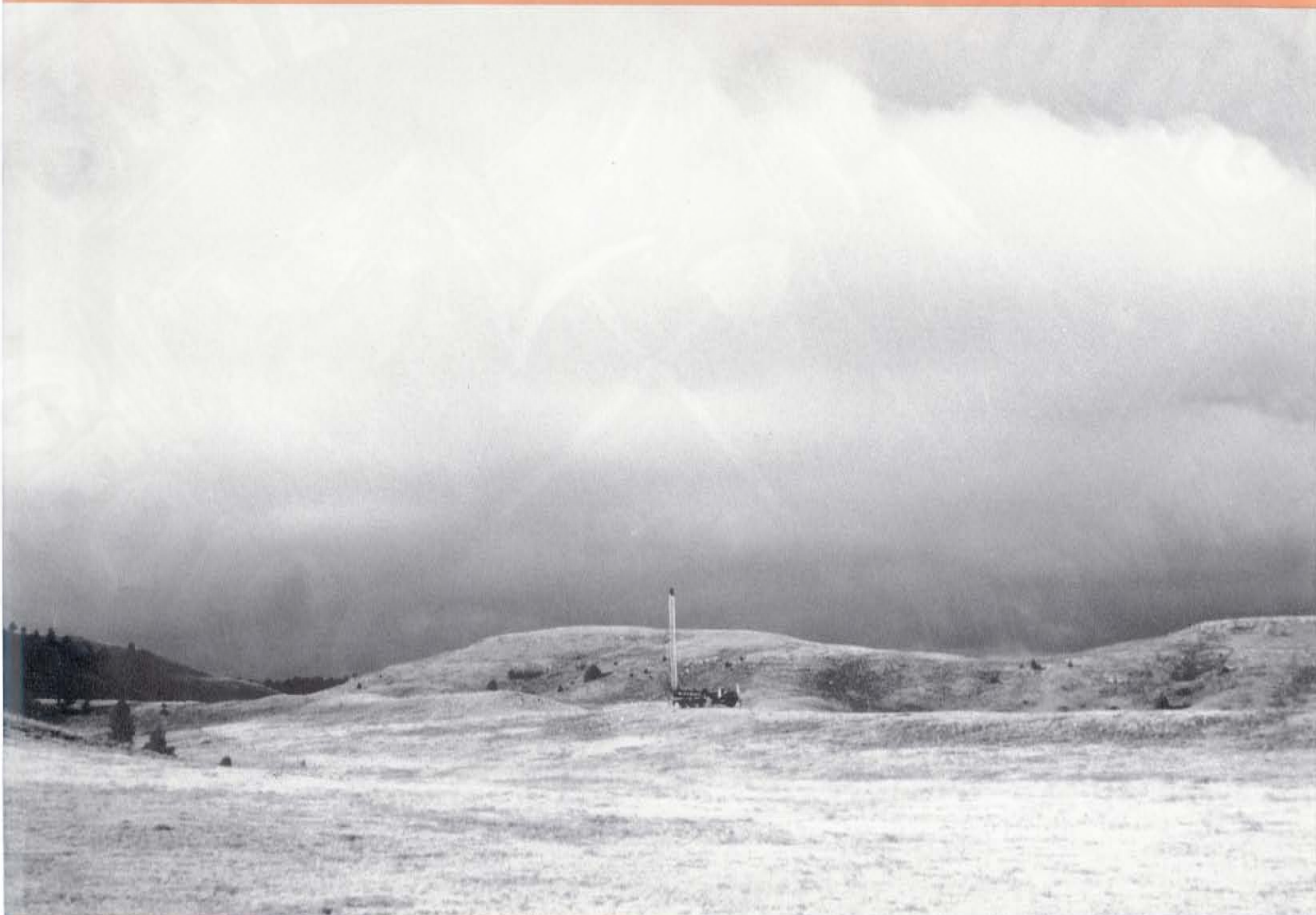
THE GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

GEOLOGY AND INDUSTRIAL MINERAL RESOURCES OF THE UPPER PATTEN CREEK AREA, PLATTE COUNTY, WYOMING

by
Ray E. Harris



Report of Investigations No. 45
1990

Laramie, Wyoming

First printing of 500 copies by Pioneer Printing, Cheyenne, Wyoming.

This and other publications available from: The Geological Survey of Wyoming
P.O. Box 3008, University Station
Laramie, Wyoming 82071-3008
(307) 766-2286

Cover photograph. Upper Patten Creek area. Hills behind the drill are underlain by the Permian-Pennsylvanian Hartville Formation divisions II and III. The area in the foreground and the ridge below the drill is underlain by Quaternary and Tertiary sediments. White volcanic ash is exposed just right of the gap in the left center, immediately above the ridge composed of Quaternary and Tertiary sediments. (See text for descriptions of these rocks and sediments.)

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Introduction

Volcanic ash, bentonite, limestone, dolomitic limestone, quartzite, onyx, and agate are found in an area at the headwaters of Patten Creek, 8 miles north of Hartville, in Platte County, Wyoming. These minerals have a variety of industrial and construction applications. Onyx and agate, semiprecious stones, also occur in the area.

This report describes the geology and mineral resources of the upper Patten Creek area, located in secs. 4, 5, 6, 7, 8, 9, 16, 17, and 18, T.28N, R.65W, and secs. 31, 32, and 33, T.29N, R.65W. The area is adjacent to Wyoming State Highway 270; it is 14 miles from the Burlington Northern Railroad siding at Guernsey, Wyoming, and 29 miles from the Chicago and Northwestern Railroad siding at Manville, Wyoming (**Figure 1**).

Funding for the field mapping, drilling, trenching, and sample analyses was obtained from the Town of Guernsey through a Wyoming Economic Development and Stabilization Board (EDSB) planning-only grant. The author appreciates the help given for this project by the Town of Guernsey and especially by Mayor Darrell Offe.

Information from the drilling and trenching programs, and sample analyses were given to the Geological Survey of Wyoming by the Town of Guernsey. The Geological Survey of Wyoming provided the field mapping and technical advice for the drilling and trenching projects.

Geology

Rocks exposed in the study area include the Permian-Pennsylvanian Hartville Formation; Tertiary and Quaternary sediments, undivided; volcanic ash of probable Tertiary age; and other Quaternary deposits. These are shown on the geologic map (**Plate 1, back pocket**). A discussion of each of the mapped units in the area, ordered from oldest to youngest, follows.

Stratigraphy

Hartville Formation

The oldest rocks exposed in the map area belong to the Permian-Pennsylvanian Hartville Formation. The formation was named by Smith (1903) for exposures near Hartville, Wyoming, 8 miles south of the study area. It was subdivided into six informal units by Condra and Reed (1935), numbered from the top (division I) to the base (division VI). Only divisions II through VI are exposed in the study area.

Division VI

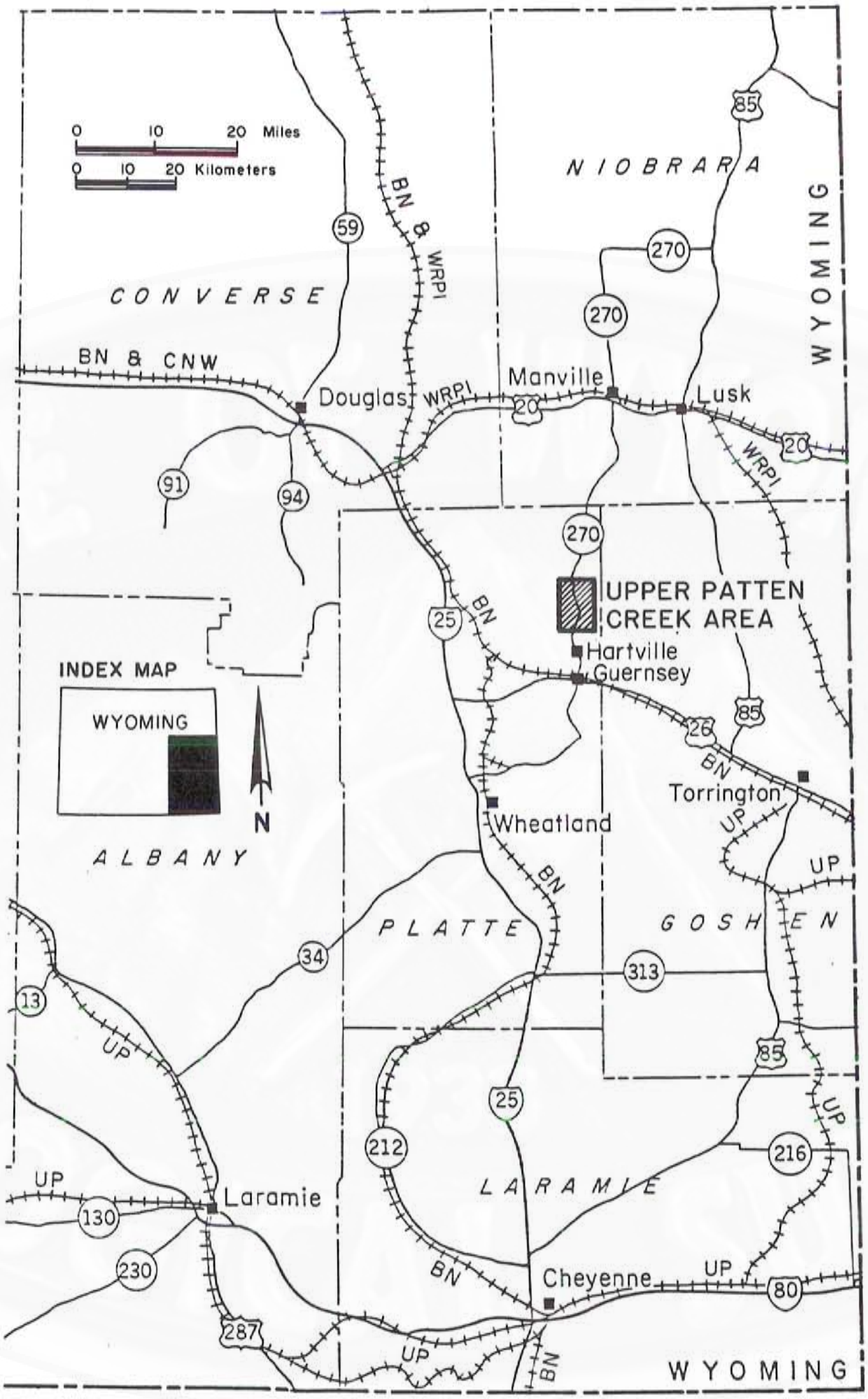
The Hartville Formation division VI overlies the Mississippian-Devonian Guernsey Formation with an erosional unconformity. At exposures outside of the study area, relief on the surface of the Guernsey Formation may be as great as 120 feet. This unconformity is developed on a paleokarst surface. Therefore, the thickness of division VI can vary by as much as 120 feet. The thickest exposures of this unit (also 120 feet) are in the vicinity of the Sunrise iron mine, 7 miles south of the study area. Near Manville, 26 miles north of the study area, division VI is absent.

Division VI consists of red and red-and-grey mottled quartz sandstone, with local calcareous zones and orthoquartzites. It is medium bedded to massive, with the bedding planes often highlighted by red and grey alternating layers. It weathers to a dark red, with the mottling and banding not apparent on weathered outcrops. Division VI quartzite is very resistant and forms a vertical cliff overlying a talus slope that usually hides the contact with underlying units. The age of this unit is uncertain (Doyle, 1987).

In the study area, only the top of the division VI quartzite is exposed (**Figure 2**). This exposure is at the base of the hills in SE 1/4 sec.17 and SW 1/4 sec. 16 (**Plate 1**). There, the unit forms a 10- to 15-foot-high cliff.

Divisions V and IV

The Hartville Formation divisions V and IV were mapped together (**Plate 1**) due to their lithologic similarity and lack of a marker bed at their contact.



EXPLANATION

Highways ◯State U.S. Interstate

Railroads BN = Burlington Northern

CNW = Chicago North Western

UP = Union Pacific

WRPI = Western Railroad Properties, Inc.

Figure 1. Index map showing the location of the upper Patten Creek area.

Figure 2. Top of the Hartville Formation division VI quartzite in the upper Patten Creek area.

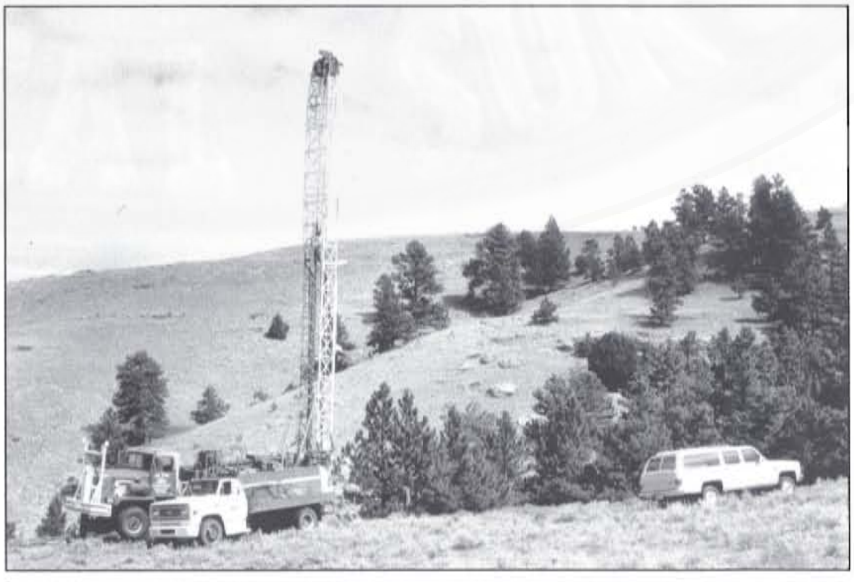
Both of these divisions consist primarily of unconsolidated red, gray, and purple shale, limestone, and dolomitic limestone, with minor thin impure sandstones. In the study area, these units are usually covered with talus from the overlying Hartville Formation divisions II and III. The best exposures of divisions V and IV are south of the conical hill in the SE 1/4, NE 1/4 sec.17. Divisions V and IV combined are about 1,325 feet thick in the study area. They were assigned an age of Atokan by Condra and others (1940).

Divisions III and II

Hartville Formation divisions III and II were mapped together (**Plate 1**). Both divisions consist primarily of carbonates with minor shales and sandstones. Only the lower part of division II is present in the mapped area. Division III consists of gray high-calcium limestone, yellowish gray dolomitic limestone; and minor red and gray shales, gray sandstones, and dark gray to yellowish gray dolomite. This unit forms ledged slopes (**Figure 3**).

Division II is composed of gray dolomitic limestone. It is characterized in other areas by thick, massive, resistant dolomitic limestone at the top of the unit; this bed is not present in the study area. The lower part of division II, which is present in the study area, is composed of medium- to thin-bedded, gray dolomitic limestone with minor red and gray shale, gray sandstone, and gray limestone. Division III has been dated by fossils as Desmoinesian, while division II is Virgilian and Missourian (Doyle, 1987; Condra and Reed, 1935).

Figure 3. Drilling in the upper Patten Creek area. Low ledgy outcrops of Hartville Formation divisions II and III occur on the hills in the background.



Tertiary and Quaternary sediments, undivided

Light brown unconsolidated silts, clays, and sands surround the Hartville Formation highlands in the study area. These units were mapped as Tertiary and Quaternary sediments, undivided. The same units were mapped as Oligocene and Miocene, undivided, by Denson and Botinelly (1949). In the study area, some of these units are Quaternary windblown silt (loess) deposits or Quaternary alluvium composed of reworked Tertiary material. These often cannot be distinguished from unreworked Oligocene and Miocene units, particularly in grass- or brush-covered areas.

Tertiary volcanic ash deposits

White volcanic ash overlies Tertiary and Quaternary sediments, undivided, in four exposures in the study area (**Plate 1**). The volcanic ash is locally covered by Quaternary colluvial deposits. The volcanic ash consists of crudely bedded to massive, consolidated to semiconsolidated material composed of fine, angular, glassy grains.

The ash weathers white and blocky (**Figure 4**). It occurs in lenticular pods up to 14 feet thick, with a lateral extent up to 100 feet. These deposits are not continuous and do not constitute a large resource.

The ashes were dated at about 3 million years old (Glen Izett, U.S. Geological Survey, personal communication, 1989). The nearest described volcanic ash deposit is located about 23 miles south of the study area in NE 1/4, SE 1/4 sec. 7, T.25N, R.66W. That ash is identified as the Lava Creek B ash of the Pleistocene Pearlette series ash (Izett and Wilcox, 1982). The ash in the study area predates the Pearlette series of ashes and is Pliocene in age.

Quaternary colluvial deposits

Quaternary colluvium, which consists mostly of displaced blocks of limestone and other durable rock talus from the Hartville Formation, is found below outcrops of that formation. This material overlies some of the Tertiary and Quaternary, undivided, sediments and locally overlies the volcanic ash deposits.

There is a deposit of colluvial material containing weathered to unweathered Precambrian and pre-Hartville Formation boulders and cobbles on the southwest slope of the conical hill in the NE 1/4 sec. 17 (**Plate 1**). The presence of this material in this locality is unexplained. Some of the Precambrian boulders are soft amphibolite- and pyrite-bearing altered igneous rock and so could not have been transported very far from their place of origin. The nearest Precambrian outcrops are 2 miles to the east. There is no evidence to suggest a diatreme at this locality other than the pervasive limonite alteration of the fine-grained surface material at this locality.

Quaternary landslide deposit

A large mass of blocks of carbonate rock in the NW 1/4, SW 1/4 sec. 8 (**Plate 1**) is mapped as a Quaternary landslide deposit. The material in this slide is composed of blocks up to 20 feet across. This type of

Figure 4. Volcanic ash outcrop (backhoe beginning to dig trench 1).

landslide is classified as a block slide (James C. Case, Geological Survey of Wyoming, personal communication, 1989).

Structure

The Permian-Pennsylvanian units dip west-northwest at about 5 degrees. The upper Patten Creek area lies on a homoclinal slope between the Whalen anticline to the east and the Broom Creek syncline to the west. No faults or changes in the regional dip were noted in the Hartville Formation in the map area.

The Tertiary and Quaternary units, undivided, and the volcanic ash beds appear to be flat lying. However, the elevation of the volcanic ash decreases from 5,265 feet above mean sea level in the northernmost two exposures (SE 1/4, NE 1/4 sec.7 and SW 1/4, NW 1/4 sec. 8) to 5,240 feet in the exposure on the south-center section line of sec. 8, to 5,190 in the volcanic ash occurrence in SE 1/4, NW 1/4 sec.17. It is not known whether this represents a regional north-south tilting of this area since the Pliocene or deposition on an uneven landscape in the Pliocene.

Mineral resources

Volcanic ash (pumicite)

Pumicite has several somewhat conflicting definitions. As used in this report and in industrial terminology, pumicite is a term related to particle size. Volcanic ejecta less than 4 millimeters in size is pumicite, while larger particles are pumice or scoria (Peterson and Mason, 1975). This means that the volcanic ash occurrences in the upper Patten Creek area are pumicite. The term volcanic ash may be used by geologists to the exclusion of the term pumicite. Tuff is another term used by geologists for consolidated volcanic ash.

The industrial properties of pumicite are high abrasiveness, low density, and high insulating capacity (Peterson and Mason, 1975). Pumicite is used primarily as a filler in concrete blocks and cinder blocks, and as lightweight aggregate (Meisinger, 1989; see also Vaudrey, 1950). Pumicite is also used as an abrasive, such as in soap and cleansing powder, and as decorative stone. The total U.S. production of pumice and pumicite in 1988 was 440,000 short tons, while 387,000 short tons were imported. Pumicite is a very transportation-dependent commodity since freight rates for high-volume/low-density commodities are a large percentage of the cost to the consumer.

Wyoming currently produces no pumicite. There are about thirty occurrences of pumicite in Wyoming outside of Yellowstone National Park (Harris and King, 1986). Most of these are located in northwestern and western Wyoming.

Five separate occurrences of volcanic ash were found in the study area; four of these outcrop, and are mapped on **Plate 1**. One occurrence was located during the drilling program in drill hole F3 (**Plate 1** and **Appendix A**).

Quality

Trenches were cut into the occurrences around drill holes A1 to A3 and D1 to D5 (**Figure 5,** trench locations shown on **Plate 1**). Samples from the drill holes and trenches were analyzed by a commercial lab for major elements and potentially deleterious trace elements (**Table 1**).

The ash is rhyolitic in composition, with a variable proportion of calcite. The calcite occurs in the matrix of the ash and was probably introduced into the ash by ground water after deposition of the ash. Thin beds of limestone are present in the ash.

Quantity

Surface exposures, drill information, and trenches indicate the total amount of ash present in the area is 356 tons. This amount is present in five separate exposures, including one in drill hole F3. The largest resources are present at trench 1 (60 tons) and the area of trench 2 (280 tons).

Uses

Due to the small amount of material present, the volcanic ash deposits in this area are best suited to

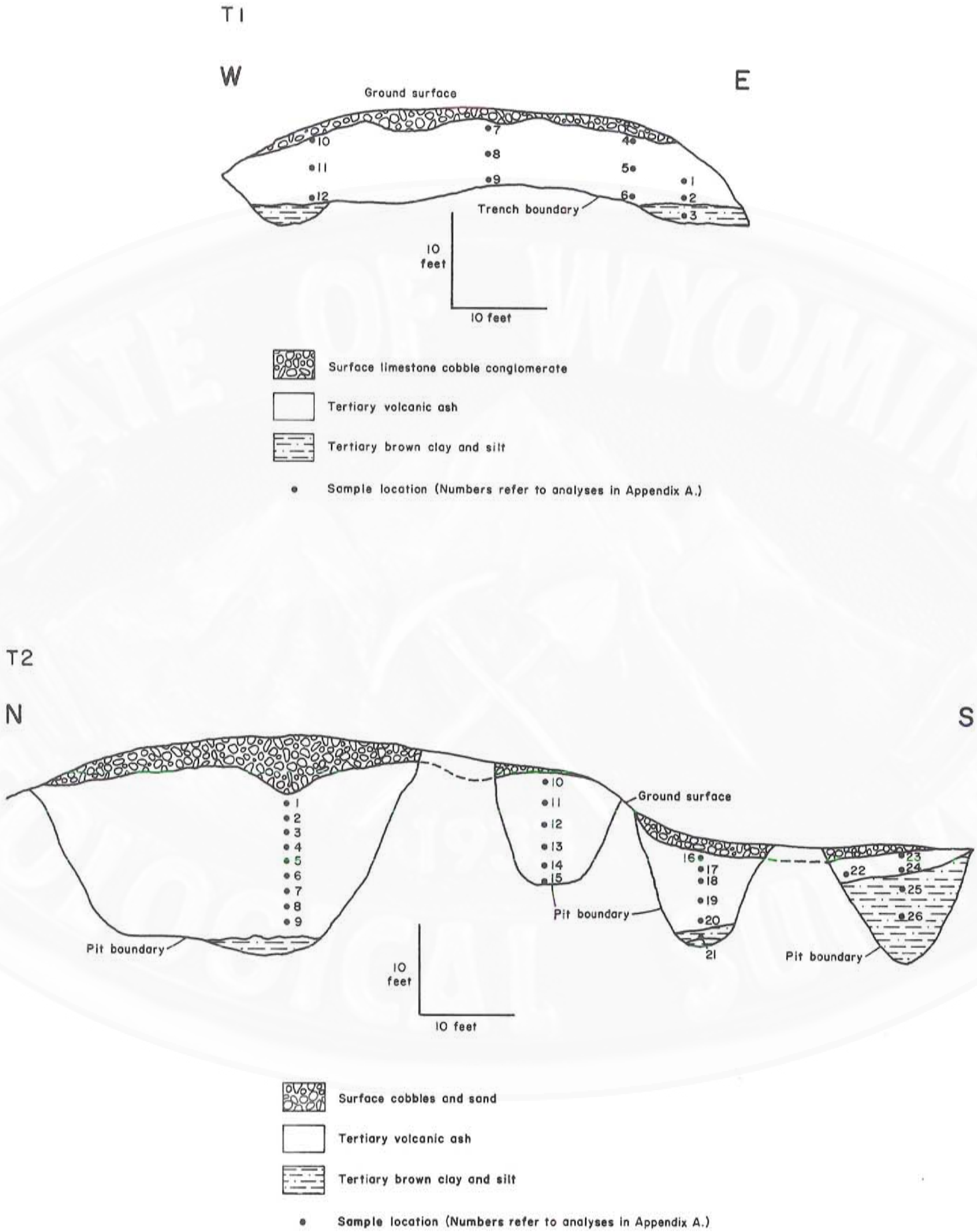


Figure 5. Cross-sectional diagrams of the two trenches dug and sampled in this study, showing sample locations.

Table 1. Chemical analyses of volcanic ash samples. Due to analytical procedures, whole-rock element totals for each sample may not total exactly 100%.

Sample number	SiO_2 %	Al_2O_3 %	CaO %	Na_2O %	K_2O %	MgO %	Fe_2O_3 %	MnO %	TiO_2 %	Ba %	Cr %	P_2O_5 %	S %	LOI %
A1-27[1]	60.94	13.91	2.41	0.86	2.16	2.95	4.35	0.09	0.60	0.07	0.04	0.33	<0.01	11.05
A3-15	63.63	12.86	2.03	0.86	2.33	2.77	3.76	0.04	0.56	0.12	0.01	0.06	<0.02	10.38
A3-30	59.75	2.10	19.73	0.01	1.09	0.01	0.24	0.02	0.08	0.02	0.01	0.05	<0.02	15.77
D1-36	23.07	3.92	36.83	0.01	1.16	1.54	1.04	0.01	0.19	0.01	0.01	0.22	<0.02	30.80
E2-45	23.01	4.82	35.23	0.01	1.07	1.75	1.54	0.04	0.23	0.01	0.01	0.10	<0.02	31.19
F2-11	61.19	11.79	6.29	0.95	4.02	1.59	1.39	0.05	0.20	0.05	0.01	0.05	<0.02	11.60
T1-1[2]	61.90	11.00	7.64	0.82	4.92	0.29	0.74	0.07	0.10	0.09	0.01	0.04	<0.02	11.13
T1-2	57.03	10.00	11.33	0.89	4.67	0.23	0.62	0.06	0.09	0.09	0.01	0.07	<0.02	13.43
T1-3	62.83	13.64	2.01	0.93	2.23	2.62	3.96	0.06	0.58	0.06	0.01	0.02	<0.02	10.41
T1-4	61.25	10.77	7.96	1.05	4.96	0.39	0.74	0.06	0.11	0.09	0.01	0.04	<0.02	11.33
T1-5	59.57	10.54	9.59	1.25	4.89	0.39	0.63	0.06	0.09	0.09	0.01	0.04	<0.02	12.33
T1-6	56.18	9.92	12.04	0.89	4.58	0.41	0.60	0.07	0.09	0.08	0.01	0.03	<0.02	14.13
T1-8	38.81	7.16	25.14	0.06	3.18	0.07	0.45	0.04	0.07	0.05	0.01	0.04	<0.02	23.47
T1-9	60.80	10.96	7.79	0.96	4.78	0.63	0.66	0.06	0.09	0.09	0.01	0.04	<0.02	12.39
T1-10	66.17	11.81	3.74	1.12	5.39	0.52	0.68	0.06	0.09	0.10	0.01	0.02	<0.02	9.33
T1-11	59.19	10.54	9.68	1.23	4.94	0.40	0.60	0.06	0.08	0.09	0.01	0.03	<0.02	12.78
T1-12	50.98	8.96	17.67	1.01	4.33	0.25	0.57	0.05	0.08	0.08	0.01	0.03	<0.02	15.57
T2-1[3]	28.07	5.90	32.03	0.20	1.85	0.85	0.85	0.06	0.14	0.03	0.02	0.10	<0.02	28.75
T2-2	58.79	12.00	5.89	0.52	3.21	2.35	1.53	0.05	0.21	0.07	0.01	1.10	<0.02	14.32
T2-3	58.21	12.06	6.06	0.46	2.95	2.52	1.71	0.06	0.24	0.06	0.01	0.12	<0.02	14.73
T2-4	49.75	9.68	14.53	0.63	3.16	1.45	1.25	0.04	0.17	0.06	0.01	0.10	<0.02	18.16
T2-5	59.76	11.78	5.86	0.67	3.56	1.96	1.41	0.06	0.20	0.07	0.01	0.13	<0.02	13.48
T2-6	64.73	12.24	3.16	1.10	4.57	1.37	0.87	0.06	0.12	0.10	0.01	0.04	<0.02	10.91
T2-7	66.82	12.72	1.33	0.98	4.66	1.43	0.78	0.05	0.12	0.09	0.01	0.01	<0.02	10.01
T2-8	59.68	11.40	6.99	1.07	4.16	1.38	0.74	0.05	0.10	0.08	0.01	0.03	<0.02	13.75
T2-9	29.46	3.25	33.68	0.01	0.65	0.69	0.90	0.01	0.13	0.02	0.01	0.14	<0.02	29.58
T2-10	47.56	8.82	17.35	0.67	3.70	0.89	0.55	0.04	0.07	0.07	0.01	0.03	<0.02	19.53
T2-11	55.69	10.22	10.64	1.04	4.10	1.27	0.79	0.04	0.10	0.08	0.01	0.03	<0.02	15.23
T2-12	60.71	10.96	6.87	0.95	4.51	1.04	0.66	0.05	0.09	0.08	0.01	0.02	0.03	12.63
T2-13	67.24	12.61	1.17	1.04	4.89	1.28	0.71	0.05	0.10	0.09	0.01	0.01	<0.02	9.52
T2-14	67.47	12.61	1.13	1.09	4.92	1.27	0.71	0.06	0.10	0.10	0.01	0.01	0.02	9.30
T2-15	66.94	12.62	1.19	1.26	4.73	1.45	0.74	0.07	0.11	0.13	0.01	0.01	<0.02	9.64
T2-16	66.69	12.74	1.65	1.15	4.76	1.38	0.86	0.05	0.13	0.10	0.01	0.03	<0.02	9.49
T2-17	65.50	12.31	2.61	1.33	4.75	1.35	0.73	0.06	0.10	0.10	0.01	0.03	<0.02	10.46
T2-18	62.35	11.76	4.90	0.96	4.38	1.32	0.68	0.05	0.10	0.10	0.01	0.04	<0.02	12.33
T2-19	64.91	12.92	1.59	0.82	3.86	2.09	1.39	0.08	0.20	0.08	0.01	0.13	<0.02	11.17
T2-20	66.46	12.74	1.23	0.96	4.40	1.70	0.76	0.06	0.11	0.09	0.01	0.01	<0.02	10.68
T2-21	63.17	12.52	1.83	0.70	2.25	2.11	3.54	0.04	0.50	0.08	0.01	0.15	<0.02	11.45
T2-22	37.81	7.42	24.97	0.15	2.89	0.64	0.54	0.05	0.08	0.05	0.02	0.05	<0.02	24.39
T2-23	64.49	13.02	1.90	0.89	4.01	2.03	0.91	0.06	0.13	0.09	0.01	0.02	<0.02	12.05
T2-24	56.11	11.33	7.53	0.43	1.91	2.74	2.76	0.05	0.39	0.18	0.01	0.55	<0.02	14.95
T2-25	60.21	13.43	1.93	0.78	2.24	3.19	3.87	0.10	0.55	0.13	0.01	0.06	<0.02	12.95
Average	56.54	10.57	9.88	.78	3.61	1.35	1.26	0.05	0.18	0.08	0.01	0.08	<0.02	14.68

[1] A - F refer to drill holes located on Plate 1 and described in Appendix A. Numbers indicate depth in the hole at which sample was taken.

[2] T1 samples are from trench 1, shown on Plate 1 and Figure 5.

[3] T2 samples are from trench 2, shown on Plate 1 and Figure 5.

local uses such as abrasives and ceramic glazes. According to Walter Johnson of Guernsey, former owner of the ranch in the east 1/2 of sec. 6, this material was used by his father in the early 1900s to sharpen plows. When fired, the ash melts to a transparent turquoise-colored glaze.

Bentonitic clay

Bentonite is a rock consisting of a mixture of montmorillonite clay that is characterized by high plasticity, high ion-exchange capacity, high viscosity, and high swelling capacity when wet. Bentonite has a multitude of uses. The primary use is as a mud for well drilling. Bentonite is also used as a binder in iron-ore pelletizing and foundry sand. Bentonite is used increasingly as a sealant or liner in waste-isolation and management projects. Other uses include mineral fillers, clarifying agents, paper coatings, animal feed additives, sewage treatment, printer's ink, and paint filler (Sargent and others, 1976).

In Wyoming, bentonite is mined and processed in the Black Hills, eastern Bighorn Basin, Kaycee, and Casper areas. Wyoming produces more bentonite than any other state.

Bentonitic clay is found in the Tertiary and Quaternary sediments, undivided, in local areas. The amount of bentonitic clay present in this area is large, as some of these units were found by drilling to be up to 40 feet thick (drill hole G, **Appendix A**). These clays have never been tested to determine their chemical composition or rheologic properties. However, they have a different occurrence than the bentonites currently mined in Wyoming, so they may have unique properties. They should be examined for use as a source of bentonite products or additives.

Limestone

Limestone is a rock consisting primarily of the mineral calcite ($CaCO_3$). It is an industrial mineral that has a wide variety of uses. Limestone is the most common type of stone produced in the United States. Only Delaware, Louisiana, and New Hampshire produce no limestone (Carr and Rooney, 1983). In Wyoming, limestone is produced for construction aggregate, especially for highway construction, and for power-plant emission control. Limestone is quarried in Montana north of Frannie, Wyoming, for use in sugar beet refining. Limestone is quarried elsewhere in the region for use in calcining phosphate and in the production of dehydrated lime.

Limestone in the Hartville Formation divisions II and III may be used for any of these products. An analysis of a limestone from the Hartville Formation division II is given in **Table 2**. This and other limestone beds in the area may constitute an important resource.

Table 2. Analysis of Hartville Formation division II limestone sample (taken at designated location, Plate 1).

Element	CaO	LOI	Fe_2O_3	SiO_2	Al_2O_3	MgO	MnO	Na_2O	P_2O_5	TiO_2
Weight percent	49.32	39.90	0.33	8.59	0.28	0.69	0.02	0.06	0.07	0.02

Dolomitic limestone

Dolomite is a rock consisting of the mineral dolomite ($CaMg(CO_3)_2$. Dolomitic limestone is a limestone containing more than 10 percent and less than 50 percent mineral dolomite. Dolomitic limestone is used as aggregate and in the production of magnesium lime. It is preferred for sugar refining in the eastern United States (Carr and Rooney, 1983).

The thick beds of dolomitic limestone, which constitute most of the Hartville Formation division II and a portion of division III, are potentially useful for construction aggregate. They are hard, and crush into equidimensional pieces. Rocks from this unit are being used in highway construction throughout eastern Wyoming. Since the upper Patten Creek area is close to Wyoming State Highway 270, the area may be considered a source of aggregate for the highway as well as other roads in the region.

Quartzite

Quartzite is a term for a rock composed primarily of quartz. As used in this report, quartzite is a sedimentary rock consisting of grains of silica sand cemented together by at least 10 percent silica (Thrush, 1968). This rock is also called orthoquartzite.

The Permian-Pennsylvanian Hartville Formation division VI quartzite exposed in the southern part of the map area has been considered for use in construction aggregate, railroad ballast (Harris, 1986), and decorative stone. A 15-foot-high face of quartzite on the south section line of sec. 16 (**Figure 2** and **Plate 1**) might be a good place for an aggregate or dimension-stone quarry.

Semiprecious stones

Onyx

Onyx is a semiprecious mineral composed of either banded quartz or banded calcite. Banded calcite onyx is often called Mexican onyx or onyx marble (Thrush, 1968).

Dark brown calcite onyx occurs in the SW 1/4, NE 1/4 sec. 32 (**Figure 6**). This rock, called *root beer* onyx, makes an attractive decorative stone, and if sufficient amounts are present, an attractive crushed aggregate for use in precast concrete. This onyx was quarried in the early and middle 1900s by the Jay Em Stone Co., Jay Em, Wyoming, for tombstones. It was also quarried by Basins, Incorporated, of Wheatland, Wyoming, for decorative rock and may be seen as the facing stone on Fowler's Department Store, northwest corner of 17th and Carey Avenue, in Cheyenne, Wyoming. Other occurrences of brown onyx were located by the author in secs. 32, 4, 5, 6, and 8. (**Plate 1**).

Agate

Agate is a semiprecious stone consisting of variegated bands of chalcedony. Fortification agate (**Figure 7**) is found on the top of the hill in the NW 1/4 sec. 5. Fortification agate is concentrically banded agate that appears, when cut, to imitate the outlines of early defensive fortifications. The fortification agate found in this area is banded with blue, salmon, and white layers. This agate can be used in jewelry and small ornaments such as desk sets. Limited amounts of this material are found in the area. However its appearance makes it attractive to the mineral collector or small-scale stone processor.

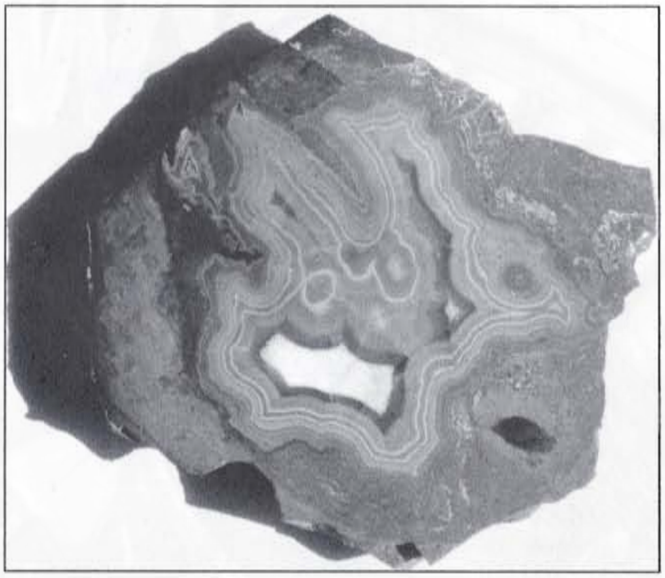


Figure 7. Fortification agate from the upper Patten Creek area. (Photograph by Wayne M. Sutherland.)

Figure 6. Brown onyx boulder from the upper Patten Creek area.

Other economic factors

The upper Patten Creek area is located close to highway transportation. The cost of industrial minerals produced from this location would be less than similar minerals produced from a more remote location. Similarly, rail transportation is available 29 miles north (Chicago Northwestern Railway at Manville) and 14 miles south (Burlington Northern Railroad at Guernsey).

There are no wilderness or roadless areas nearby, requiring special environmental protection. Small amounts of water are available from wells and springs in the area. A water pipeline serves Hartville, 8 miles by road from the study area. Electrical power lines and natural gas and petroleum pipelines are nearby. If a mineral development takes place in this area, a power, water, and land infrastructure should not be too costly to install.

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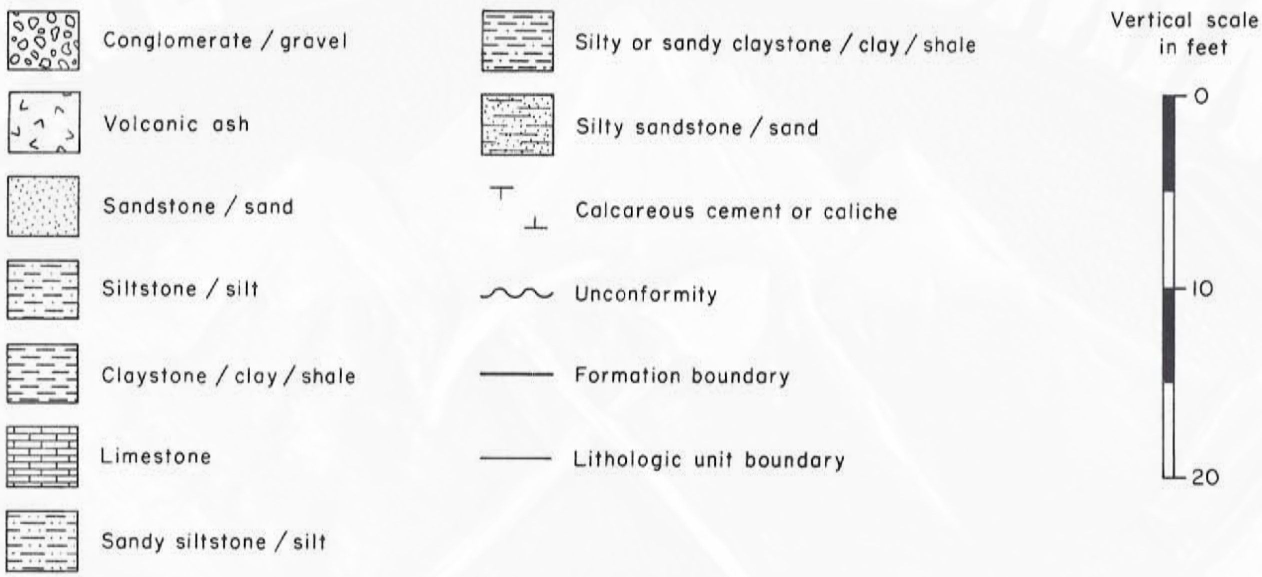
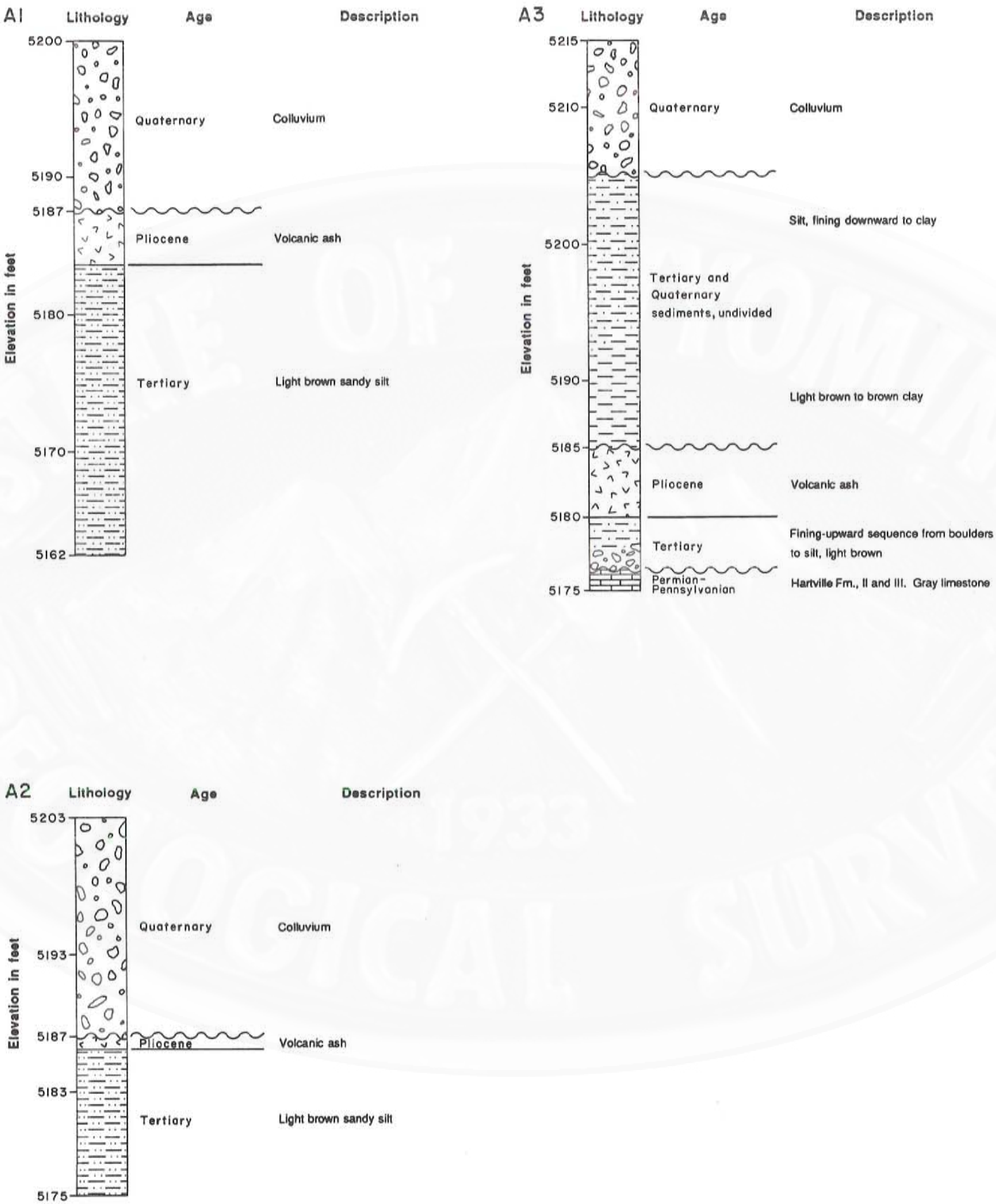
Appendix A

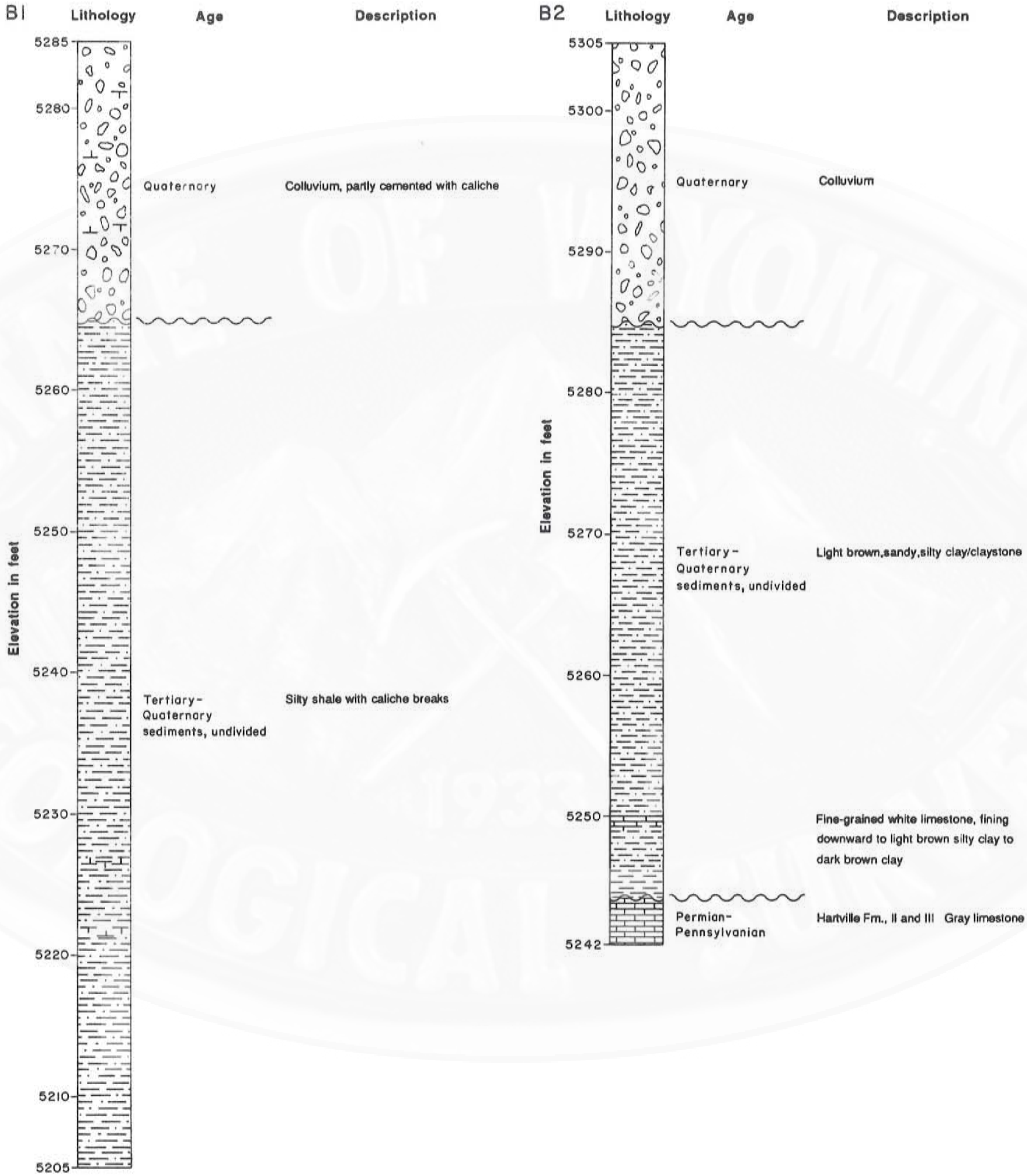
Lithologies in drill holes

EXPLANATION OF LITHOLOGIC SYMBOLS USED IN APPENDIX A

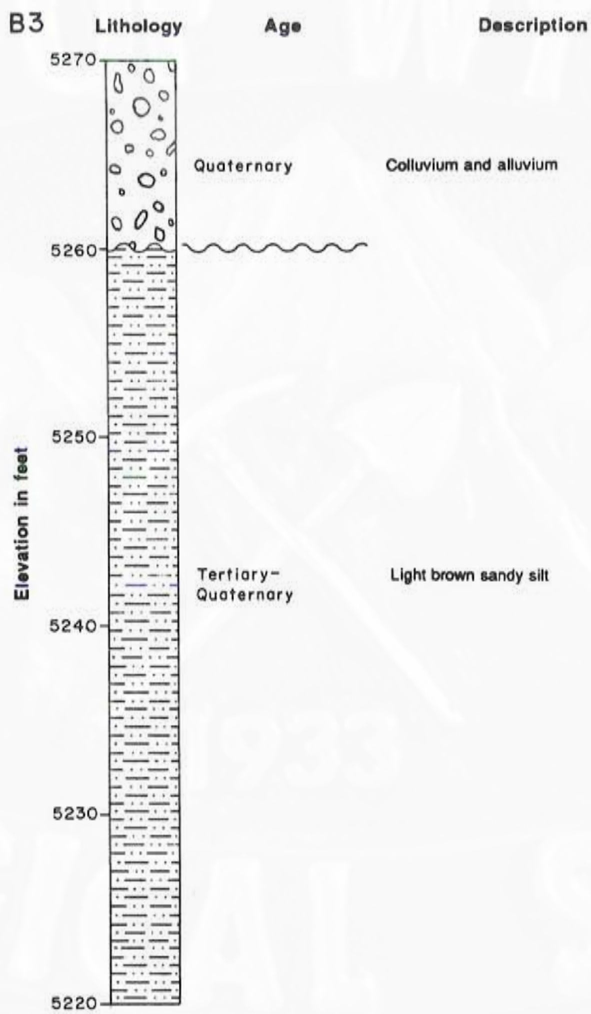




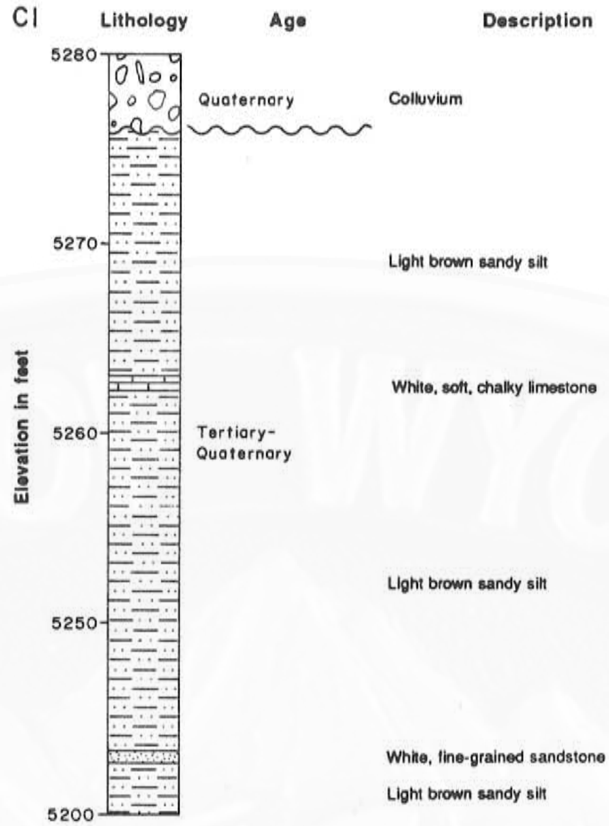
Lithologies in drill holes A1, A2, and A3.

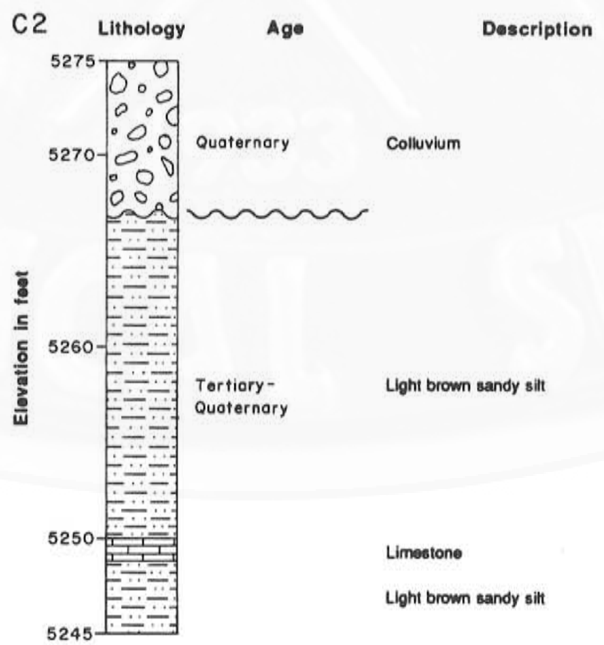


Lithologies in drill holes B1 and B2.

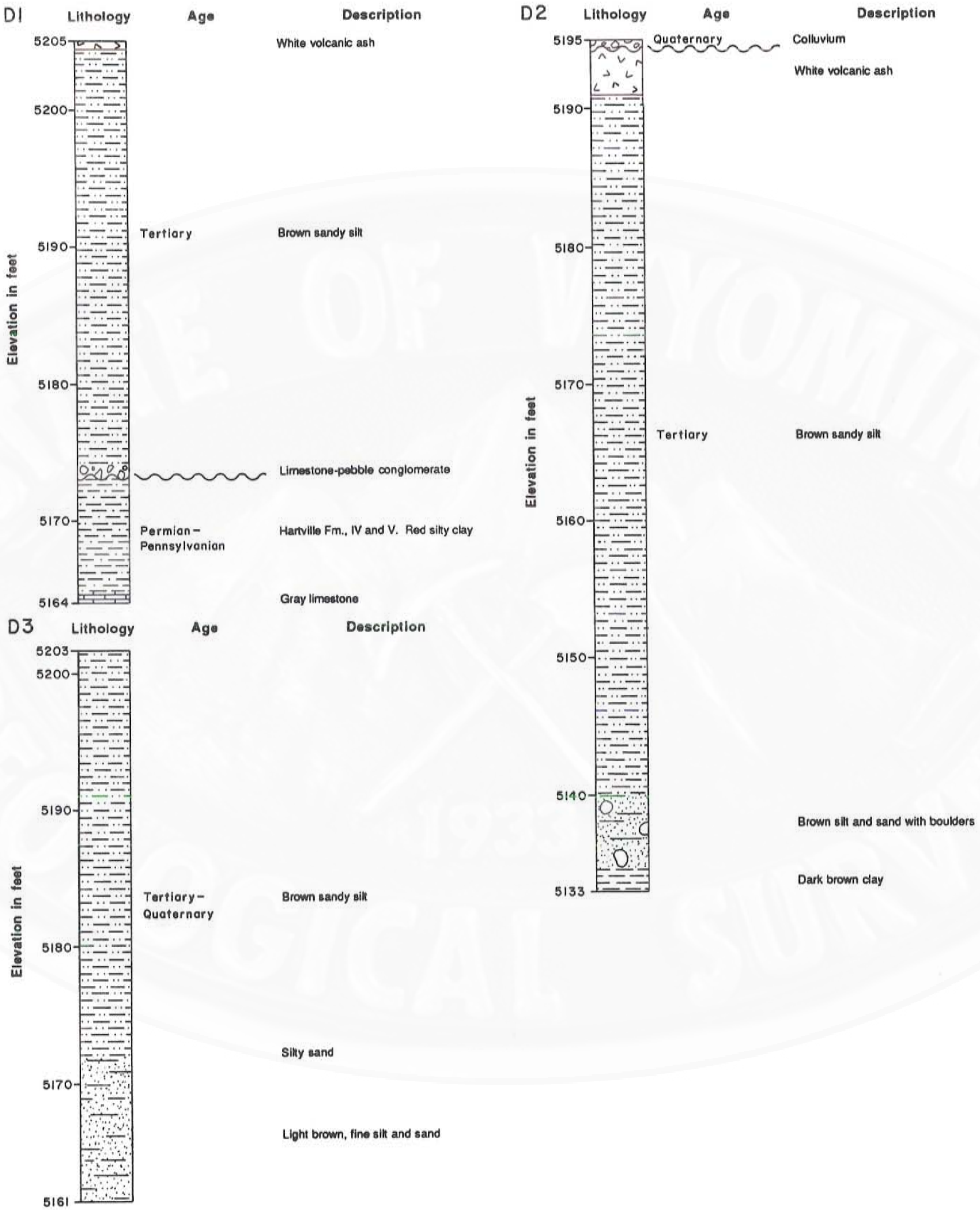


Lithologies in drill hole B3.

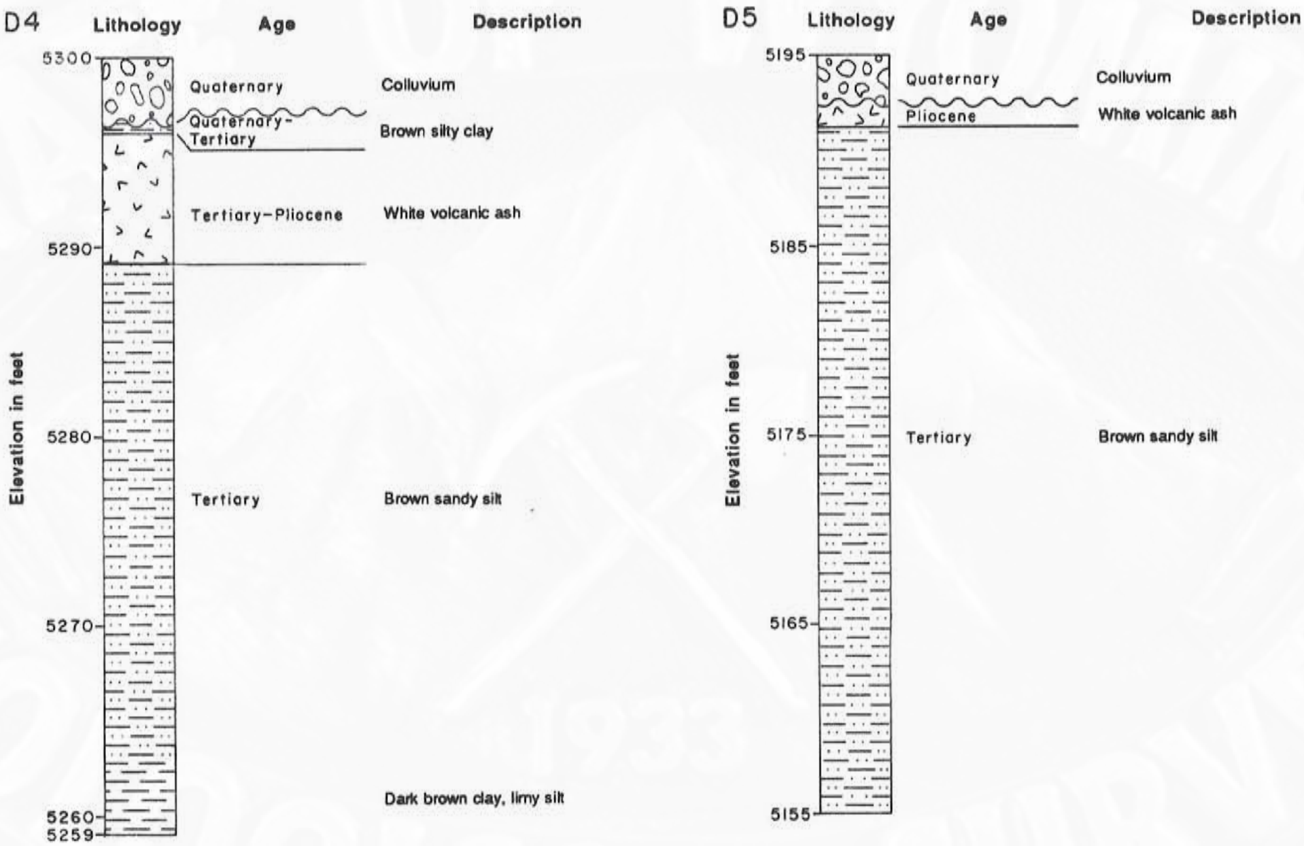




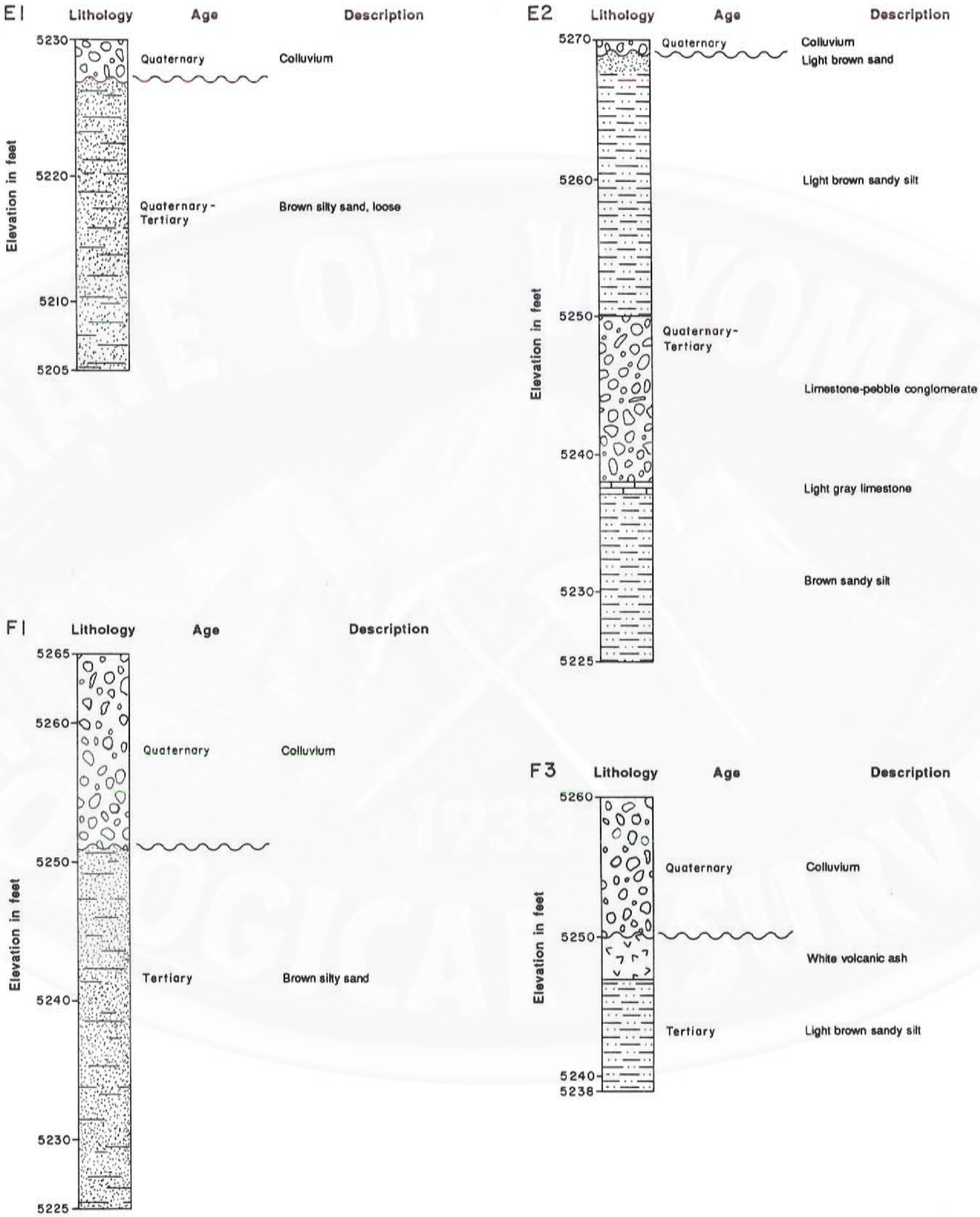
Lithologies in drill holes C1 and C2.



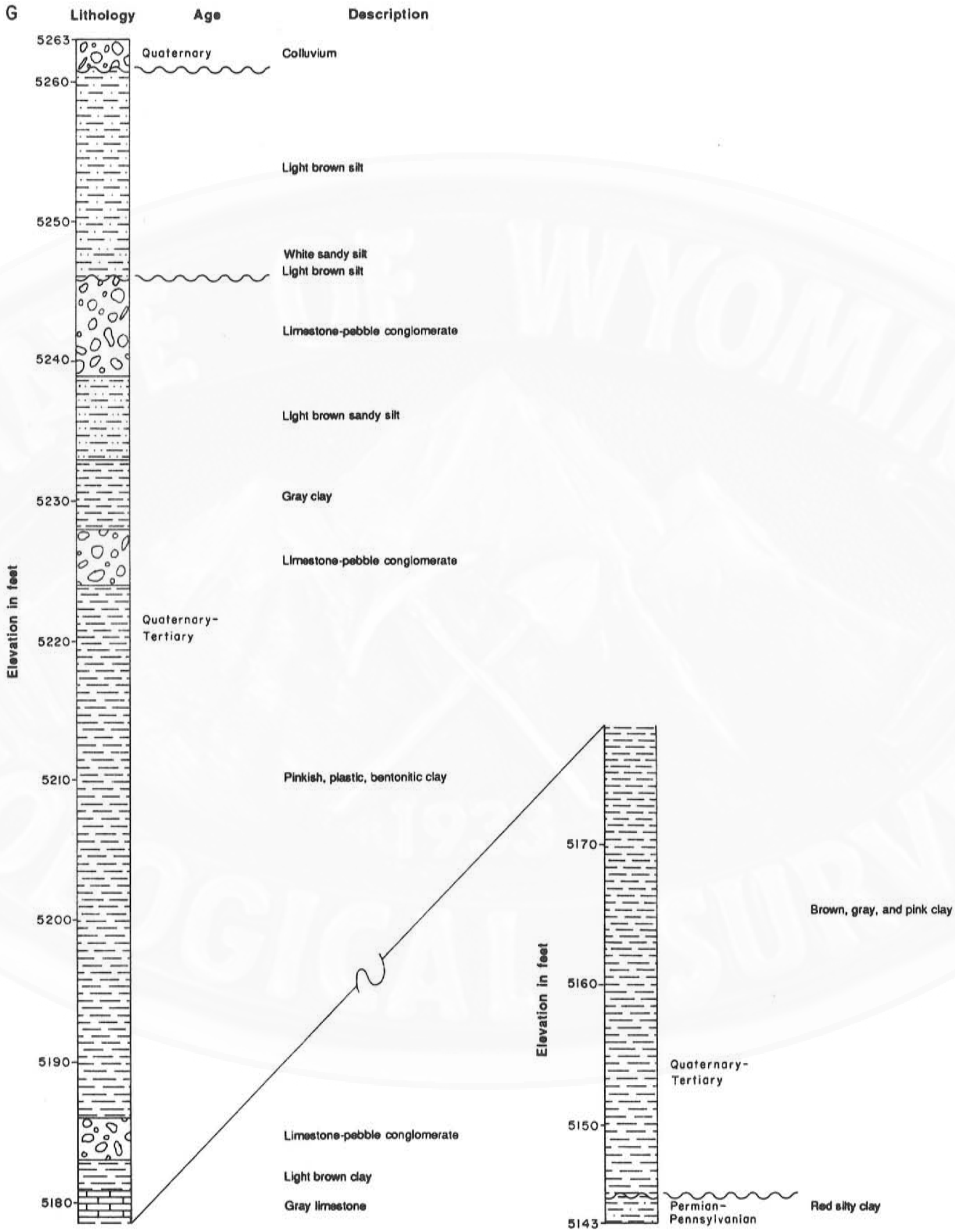
Lithologies in drill holes D1, D2, and D3.



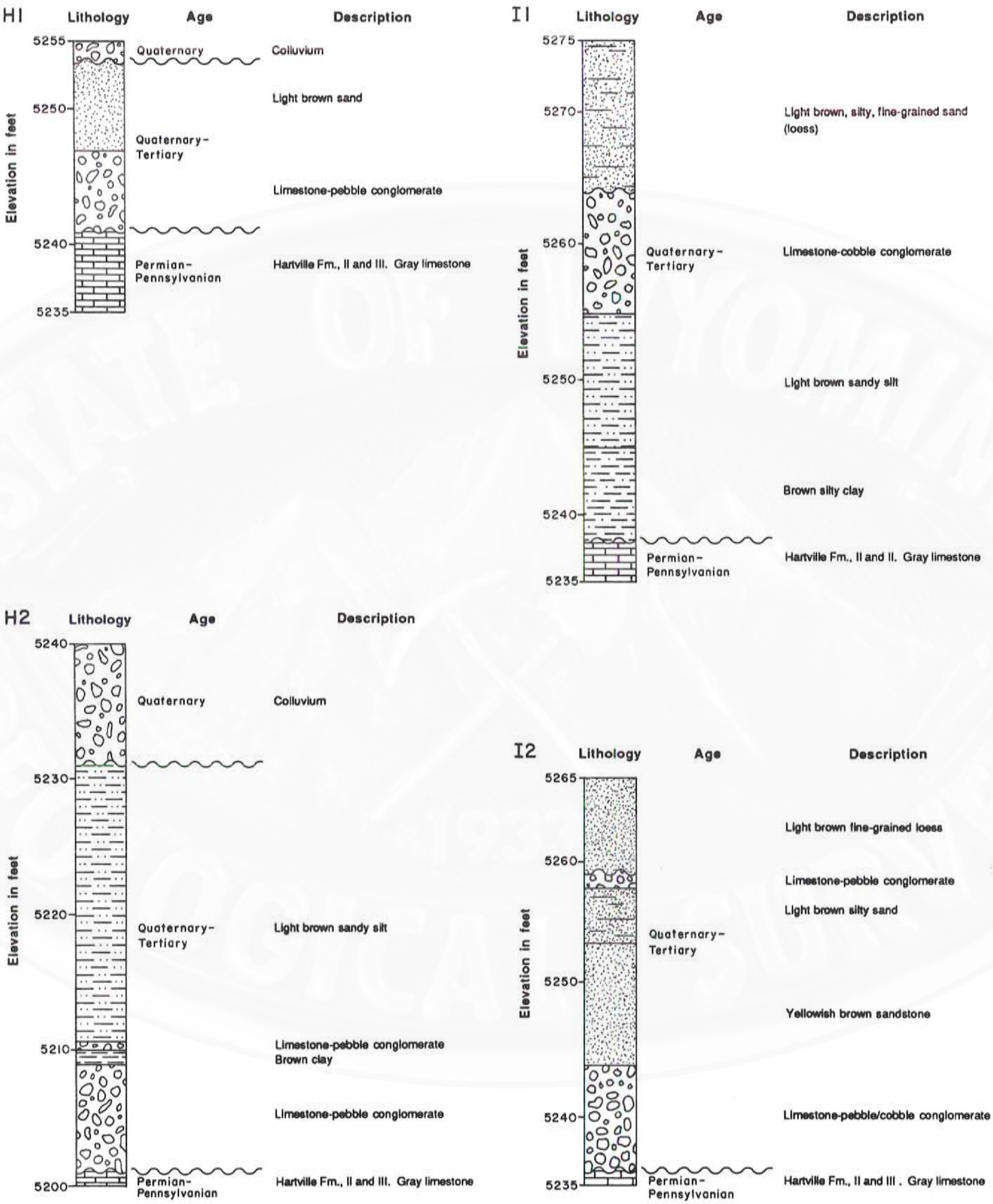
Lithologies in drill holes D4 and D5.



Lithologies in drill holes E1, E2, F1, and F3 (F2 caved after 10 feet of gravel).



Lithologies in drill hole G.



Lithologies in drill holes H1, H2, I1, and I2.

Geology and industrial mineral resources of the upper Patten Creek area, Platte County, Wyoming

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