacker Park into Cooper River.)

This is the site of the first reported find of an articulated dinosaur skeleton in the Western Hemisphere. A partial skeleton of Hadrosaurous foulkii was discovered in a now abandoned marl pit here in the late 1830s. The remainder was salvaged in 1858 and donated to the Philadelphia Academy of Sciences where it was the first dinosaur specimen to be mounted for display. This was the first dinosaur specimen to be exhibited in the New World.[92] In 1990, The Wagner Free Institute of Science in Philadelphia, Pennsylvania, a site associated with Dr. Joseph Leidy, was designated a National Historic Landmark. Dr. Leidy served as the President of the Wagner Free Institute during the last six years of his life.[93] A copy of

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[91] Hunt, Robert M. Jr., The Agate Hills--History of Paleontological Excavations 1904-1925 Lincoln, Nebraska: University of Nebraska Museum, 1984.

U.S. Department of the Interior, National Park Service. Agate Fossil Beds--Handbook 107. Washington, D.C.: Government Printing Office, 1980.

[92] Leidy, Joseph. "Hadrosaurous foulkii, a new saurian from the Cretaceous in New Jersey." in the Proceedings of the Academy of Natural Sciences of Philadelphia, Vol. 10, (1858), pp. 215-218.

Cope, Edward Drinker. "On the characters of the skull in the Hadrosauridae." in the Proceedings of the Academy of Natural Sciences of Philadelphia, Vol. 35, (1883), pp. 97-107.

[93] For further information the reader should consult the following sources:

Spamer, Earle E., and Forster, Catherine A. A Catalogue of Type Fossils in the Wagner Free Institute of Science, Philadelphia, Pennsylvania: With a History of Paleontology at the Institute. Philadelphia, Pennsylvania: Wagner Free Institute, 1988.

this nomination form is included in this study.

Poricy Park Fossil Beds, Navesink, New Jersey:

(Located just north of Lincroft, New Jersey east of the Middletown-Lincroft Road) The marine deposits here are related to the well know Late Cretaceous rise in sea level, which inundated and flooded widely over the continents of the world.

Riker Hill Quarry, Roseland, New Jersey (NNL):

(Located 500 yards south of the Morristown and Erie Railroad crossing over Eagle Rock Avenue, Roseland, Morris County) Since its discovery in 1968 this site has produced more than 1,000 specimens of dinosaur and other vertebrate animal footprints, insect trails and other impressions of the fauna of the Late Triassic times. This site is similar to the Rocky Hill Quarry in Connecticut.

NEW MEXICO

Ghost Ranch, Rio Arriba County, New Mexico (NNL):

(Found on the southeast side of the small hill closest to the high mesa "behind the swimming pool." The quarry is almost 0.5 mile northeast of the pool, on the Ghost Ranch northwest of Abiquiu, Rio Arriba County, New Mexico.) Ghost Ranch has produced dozens of exceptionally well-preserved skeletons of one of the earliest known and most primitive members (Coelophysis) of the carnivorous dinosaurs (suborder Theropoda). Individuals from all ages are represented in the quarry thus allowing growth stages of this animal to be studied.[94]

Prehistoric Trackways, (Robledo Mountains) Las Cruces, New Mexico:

This site contains fossil footprints that form trackways from the Permian age. The trackways are unique in length and represent most taxonomic groups, including many prints from unknown animals, The trackways illustrate the emergence of life from the water to the land more that 280 million years ago.

Tucumcari Mountain (Saddleback), New Mexico:

This was the site where J. Marcou first identified the Jurassic in the United States.

Bolt, Eugene and Glassman, Susan."National Register of Historic Places Inventory-Nomination Form--Wagner Free Institute of Science." Philadelphia, Pennsylvania: Wagner Free Institute of Science, 1990.

[94]Northrop, Stuart A. "Evaluation of the Ghost Ranch, New Mexico site for designation as a Natural Landmark." Washington, DC.: National Park Service, 1974.

NEW YORK

Petrified Sea Gardens, Saratoga County, New York (NNL):

The Petrified Sea Garden preserves a unique formation for bacterial reefs that turned into fossilized stone. These ancient algal build-ups, or stromatolites, were the basis for the first description of stromatolites in North America by Professor James Hall of the New York State Geological Survey in 1883. Hall's report led to an investigation of modern living stromatolites in Green Lake, near Syracuse, by C.A. Davis and Charles D. Walcott that led to the conclusion in 1914 that blue green algae were responsible for the formulation of stromatolites through geological time.

NORTH CAROLINA

Egypt Mine, Cummock, North Carolina:

(This is a coal mine shaft approximately 0.75 mile north of Deep River in Lee County, North Carolina) In the 19th century this site produced various fossil vertebrates, the most important of which are the two tiny jaws of Dromatherium and Microconodon that were long thought to be the oldest true mammals. They are now considered to be mammal-like reptiles. Therapsids were important contemporaries of the early dinosaurs.[95]

OREGON

John Day Fossil Beds National Monument, Oregon (NP):

While the John Day Fossil Beds National Monument is both a National Natural Landmark and a unit of the National Park System. The park preserves a vast record of the history of the past from more than 50 million years ago to 5 million years ago, during the Cenozoic Era, or the Age of Mammals. The Sheep Rock and Painted Hills units of the park are both believed to qualify for designation as National Historic Landmarks. The existing "James Cant Ranch National Historic District" within the boundaries of the park has nothing to do with the sciences of paleontology or geology.

SOUTH DAKOTA

Badlands National Park, Interior, South Dakota (NP):

The rocks at Badlands National Park preserve a rich variety of mammalian fossil deposits from the Oligocene Epoch dating from 37 to 23 million years ago. These fossil resources represent the most complete window to the Oligocene Epoch available to scientists in the last one hundred years. Because of the Badlands fossils, the Oligocene is called the "Golden Age of Mammals."[96]

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[95] Marsh, O(thneil) C. "Note of Mesozoic Mammalia." in the Proceedings of the Academy of Natural Sciences of Philadelphia, (1891), pp. 237-241.

Osborn, H.F. "A new mammal from the American Triassic." Science, Vol. viii, (1886), p. 540.

-----------. "Observations upon Triassic mammals Dromatherium and Microconodon." in the Proceedings of the Academy of Natural Sciences of Philadelphia (1886), pp. 359-363.

[96] The literature on the fauna of the Late Eocene and Oligocene Eras at the Badlands National Park is extensive. Listed below are some critical references to this literature.

Bijou Hills, Charles Mix County, South Dakota (NNL):

The Bijou Hills are a series of quartzite-capped buttes that extend in an east-west direction for about 12 miles, and are seldom more than a mile in width. The Twin Buttes at the west end of the hills were conspicuous landmarks for early day travelers along the Missouri River. They appear on maps as early as 1855 and their geology has been described and debated for more than l35 years. F.V. Hayden visited this area in 1853 and described its paleontological resources (Tertiary mammal fossils).

TEXAS

Dinosaur Valley State Park, Somervell County, Texas (NNL):

Dinosaur Valley State Park, four miles east of Glen Rose, contains fossil footprint trackways exposed in the bed of the Paluxey River and tributary creeks that give important information on the habits and locomotion of the large dinosaurs.

Greenwood Canyon, Montague County, Texas (NNL):

Greenwood Canyon is one of the three or four most important fossil localities of the Cretaceous age known in the world, and is the most important site of Early Cretaceous mammalian remains in the Western Hemisphere. It is the sole surviving locality to produce more that a single mammalian tooth representing the first half of the Cretaceous, a very important period in mammalian evolution.

Guadalupe Mountains National Park, Salt Flat, Texas (NP):

The Guadalupe Mountains National Park contains one of the finest examples of an ancient marine fossil reef on Earth. This reef formed 250 million years ago during the Permian Age when Texas was covered by a vast shallow tropical sea. Over millions of years, calcareous sponges and algae combined with other lime-secreting marine organisms and vast quantities of lime that precipitate directly from sea water to form the 400-mile-long, horseshoe-shaped Capitan Reef.

Leidy, Joseph. The Extinct Mammalian Fauna of Dakota and Nebraska. New York: Arno Press, 1869 (reprint 1974).

Penrose Conference on Late Eocene and Oligocene Climatic and Biotic Evolution (Unpublished Guide to the White River Badlands), 1989. (Files of Badlands National park).

Retallack, G. L. "Late Eocene and Oligocene Paleosols from Badlands National Park, South Dakota." Geological Society of America Special Report #193, (1983).

Romer, Alfred Sherwood. Vertebrate Paleontology. Chicago: University of Chicago Press, 1933 (third edition 1966).

Shuler, Jay. Fossil Exhibit Trail Guide. South Dakota: Badlands Natural History Association, 1989.

UTAH

Cleveland-Lloyd Dinosaur Quarry, Emery County, Utah (NNL):

The Cleveland-Lloyd Dinosaur Quarry has provided more than 10,000 fossil bones from at least eleven different genera of the Jurassic Period, ten of which are dinosaurs and one a turtle, Glyptops. The quarry appears to represent a unique predator trap not duplicated anywhere in the world.

VIRGINIA

Balcony Falls, Virginia:

Balcony Falls is important in historical geology because it was here that Charles D. Walcott unlocked the key to understanding the stratigraphic succession in the Appalachians south of New York. Beginning with this discovery geologists were able to firmly place the Cambrian throughout the Appalachians.[97]

WASHINGTON

Gingo Petrified Forest State Park, Washington:

No information available at this time.

WISCONSIN

Dr. Fisk Holbrook Day House, Milwaukee County, Wisconsin, (NR):

Dr. Fisk Day Holbrook was an amateur geologist and paleontologist who gained national recognition in the late 19th century for the excellence of the fossil specimens in his collection. Today his fossils and geological specimens are found in the collections of the Smithsonian Institution, Harvard Museum and the Field Museum in Chicago. By assembling collections and publishing a few papers Dr. Day and his colleagues stimulated paleontological and stratigraphic research in the Mid-West and contributed to the study of the Silurian and Devonian rocks of the area. This site is recommended for designation as a National Historic Landmark in this theme study.

Horlick Reef, Quarry Lake Park, Racine County, Wisconsin:

The Horlick Reef is second only in importance to the Schoonmaker Reef in North American reef studies. This site is recommended for designation as a National Historic Landmark in this theme study.

Green Geological Collection and Museum Building, Milwaukee, Wisconsin:

This collection preserves one of the last remaining intact gentleman geologists (Thomas A. Greene) collections of fossils and minerals from the 19th century. The museum building was erected in 1911 by Greene's heirs to specifically hold his collection when donated to the Milwaukee Downer College, now the property of the University of Wisconsin-Milwaukee. The Greene collection is believed to be of inestimable scientific value to future geological work in the study of the Silurian and Devonian age eras in the Mid-West. This site is recommended for designation as a National Historic Landmark in this theme study.

Milwaukee Formation Exposures, East Brook Park, Milwaukee, Wisconsin:

The Milwaukee Formation Exposures have served as an important source of Middle Devonian fossils from the west edge of the Michigan Basin. The site was first described by geologist I.A. Lapham in the 19th

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[97]Secord, J.A. Controversies in Victorian Geology: The Cambrian-Silurian Dispute: Princeton, New Jersey: Princeton University Press, 1986.

century.

Schoonmaker Reef, Milwaukee County, Wisconsin:

The Schoonmaker Reef was the first fossil reef to be recognized in North America. This site served as the sole model for North American reef studies for more than 80 years and has been studied by such famous geologists as James Hall, T. C. Chamberlain, I.A. Lapham and others. Schoonmaker also served as the main source of Lime for the City of Chicago in the 1850s and 1860s. This site is recommended for designation as a National Historic Landmark in this theme study.

WYOMING

Bone Cabin Fossil Area, Albany County, Wyoming (NNL):[98]

After Como Bluff, the Bone Cabin Fossil Area is the most significant Jurassic fossil locality in the United States. The number and specimens of dinosaur fossils excavated from this site represent a major contribution to our knowledge of the Morrison Formation.

Como Bluff, Carbon County, Albany County, Wyoming (NNL):

(The area north of US Highway 30 and the Union Pacific Railroad and south of Rock Creek. This region contains several dozen quarries)

Since its discovery in 1877 this area has been worked by hundreds of individuals and is probably the most famous dinosaur location in the world. The discovery of Como Bluff by William Harlow Reed "...probably had greater impact on the study of paleontology than any other event save publication of Darwin's theory."

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[98] The literature on the paleontological resources in Wyoming is extensive. John Ostrom's report to the National Park Service prepared in 1970 remains the best source of information concerning the history, scientific significance and location of these sites. More modern and less technical sources cited below are also recommended:

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Ostrom, John H. Report to the National Park Service on Mesozoic Vertebrate Paleontological Sites for Possible Inclusion in the Registry of Natural Landmarks, Yale University, 1970.

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Fossil Butte National Monument, Kemmerer, Wyoming (NP):

Fossil Butte National Monument contains the most noteworthy concentrations of fossil fish even found in the United States. The only comparable location for this type of resource is the fish quarry near Solenhofen, Germany. The fossil fish date from the Eocene age and are found in the Green River formation.

Freeszout Hill Quarries, Carbon County, Wyoming:

These numerous highly productive quarries contain numerous sauropod and other dinosaurian remains.

Green River Basin, Wyoming:

(Middle Eocene Green River and Eocene Bridger formation) This is a large roughly triangular area of southwestern Wyoming with the Uinta Mountains as its southern boundary, the Rock Springs Uplift and the Wind River Mountains as its eastern and northeastern boundary, and the overthrust belt as its western boundary. Leidy, Cope and Marsh all worked in this area described names for the mammal genus that stirred the greatest amount of attention--Unitatherium.

Lance Creek Fossil Area, Niobrara County, Wyoming (NNL):

The Lance Creek Fossil Area is comparable to the Como Bluff area in geological age and in the quality of the fossil resources. The area represents one of the most fossiliferous continental deposits of the Mesozoic age anywhere in the world.

Sheep Creek Quarries, Albany County, Wyoming:

The Sheep Creek area is only slightly less significant than the Bone Cabin and Como Bluff areas to the south. Sheep Creek has produced a number of impressive specimens of dinosaurs, chiefly sauropods. In 1898 William Harlow Reed found a fairly intact skeleton of Diplodocus here. (Actually the remains of four individuals). This specimen became known as Diplocodus Carnegii in honor of Andrew Carnegie.

Economic Geology

The subject of economic geology and its practical manifestations of prospecting and mining have been covered extensively by the Cultural Resources Preservation Programs of the National Park Service. A good source of information on this subject is Death Valley to Deadwood; Kennecott to Cripple Creek which records the proceedings of the 1989 Historic Mining Conference held in Death Valley National Monument in 1989. The proceedings of this conference contain a wealth of information pertaining to the identification, recordation, and preservation of historic mining sites and are required reading for anyone working in this area.[99]

Background

The preservation of mining-related sites and objects, especially in the Western United States, has a long history.[100] Shortly after the days of the '49ers pioneers began to build monuments to their participation in this event. The collection and preservation of mementos followed each gold or silver rush. By the turn of the century the pioneers were erecting monuments to James Marshall at Coloma, California, establishing historical societies in Arizona, and setting aside the founder's cabin at Skagway, Alaska. This trend continued into the twentieth century. The beginning of Deadwood, South Dakota's annual "Days of '76", Tombstone's "Helldorado Days" and Skagway's "Days of '98" presented what local promoters imagined visitors might want to see.[101]

A more scholarly approach to the study of western mining history evolved in the 1960's with the National Historic Landmarks Survey of Western Mining Sites and the publication of Prospector, Cowhand and Sodbuster in 1967. The National Park Service evaluation of mining sites in these studies still reflected the popular view of looking at towns rather than mining sites or mills.[102]
With the listing of many mining sites and towns as National Historic Landmarks many areas were able to receive grant monies and/or rehabilitation tax credits to support the preservation of these sites. The passage of "The Mining in the National Parks Act" (P. L. 94-429) in 1976, established a process to report on threats or damage to National Historic Landmarks from surface mining projects.[103]

In the 1960's and 1979's many states, including Nevada, Colorado, and California, began to survey and identify their historic mining sites and to take concrete steps to preserve or at least record this class of historic resources. California, for example, undertook several important preservation projects involving sites at Coloma, Columbia, Sutter's Fort, and Grass Valley, California. Many other western states established state parks, dedicated to the history of mining. Tombstone and Jerome, Arizona, Bannack, Montana, and South Pass City, Wyoming are a few examples.[104]

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[99]Barker, Leo R. and Huston, Ann E. ed., Death Valley to Deadwood; Kennecott to Cripple Creek-Proceedings of the Historic Mining Conference, January 23-27, 1989, Death Valley National Monument. San Francisco, California: National Park Service, 1990.

[100]Ibid., p. 3.

[101]Ibid.

[102]Ibid., p. 4.

[103]Ibid.

[104]Ibid.

In 1977, when Congress passed the "Surface Mining Control and Reclamation Act (SMCRA, P. L. 95-87), which provided grants to the states through the Office of Surface Mining to close dangerous mine openings and clean up life-threatening hazards, many states initiated clean-up programs, often within historic mining districts. With the passage of this act, and other legislation, Congress created a mechanism for the destruction of historic mining resources before federal agencies could react and put into place systems to evaluate and protect or mitigate the loss of theses significant resources.[105] It was this action that caused the historic preservation community to come together in Death Valley in 1989 to attempt to develop programs and processes to identify and record historic mining sites before they are lost. The published proceedings of this conference represent the best source of information available today on this subject.

One of the most valuable aspects of the Death Valley Conference was the publication of the papers of historians and archaeologists regarding the application of National Register and National Historic Landmarks Survey criteria in the process of survey and identification of historic mining sites. Some of the more valuable contributions include Ann Houston, "The Survey and Inventory of Mining Properties;" Linda Greene, "The Need and Procedures for Inventorying Abandoned Historic Mining Sites;" Bruce Noble, Jr., "Evaluating Historic Mining Resources: A National Register Prospective;" Robert Spude, "Mining Technology and the National Register" and Donald Hardesty, "Mining Property Types: Inventory and Significance Evaluation." [106]

One of the most valuable products to follow the Death Valley Conference was the publication of National Register Bulletin #42: Evaluating and Nominating Historic Mining Sites.[107]This bulletin covers many of the problems likely to be faced in the nomination of this class of properties. While a brief summary of these issues is given below, the reader should consult the Bulletin #42 before proceeding with any National Register or National Historic Landmark nomination involving a Historic Mining Site. A through reading of this bulletin is absolutely essential before proceeding with the nomination of any historic mining site to either the National Register of Historic Places or as a National Historic Landmark.

National Register Bulletin #42 Summary

Mining sites encompass a range of types of historical and cultural properties. They vary from iron works, to precious metal mills, to dredges and their associated outbuildings. They include mercury furnaces from the Mexican-era in the West, Russian coal mines in Alaska, the expansive open pits of the Iron Range of Minnesota, and the copper mines of the Southwest. Although the various metals require different technologies to extract economically valuable metal from ore, there are many similarities in extraction, benefaction (the initial process of purifying ore), and refining. Coal and oil fields, however, require unique technologies developed for the extraction of fossil fuels.

The tenuous nature of mining activity has left a legacy of historic properties that pose challenges to our traditional rules for evaluating significance and integrity. Many mining site structures were built for temporary use and quickly abandoned once the minerals had been exhausted. The resources have subsequently fallen victim to decades of neglect, aggravated by vandalism and severe weather. In other cases, mine sites were shortlived. Rawhide, Nevada, for example, witnessed a whirlwind of gold rush activity in 1907, but had faded to obscurity by the following year. The significance of such sites will have to be based on their archeological potential and not on the complete lack of standing structures remaining today.

For the purpose of the National Register and the National Historic Landmarks Program, a historic mining

[105]Ibid., p. 4-5.

[106]Ibid., pp. 16-43.

[107]Noble, Bruce., Spude, Bob and Hardesty, Donald L., Bulletin 42: Evaluating and Nominating Historic Mining Sites. Washington, DC.: National Park Service, 1992.

site is any site or associated works constructed for the extraction of minerals or constructed to support the extraction, benefaction, and refining of minerals.

DEVELOPING HISTORIC CONTEXTS

Mining camp architecture has traditionally been the focus of many mining-related National Register nominations. Too often, however, mining areas are evaluated for their architectural resources without fully considering the role once played by industrial features like mine sites and mills. In many cases, industrial features of mining sites receive scant attention because the entire site lacks any remaining buildings, structures, and objects. The transient nature of the mining frontier and the frequency with which mining sites have been abandoned means that many mining resources occur either as simple earthen protuberances or as sub-surface deposits. Because present-day mining can obliterate historic mining features, above-ground remains represent a small percentage of the once numerous mining operations. Even historic machinery is often scavenged from isolated mining sites and displayed in distant museums.

This puzzling scene is further complicated by the fact that fluctuations in the international metals market often resulted in several boom and bust periods within a single mining district. Each period witnessed the introduction of new technologies or machinery which is now layered over the remains of previous mining activity. Thus, a single mining district may contain features which date to several distinct mining periods.

Along with booms and busts and evolving technologies, the metals sought by nineteenth century prospectors tended to change over time. Most prospectors initially sought easily worked gold, then moved to silver, and finally to base metals. For example, the Butte, Montana mines were first located during the great Montana gold rush of the 1860s. After the decline of the readily accessible placer gold, the local economy slumped until a fresh discovery made Butte a huge silver producer in the late 1870s. Silver mining collapsed in 1893, but by then the copper mines on Butte Hill had come into production. Other early Western mining towns witnessed similar, though less phenomenal, histories as silver mines became tungsten mines and gold mines became arsenic mines.

The preceding discussion demonstrates that the initial evaluation of mining sites can pose some readily apparent challenges. To briefly recap, the industrial features of mining sites have not always been fully appreciated. In addition, many of the industrial features which typify mining sites have either been demolished or seriously damaged through neglect. Finally, evolving technologies and changes in the types of minerals being mined can create a scenario where resources dating to a variety of periods may be contained within a single mining district.

Before venturing into the field to locate historic mining resources, the potential complexities of evaluating these diverse and enigmatic resources can be addressed by documenting **historic contexts**. A historic context can be described as a particular historic theme that is further delineated by a time period and a geographic area. (For example, "Silver Production in Butte, Montana, 1879-1893.") Historic contexts will help to unravel the separate threads of mining history which may exist within a single geographic area. Furthermore, an individual property associated with a given historic context can be compared with other properties related to that context to reach decisions about the relative significance of related properties.

With regard to historic contexts for mining areas, the theme component of the context will obviously revolve around some aspect of mining history. However, the themes should not be defined too narrowly. In addition to considering mining technology, research done to develop themes should consider topics like transportation, water systems, habitation, the role of ethnic workers, and the role played by prominent figures in the mining industry.

In defining an appropriate time frame, an historic context (or series of contexts) should attempt to span from the time of a mining region's initial discovery to the point of its abandonment or decline. Although each mining district will have its own unique history, each district will experience a series of similar phases during the course of their development. Generally speaking, each district will have: 1) a discovery phase, 2) a development or boom phase, 3) a mature phase emphasizing production, and then 4) a bust or decline phase. These phases may be recurring if a new technology is discovered to work the lower grade ore or if other developments occur, such as the advent of uses for discarded ores or the new availability of cheaper transportation, fuel, or labor. Awareness of these common phases may help to determine the correct time period for mining district historic contexts.

The geographic component of a historic context can relate to political boundaries which define the extent of a town, county, state, or Federal land management unit (ie. a national park or national forest). The geographic definition may simply be the mining district boundaries established during a miners' meeting and duly recorded in the county court house. The US Geological Survey (USGS) has also drawn boundaries for mining districts that may clearly define the geographic extent of historic mining activity. In addition, for over a century USGS has published "bulletins" which include maps of mining regions. These maps may also assist with the development of historic contexts.

In conclusion, historic contexts must be documented in order to allow for confident evaluations of a historic mining property's significance. Because most mining sites are ruinous or mere imprints on the landscape, they can pose difficult integrity questions. Significance must be determined based on an understanding of an area's history before making decisions about National Register eligibility. In some cases, significant historic properties may be entirely overlooked without a proper historic context. Even ruinous sites can be significant if they yield information valuable in historic archeology, especially if the site contains remains of engineering works that help to illustrate the broader historic context of technological innovation and diffusion. For example, the nomination of the Dubuque, Iowa lead mines was based on a written historic context and on archeological evidence that revealed a great deal about mining and smelting technology in the early 1800s. The nomination of these lead mines occurred in spite of the fact that no standing structures remained at the site of this previously active mining district.

Sources of Information

A number of sources may assist with the development of historic contexts. The USGS has published mining district maps showing geologic formations and minerals throughout the United States. In addition, descriptions of mining districts are contained in a series of USGS Bulletins, Monographs, Professional Papers, and other publications. These sources supply information on ore deposits. Some mining districts, especially in the West and Alaska, received thorough evaluation and mapping by the USGS. These evaluation led to the publication of reports that describe mines, prospects, and company activities, as well as geographic and cultural information. Information in these reports can be crosschecked with corporate descriptions in the Mines Handbook (after 1905) and The Mineral Industry (after 1892). Other useful government reports include the annual reports of the US Mining Commissioner, 1866-1876, the reports of the Director of the Mint, and the Bureau of Mines annual report (later called the Minerals Yearbook). These reports may include specific data on a particular mine or mining district.

Some states published annual reports issued by state geological surveys, mining commissioners, or department of mines. Specific information about mine ownership can be found in the mineral patent records of the Bureau of Land Management (BLM). Created through a merger of the Grazing Service and the General Land Office in 1946, BLM offices will also contain records of mineral patents issued by the General Land Office. Deed records housed in the local county court house may provide an additional source of mine ownership information. If litigation occurred, extensive files may be found in the Justice Department records in the National Archives.

State and local histories may contain information on mines and mining in a particular locality. Period journals and newspapers provide a panoply of promotional information about a mine. Both successful and unsuccessful mining camps and towns frequently had newspapers that touted each mine or prospect. Individual mines and mining companies also distributed abundant literature. The productive ones produced annual reports which might include photographs and diagrams that typically described the vast extent of both works and machinery. Although mining town newspapers and company literature can provide fascinating local color, these sources must be used with caution based on their inclination to accentuate the positive and ignore the negative.

Mining activity was well documented by early photographers. Archives, museums, and other sources should be contacted for historical photographs to assist with historic context research. Photographs of mine equipment and mill machinery for a specific mine may not exist, but contemporary photographs of nearby mines and mills should help to understand what type of material culture and industrial archeology characterized a particular mining region.

Although frequently difficult to locate, early mining district record books which document the formation of miners' committees can serve as an important source of historic context material. These committees acted to establish district laws and to record the tenuous ownership of mineral deposits. (Only a patent issued by the Federal government would legally secure ownership.) A hypothetical example of the value of these early records might involve a prospect pit discovered in an 1860s gold district, but abandoned after the first rush. Lacking these records to provide historic context information that links the site with the early gold rush era, the evaluation may be based solely on the marginal integrity that the site exhibits today. Such an evaluation would overlook the prospect pit's critical association with a significant period in mining history.

There are many books and other sources of information on the history of mining. These studies will help to provide a general understanding of mining history. The difficult task is to combine the historic context information in these sources with the guidance provided in other National Register publications and then use these materials to conduct successful field evaluations and prepare nominations for actual mining sites.

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Summary

The above information concerning National Register Bulletin #42 represents only a brief portion of what is contained in this important publication. This publication is required reading before proceeding with a nomination of any mining site.

ECONOMIC GEOLOGY

ARKANSAS

In 1857-58, the first geological survey of Arkansas was conducted by Dr. David Dale Owen. Two reports were published as a result of his work, the First Geological Reconnaissance of Arkansas and the Second Geological Reconnaissance of Arkansas.

Bauxite Mines, Vicinity of Little Rock, Arkansas:

Bauxite was first identified by Dr. John Branner, State Geologist for Arkansas from 1887-1893, from a sample brought in by a local contractor, Ed. Weigel, who was using it to pave roads near Little Rock. Eventually, this led to the discovery of the largest bauxite deposit in the United States and has resulted in over 80 million tons of bauxite being mined in Arkansas since 1898.[108] Although no specific site related to this mining industry in Arkansas was recommended for consideration as part of this study effort, sites associated with this industry should be examined by the State Historic Preservation Officer for listing in the National Register of Historic Places.

Barite Mines, Hot Springs County, Arkansas:

Barite deposits in Hot Springs County Arkansas were first described in a published report of the Arkansas Geological Commission about 10 years prior to the mining operations. Within another 10 years, the Chamberlain Creek barite deposits was furnishing over half of the nation's supply. Sites associated with this industry should be examined by the State Historic Preservation Officer for listing in the National Register of Historic Places.[109]

Crater State Park (Diamond Mine), Arkansas:

This is the only diamond mine in existence in the United States today.

Novaculite Quarries (Ouachita Mountains), Blanhard Springs, Arkansas:

(No information to date on this site)

CONNECTICUT[110]

Chesire Barite Mines, Cheshire, Connecticut:

Benjamin Silliman, the founder of the Science Department at Yale University and the American Journal of Science (1818), is credited with the first identification of barite at this site in 1811. Barite is a very dense mineral that is mined for use in oil-well drilling muds and as the chief source of barium (barium sulfate) compounds. From this discovery came the development of the first barite mine in the United States.

Higley Copper Mine, East Granby, Connecticut:

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[108] Arthur A. Socolow ed., The State Geological Surveys: A History (No place of publication: American Association of State Geologists, 1988), p. 25.

[109] Ibid.

[110] Altamura, Robert J. "A History of the State Geological and Natural History Survey of Connecticut" in Socolow, op. cit., p. 25.

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Coins made from copper from this mine may have been the first coins struck in the American colonies. The coins were designed and made by Dr. Samuel Higley of Simsbury who is also credited with having processed the earliest known steel made in American in 1727.

Hoadley Neck Quarry, Guildford, Connecticut:

The rock from this quarry is biotite granite gneiss with a dark reddish gray color. This stone was used to build the pedestal of the Statue of Liberty and the anchorage for the first Brooklyn Bridge. This quarry was owned by the Norcross Brothers, the builders of many prominent late 19th-century buildings designed by Henry Hobson Richardson and his contemporaries.

Jinny Hill Barite Mine, Chesire, Connecticut:

The Jinny Hill Mine is reported to be the first barite mine in the United States. It began operations in 1838 and ended in 1877. The Jinny Hill Mine as well as other barite mines near Cheshire supplied barite for use in the manufacture of paints by New York City companies.

Old Newgate Prison Copper Mine, East Granby, Connecticut:

This copper mine is reported to be the first copper mine in the United States. It may also have been the first incorporated mining operation in the United States. This site was designated a National Historic Landmark in 1972. The documentation for this site needs to be revised to determine if this was the first working copper mine in the United States.

Old Mine Park Archeological Site, Fairfield County, Connecticut (NR):

The Old Mine Park Archeological Site is significant for the role it played in mineralogy and in the development of technologies of extraction and processing of minerals, particularly tungsten. The Old Mine park Archeological Site reflects the transition from very small-scale collection of a variety of minerals in the mid-18th century, through small-scale exploration of limestone in the 18th and 19th century, to pioneering attempts at intensive large-scale mining of tungsten in the late 19th century and early 20th century, when commercially valuable properties of tungsten were first realized.

Ore Hill Iron Mine, Salisbury, Connecticut:

The Ore Hill Iron Mine is an example of the colonial mining operations of Connecticut. The Salisbury district was one of the most important iron producing areas in the nation and was once one of the most important iron-ore producing areas in the nation.

Portland Brownstone Quarries, Portland, Connecticut:

Brownstone was a very important building stone in the late 1800s. The Portland quarries were the queen of the brownstone quarries in Connecticut and perhaps in the country. Brownstone was shipped for use in buildings in New York, New Jersey, and as far away as California.

Strickland Quarry, Portland, Connecticut:

The Strickland Pegmatite Quarry has been described is the best single pegmatite locality in the state of Connecticut. Pegamtite is a very coarse-grained igneous or metamorphic rock that has the composition of granite and often contains unusual minerals, including gems and rare elements. The quarry is an important source of diverse minerals and has served as a famous teaching and collecting site over the years.

Trumball Tungsten Mine, Trumball, Connecticut:

Tungsten ore, sheelite, was reportedly first mined from this site in 1828. Today the property is a park with recreation grounds.

Hale Pegmatite Quarry, Portland, Connecticut and the Branchville Pegamite Quarry, Ridgefield, Connecticut:

Bertram B. Boltwood made the first radiometric age determinations in the world using analyses that included uraninite crystals from these quarries. The Hale and Branchville deposits contain rare-metal pegmatites. In 1904 Ernest Rutherford of McGill University presented ideas on how progressive accumulation of daughter products might be used to measure geologic time. Those ideas were put to use by Bertram B. Boltwood of Yale, who in 1906, following the suggestion made by Rutherford, looked at analyses of uranium minerals including uraninite analyses from the Hale and Branchville pegmatites, and made the first radiometric age determinations. Radiometric age dating indicated that the scale of geological time was much greater than geologists previously thought.

These quarries were also the source of the first commercial production of feldspar in New England and New York. In recent years the quarries have been valued as a source for the production of beryl, the ore mineral of beryllium.

COLORADO

Rulison Project Site, Colorado:

(No information is available on this site at this time)

GEORGIA

Soapstone Ridge, Dekalb, Georgia (NR):

This is the largest outcrop of soapstone in the United States. The formation was utilized by Archaic Period Indians of the Southeast (7000-1000 BC) as a quarry site for soapstone bowls, tools and other items.

ILLINOIS

Lead Hill, Hardin County, Illinois:

Lead was mined from this site in the early 1800s in what is now the Illinois-Kentucky Fluorspar Mining District. The fluorspar, originally regarded as a gangue mineral and discarded as waste, subsequently became the principal ore mined in the region. The Illinois-Kentucky Fluorspar Mining District still produces more than 90% of all the fluorspar mined in the United States.

Rose Hotel, Hardin County, Illinois (NR):

The Rose Hotel is one of the oldest buildings in the State of Illinois. Constructed in 1813, the hotel was occupied by numerous geologists exploring the Illinois- Kentucky fluorspar mining district. It is likely that David Dale Owen, Joseph Norwood, and Amos H. Worthen stayed there, as well as legions of geologists from the modern Illinois State Geological Survey.

IOWA

Mines of Spain, Dubuque County, Iowa (NR):

The Mines of Spain are believed to be Iowa's single most significant geological and historic resource.[111] Galena (lead) ores from the Ordovician-age Galena Group rocks of the upper Mississippi Valley district have been mined here for at least 300 years.[112] This site is now being separately documented and evaluated for possible designation as a National Historic Landmark.

LOUISIANA

Salt Mines and Offshore Oil Drilling Site (Various Locations):

The unique geology of the coastal area of Louisiana has fostered two significant industries--salt mining and offshore oil mining and exploration. Representative sites from these industries should be nominated to the National Register as representative examples of the extractive mining industries so important to the economic history of Louisiana.[113]

MISSOURI

Meramec Spring Park, St. James, Missouri:

Museum, open-pit iron mine, and charcoal furnace; site of development of frontier iron industry and related geology/hydrology.

Schaperkoetter Clay Pit, Missouri:

Last remaining example of a diaspore pit.

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[111] Letter from Dr. Donald L. Koch, State Geologist and Bureau Chief, Iowa Department of Natural Resources, Geological Survey Bureau, to Dr. Harry Butowsky, National Park Service, National Historic Landmarks Survey, April 17, l990.

[112] Anderson, Duane C., Prior, Jean C., and Roosa, Dean M., "National Natural Landmark Nomination--The Mines of Spain" (Washington, DC: National Park Service, 1984).

Calvin, Samuel and Bain, H.F., "Geology of Dubuque County." Iowa Geological Survey annual Report, Vol. 10, (1900), pp. 379-622.

Owen, David Dale, Report of a Geological Survey of Wisconsin, Iowa, and Minnesota Philadelphia: Lippincott, Granbo and Co., 1852.

[113] For further information the reader should contact:

The Catto Pine Island Oil and Historical Society
P. O. Box 897
Oil City, Louisiana 71061
(318) 995-6845

NEW JERSEY

Bog Iron and Batso Village, Hammonton, New Jersey:

New Jersey's bog iron ore industry began here as early as 1730 and became increasingly important in the American Revolution. The existence of these furnaces caused the British Parliament to consider passing a law to forbid the Colonies from manufacturing wrought iron and steel. During the War for Independence ore from this site was forged into cannonball shot, shells and muskets for the Continental Army.

Franklin-Sterling Hill Mineral District, Sussex County, New Jersey:

The Franklin-Sterling Hill Mineral District is the site of a unique pair of zinc ore deposits that were important to the development of northern New Jersey from the earliest settlement of North America. Discovered in 1640 by Dutch surveyors, the red mineral, zincite, was used in the 19th century in the production of zinc oxide for paint, zinc metal for brass used in standard weights and measures and, for a protective coating for the steel cables used in the construction of the Brooklyn Bridge. The site also ranks as the foremost mineral district in the world because of the large numbers of mineral species (over 330) that have been found there.

Schuyler Copper Mine, Bergen County, New Jersey:

The Schuyler Copper Mine, one of the oldest mines in the United States, opened in 17l0 by a Dutch settler Arent Schuyler. During the 1750s Arent's son John worked with Benjamin Franklin to obtain the first steam engine in the Colonies to pump water from the mine workings. The mine produced a high-grade copper ore until it was abandoned in 1903.

OHIO

Samuel P. Hildreth House, Marietta, Ohio:

Dr. Samuel P. Hildreth (1783-1863), was an acute observer of natural phenomena in the fields of medicine, biology, archeology and geology. Dr. Hildreth achieve a reputation as the best informed man on the geology of Ohio in his time. His publication entitled "Observations on the Bituminous Coal Deposits of the Valley of the Ohio" brought him the recognition of both British and American scholars. This publication described the coal deposits of Ohio, West Virginia and Pennsylvania and estimated their economic value. British geologists regarded it as the most significant publication on geology to come out of North America by 1837.

PENNSYLVANIA

Wyoming-Lackawanna Coal Field, Wilkes-Barre and Scranton, Pennsylvania:

This anthracite coal field in northeast Pennsylvania is illustrative of the discovery and exploitation of the unique hard-burning and clean-burning anthracite coal from this area of Pennsylvania that fueled the industrial revolution in the United States. Steamtown NHS is situated in the middle of this field.

Coal Park, Keyser Valley Site

SOUTH DAKOTA

Homestake Gold Mind (part of the City of Lead Historic District), Rapid City, South Dakota (NR):

The Homestake Gold Mine has operated for more than 100 years. It consists of a mill complex, an open cut mine and a deep mine shaft which is the largest deep mine shaft in the country. The Homestake was the foundation of the second Hearst fortune and was the major impetus in the development of the Black Hills as a Mining district.

TENNESSEE

Iron, Mining and Furnace Sites (Multiple Properties) in Tennessee, South Carolina, North Carolina, Kentucky and Alabama:

The Southeastern United States had extensive iron mining and processing facilities from colonial times through the early 20th century, which took advantage of deposits of coal, iron ore and wood for charcoal. When more information is available it is recommended that the State Historic Preservation Offices within these states nominate one representative example from each state for designation as a National Historic Landmark.[114]

UTAH

Bingham Canyon Open Pit Copper Mine, Utah:

The Bingham Open Pit Copper Mine was the first site in the world where a low-grade porphyry copper deposit was exploited thereby demonstrating important new advances in mining technology in the utilization of low-grade ore.

WISCONSIN[115]

Mineral Point Hill, Iowa County, Wisconsin, (NR):

Mineral Point Hill is the site where the original discovery of lead ore was made in Wisconsin in 1825.

Neda Open Pit Mine, Dodge County, Wisconsin:

The Neda Open Pit Mine is the site of the earliest iron mining operation in Wisconsin. The site was also the focal point of numerous debates over the origin and age of oolitic ironstones at the Ordovician/Silurian boundary.

Pendarvis House, Mineral Point, Wisconsin (NR):

The Perndarvis House was constructed Cornish miners during the heyday of lead mining in the southwest Wisconsin zinc-lead zone. The buildings and area represent the opening of Wisconsin's frontier in 1832.

Trimborn Quarry Site, Wilwaukee County, Wisconsin:

The Trimborn Quarry Site is an excellent example of an undisturbed lime industry site from the late 19th century. In a letter dated May 7, 1991 to Harry Butowsky, The Milwaukee County Department of Parks, Recreation and Culture declined, at this time, to support the study and designation of this sites as a National Historic Landmark.

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[114]Jones, James B. The Development of Coal Mining on the Tennessee-Cumberland Plateau, 1880-1930-Research Series #6. Nashville, Tennessee: Tennessee Department of Conservation, 1988. Smith, Samuel D., Stripling, Charles P., and Brannon, James M. A Cultural Resource Survey of Tennessee's Western Highland Rim Iron Industry, 1790s-1930s-Research Series #8. Nashville, Tennessee: Tennessee Department of Conservation, 1987.

[115]Wisconsin is one of the few states that has completed a cultural resources management plan that includes chapters relating to geology extraction industries or mining. For further information the reader should consult the following source.

Wyatt, Barbara ed., Cultural Resources Management in Wisconsin, Vol. 1. Madison, Wisconsin: State Historical Society, 1986.

Planetary Geology

TEXAS

Lunar Receiving Laboratory, Johnston Space Center, Texas:

The Lunar Receiving Laboratory was built at the Lyndon B. Johnson Space Center to provide a facility to store and test material returned to the earth by the Apollo astronauts. NASA conducts ongoing research in the life sciences and lunar geology at this site. The Lunar Receiving Laboratory was considered for National Historic Landmark designation as part of the Man in Space national Historic Landmark Theme Study completed by the National Park Service in 1984. It was not recommended for designation at that time because its significance was achieved within the last 50 years.

Miscellaneous Sites

ARIZONA

Yavapai Point Museum, Grand Canyon, Arizona (NP):

The Yavapai Observation Station was one of the first formal settings for interpretation in the National Park System and the first to be located at the site of the phenomenon to be interpreted. The station was designed to be the focal point of the Grand Canyon's entire interpretive program concerning the geological forces that created the Grand Canyon. A National Register Nomination for this site is in progress.

OHIO

Orton Hall and the Orton Geological Museum, Columbus, Ohio (NR):

Orton Hall, home of the Department of Geology and Mineralogy at the Ohio State University is a unique building constructed of Ohio building stones arranged in stratigraphic order. The oldest rocks form the lower courses of the building, and successively higher courses are of progressively younger rocks. The interior of the building also utilizes native Ohio materials, some of which are carved to portray geological themes. Of particular interest are the carved gargoyle-like fossil vertebrates at the top of the building's tower. The building is named after Dr. Edward Orton, Sr., the third state Geologist of Ohio.

PENNSYLVANIA

Pulpit Rock, Huntington County, Pennsylvania:

In 1839 Henry D. Rogers, the first state geologist for Pennsylvania and New Jersey, hired artist George Lehman to draw a lithograph of Pulpit Rock, to illustrate a state survey of this site. The Pulpit Rock lithograph was the frontispiece of Henry Roger's monumental report on the geology of Pennsylvania, published in 1858. This was the first instance of the use of a recognized artist to illustrate a government geology report.

Henry Rogers, and James Booth and John Frazer (his assistants) met near
Pulpit Rock in 1836 to resolve the geological order or the rocks of Middle Pennsylvania. All subsequent work in the Appalachian mountain belt of the Atlantic states was based on this work.

WISCONSIN

Science Hall, University of Wisconsin, Madison, Wisconsin (NR):

Science Hall at the University of Wisconsin housed as the geology department office, classrooms and laboratories of Charles Van Hise during his tenure as professor of geology and president of the University of Wisconsin.

National Historic Landmark Nominations
Geology Theme Study

Physical Geology

Farm Creek/Farmdale Geological Exposure, Illinois (Final-National Register Nomination)

Decorah Ice Cave, Iowa (Final-National Register Nomination)

Paleomagnetics Laboratory, California (I will prepare if time permits)

Science Hall, Wisconsin (University of Wisconsin may prepare)

Van Hise Rock, Wisconsin (In preparation by contractor)

Paleontology

Big Bone Lick, Kentucky (Final-National Register Nomination)

Dinosaur Ridge, Colorado (In preparation by RMRO)

Dr. Fisk Holbrook Day House, Wisconsin (In preparation by contractor)

Green Geological Collection and Museum Building, Wisconsin (In preparation by contractor)

Kimmswick Bone Bed, Missouri (Final-National Register Nomination)

Mazon Creek Site, Illinois (In preparation by contractor)

Petrified Sea Gardens, New York (I will prepare if time permits)

Schoonmaker Reef, Wisconsin (In preparation by contractor)

Soldier's Home Reef, Wisconsin (I will prepare if time permits)

Economic Geology

Shaganawamps--The Mine Lot, Connecticut (Final-National Register Nomination)

Parker Cleveland House, Maine (In preparation by the SHPO)

Miscellaneous Sites

Wagner Free Institute of Science (Final-Previous NHL nomination; to be used as an example)