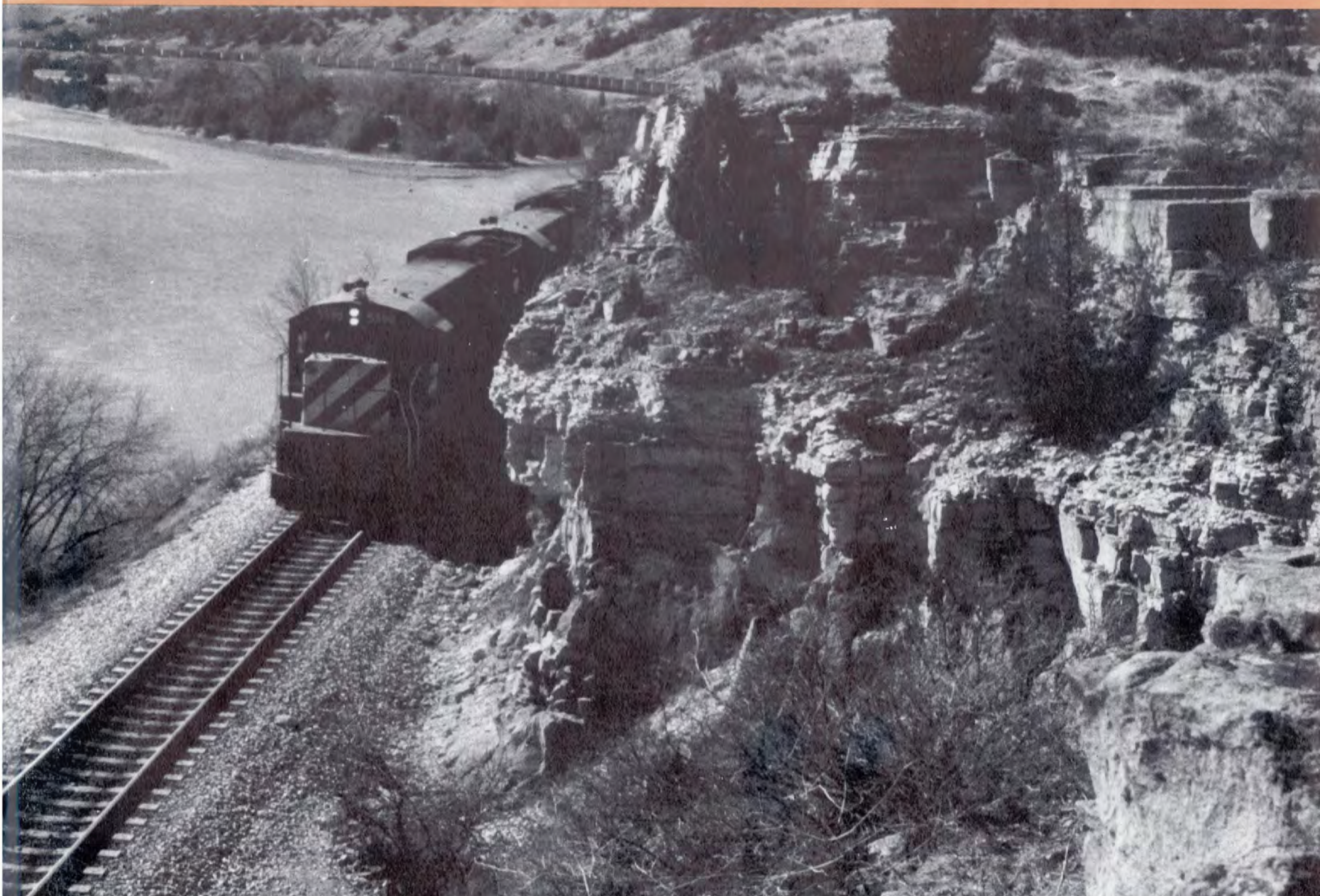
THE GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

THE CASSA SILICA ROCK DEPOSIT, PLATTE COUNTY, WYOMING

by
Ray E. Harris



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1988

Laramie, Wyoming

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Cover photograph: The Cretaceous Cloverly Formation, at the site of the Cassa silica rock deposit: upper orthoquartzite (upper cliff), middle unit (thin ledges), and lower orthoquartzite (lower cliff). The orthoquartzites constitute the silica rock resource. The deposit is adjacent to rail transportation and water (the North Platte River).

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Introduction

Silica (SiO_2) is the primary ingredient for the manufacture of glass and related products. It is also produced for a variety of industrial uses. Quartz is the most common naturally occurring silica mineral. The primary sources of silica are ancient and recent quartzose sandstone or sand deposits and pegmatitic quartz.

This report describes the geology and silica resources of a deposit of sandstone exposed 1 mile north of the railroad siding and former townsite of Cassa, Wyoming. The deposit is located in secs. 25, 26, 27, 34, 35, and 36, T.29N., R.68W., about 4 miles southeast of Glendo, Platte County, Wyoming. It is adjacent to Wyoming State Highway 319 and the Burlington Northern Railroad (**Figure 1** and **cover photo**). The deposit contains an upper sandstone unit that averages 18 feet thick, exposed at or near the surface over an area of 600 acres. The sandstone averages about 99 percent silica. A lower sandstone averaging 96 percent or more silica is also present in part of the area. In both sandstones, the sand grains and the cement are composed of quartz. The sandstones are classified as orthoquartzites (Pettijohn, 1949).

Bates and Jackson (1987) define silica rock as "an industrial term for certain sandstones and quartzites that contain at least 95 percent silica (quartz)." Silica sand is the term used to describe similar deposits that are unconsolidated or easily disaggregated. The term silica rock is used to describe the material in the Cassa deposit.

Silica deposits like the one at Cassa are uncommon west of the Mississippi River. This deposit could supply Rocky Mountain, Great Basin, and possibly West Coast glass markets. Also, new technologies and transportation considerations may make it possible to establish production to serve a worldwide market. The presence of transportation routes, water, and power at the deposit site; the nearby presence of other raw materials needed for the manufacture of glass (limestone and feldspar); and the closeness of soda ash production (300 miles) also contribute to the economic viability of this deposit (**Figure 1**). These factors may favor the construction of a glass manufacturing plant near the deposit.

Funding for the drilling program on this site and for analysis of samples was obtained by the Platte County Board of Commissioners from the Wyoming Economic Development and Stabilization Board (EDSB) through a planning-only grant. This grant was given to provide a preliminary estimate of the amount and grade of the silica rock resource. Information from this drilling project and analytical results were given to the Geological Survey of Wyoming by the Platte County Board of Commissioners and EDSB. The Geological Survey of Wyoming also provided technical advice for the drilling program.

This is the second of two similar studies. The first, *The Plumbago Creek silica sand deposit, Albany County, Wyoming* (Harris, 1988) discussed a silica sand deposit with different characteristics. The Plumbago Creek deposit is larger and contains lower grade material. However, it is easily disaggregated and may be easily mined and processed (Harris, 1988). The extremely high grade (nearly 99 percent SiO_2) of the silica rock in the Cassa deposit may make it attractive to manufacturers interested in high-purity material, even though the costs of crushing the rock to mill-feed specifications may be higher than for a silica sand deposit.

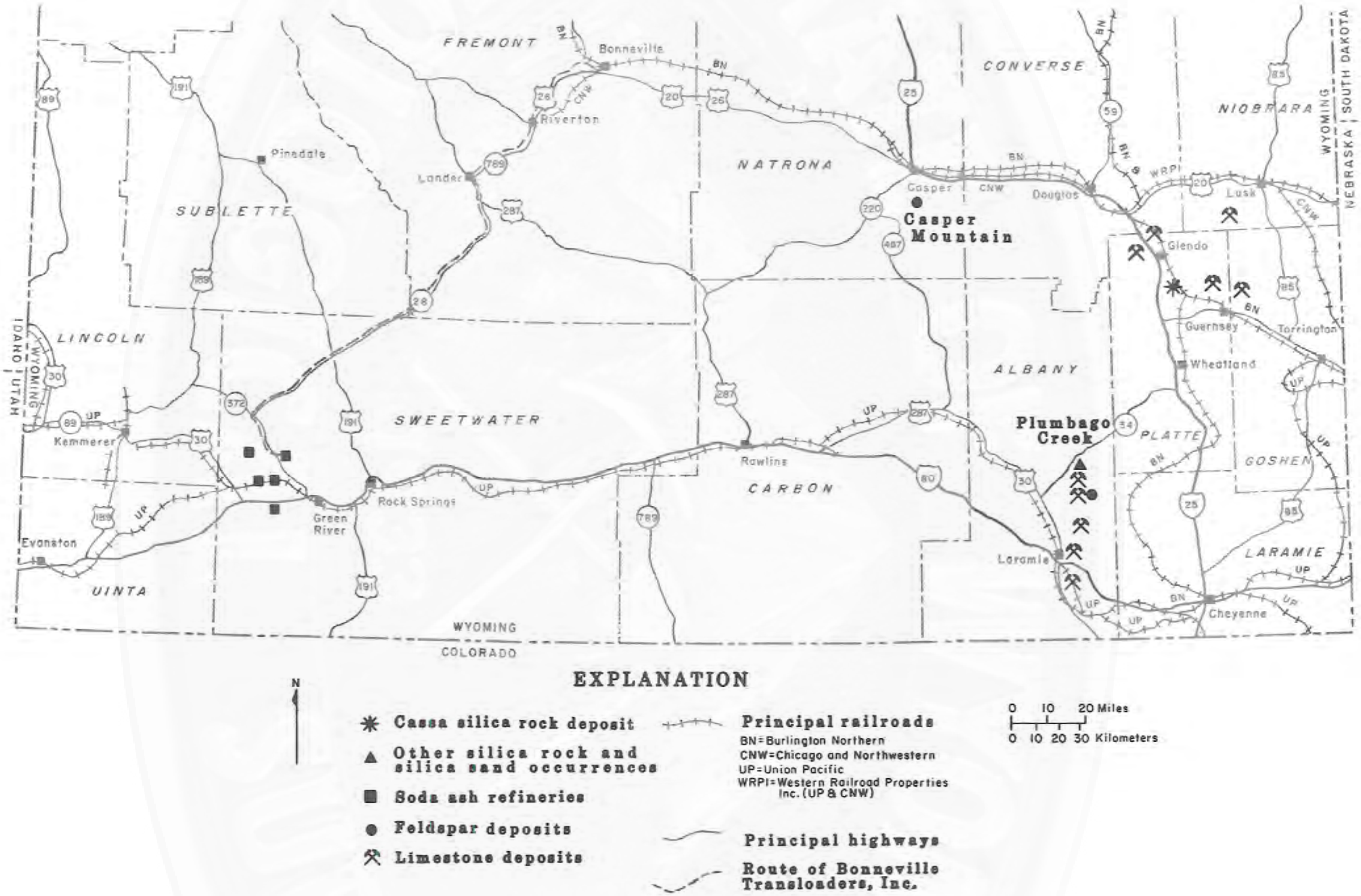


Figure 1. Regional map showing the location of the Cassa silica rock deposit, other nearby sources of raw materials for the manufacture of glass, and transportation routes.

Geology
Stratigraphy

Rocks exposed in the vicinity of the Cassa silica rock deposit include the Jurassic Morrison Formation, the Cretaceous Cloverly Formation (the host unit for the silica rock), the Cretaceous Thermopolis Shale, and Tertiary and Quaternary deposits. These are shown on the geologic map (**Figure** 2) and four cross sections (**Figure 3**). The following is a discussion of each of the mapped units in the area.

Morrison Formation

The Morrison Formation (upper Jurassic) underlies the silica rock deposit, and is the oldest unit exposed in the mapped area. The formation was first named and described by Eldridge (*in* Emmons and others, 1896) for exposures near the town of Morrison, Colorado, southwest of Denver. In the Cassa area, the Morrison Formation consists of greenish gray, gray, dark red, and light red silty claystone; thin beds of yellowish medium- to coarse-grained sandstone; siltstone; sandy siltstone; and sandy claystone. Love and others (1949) reported that thin beds of freshwater limestone are present in the unit. No limestone units are present in the small area of exposure of the Morrison Formation at the Cassa locality, nor were limestones noted in any of the six holes drilled for this study (**Appendix** A).

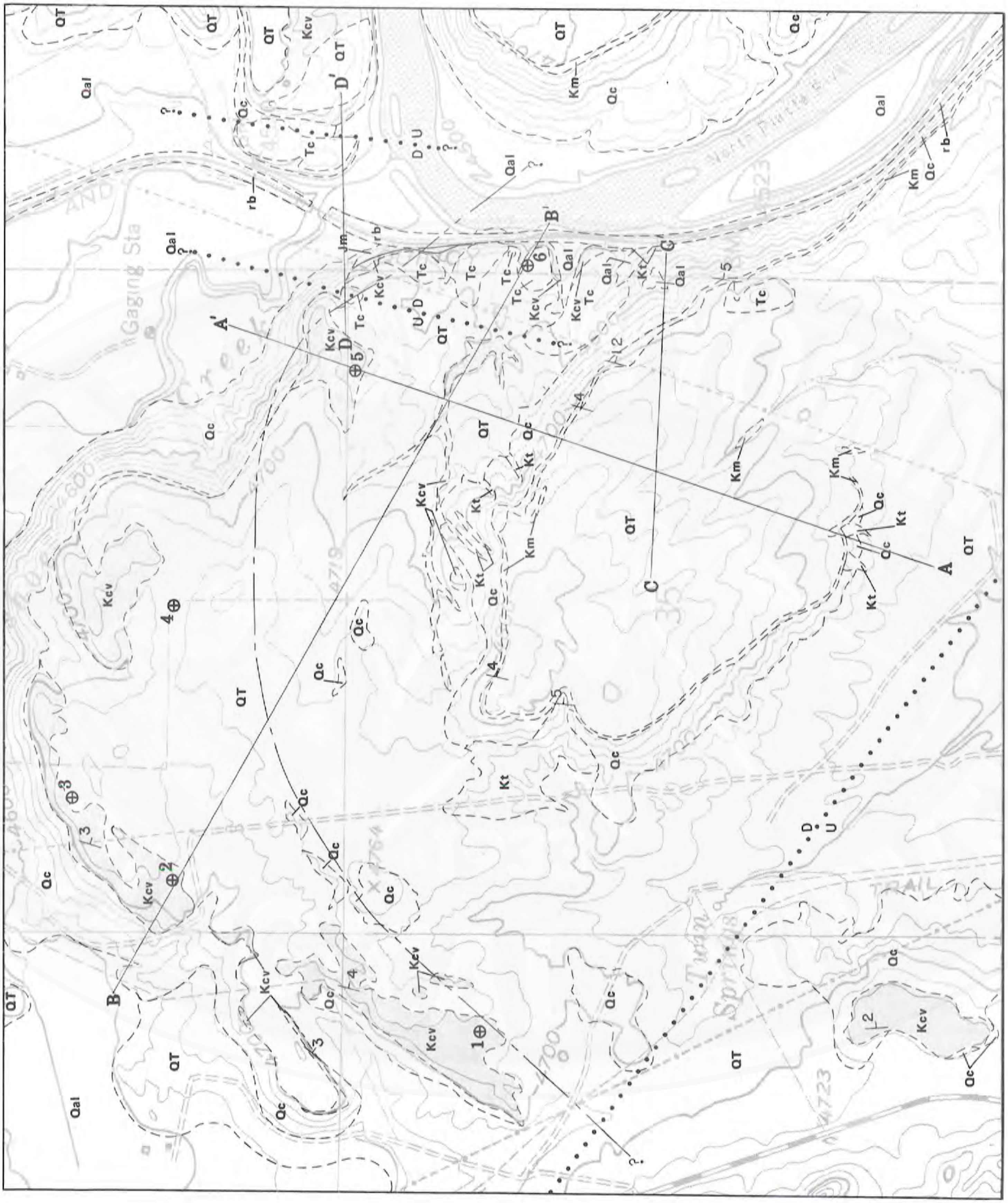
The Morrison Formation is 150 to 220 feet thick in the Glendo area (Love and others, 1949). Only the upper 60 feet are exposed in the Cassa study area in the north end of the railroad cut (W1/2NW1/4NW1/4 sec. 36, T.29N., R.68W., **Figure 2**). Throughout the rest of the mapped area, this unit is covered by colluvium consisting of blocks of the overlying Cloverly Formation.

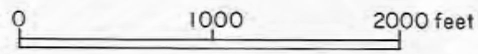
Cloverly Formation

The Cassa silica rock deposit consists of an upper orthoquartzite and a basal orthoquartzite in the Lower Cretaceous Cloverly Formation. In most places, only the upper orthoquartzite is exposed. The lower parts of the formation are covered by blocks of the upper orthoquartzite. The lower beds in the Cloverly Formation are only exposed in the railroad cut along the west edge of sec. 36, T.29N., R.68W. (**cover photo**), but were encountered in all six drill holes (**Appendix A**).

The Cloverly Formation was named and described by Darton (1904) from exposures near Cloverly, 15 miles northeast of Basin, Big Horn County, Wyoming. The Cloverly Formation is stratigraphically equivalent to other units in surrounding states. In northeastern Wyoming, the Inyan Kara Group, consisting of a lower Lakota Sandstone, middle Fuson Shale, and upper Fall River Sandstone, occupies the same stratigraphic position as the Cloverly Formation at Cassa. In Colorado, the Dakota Group includes Cloverly-equivalent rocks (McGookey and others, 1972).

The Cloverly Formation unconformably overlies the Jurassic Morrison Formation (Love and others, 1949). In the Cassa area, this contact is usually the base of the lowest white sandstone. In drill hole 3 (**Appendix A**), the contact was located at the top of the uppermost greenish claystones. In the railroad cut in SW1/4NW1/4NW1/4 sec. 36, white fine-grained sandstone of the Cloverly Formation rests on yellowish to greenish siltstone, claystone, and thin yellow sandstone of the Morrison Formation (**Figure** 4). There is moderate relief on the upper surface of the Morrison Formation caused by pre-Cloverly erosion.


A
A'
B
B'
C
C'
D
D'
Qal
QT
Qc
Kcv
Kt
Km
Tc
Jm
rb
Gaging Sta
TRAIL



EXPLANATION

QUATERNARY

- Qc — Colluvium
- Qal — Alluvium

QUATERNARY AND TERTIARY, UNDIVIDED

- QT — Silt, sand, and gravel

TERTIARY

- Tc — Conglomerate

EARLY CRETACEOUS

Thermopolis Shale

- Km — Muddy Sandstone Member
- Kt — Lower black shale

Cloverly Formation

- Kcv — Orthorquartzite, quartz sandstone, siltstone, shale, and other lithologies

JURASSIC

- Jm — Morrison Formation
- 2 ⊕ — Drill hole location
- rb — Railroad bed
- —— — — Contact, dashed where approximately located
- • • • • • • Fault, inferred
- 3 — Strike and dip of beds
- A——A' Cross section location (see Figure 3)
- —— – —— Maximum northern extent of lower orthoquartzite in subsurface

Figure 2. Geologic map of the Cassa silica rock deposit, T.29N., R.68W.

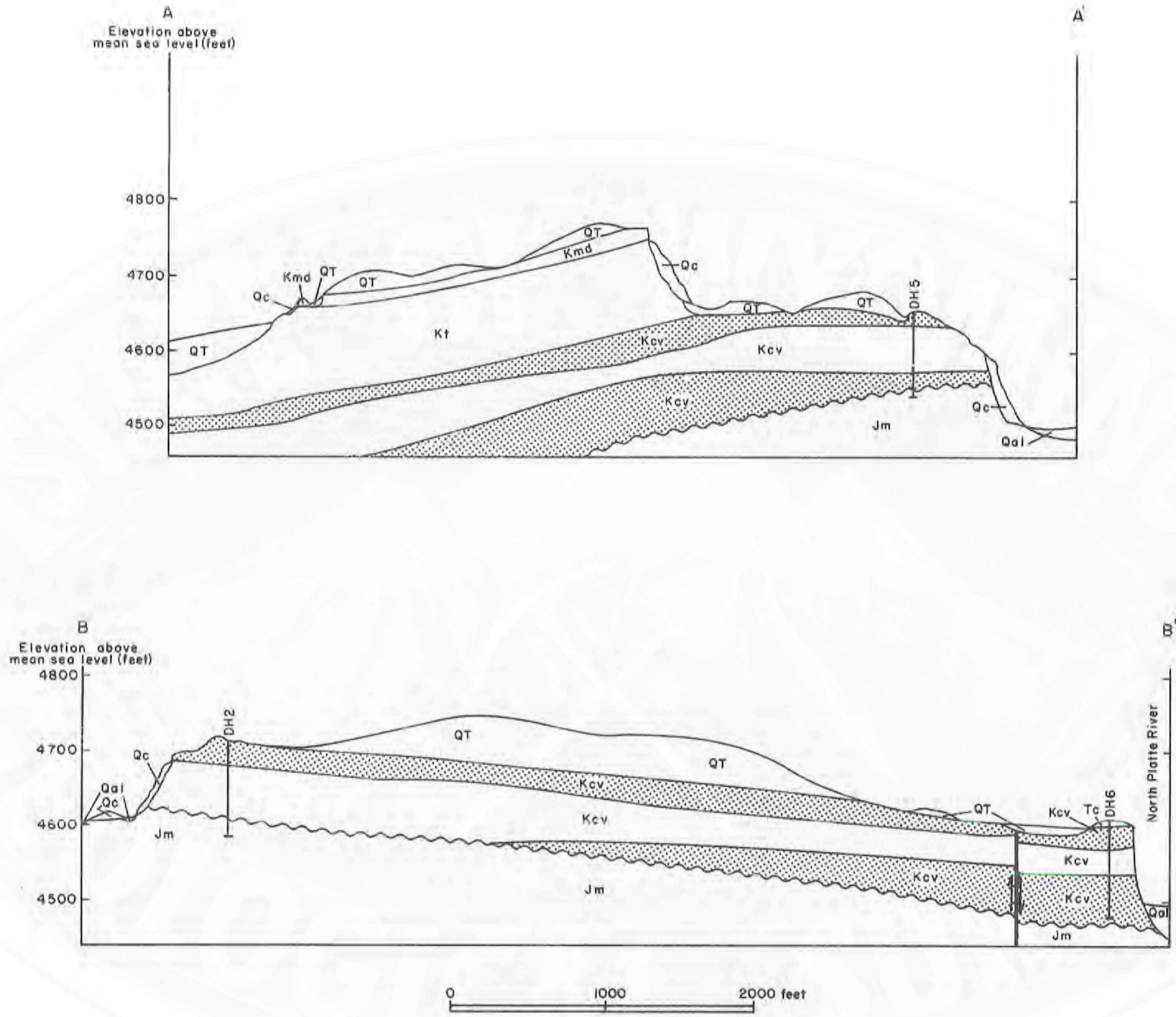
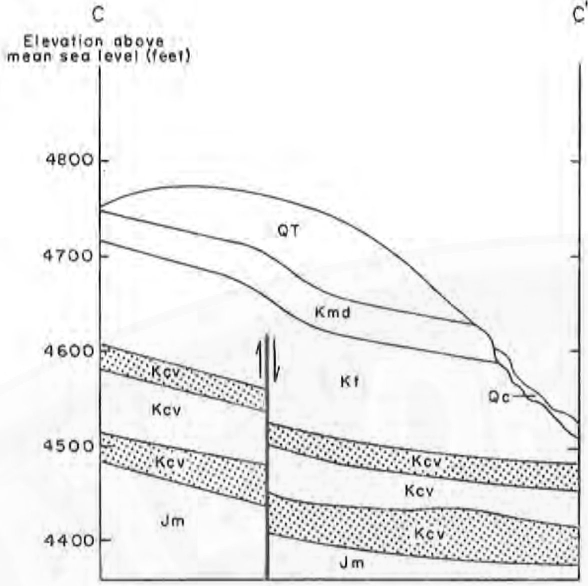
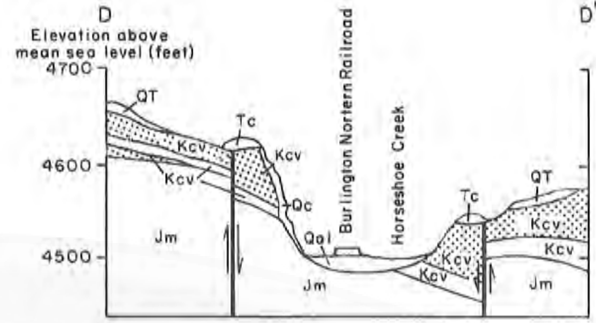
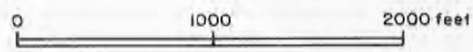


Figure 3 (this and opposite page). Cross sections of the Cassa silica rock deposit.







EXPLANATION

Quaternary

- Qc — Colluvium
- Qal — Alluvium

Quaternary and Tertiary, undivided

- QT — Silt, sand, and gravel

Tertiary

- Tc — Conglomerate

Lower Cretaceous

Thermopolis Shale

- Kmd — Muddy Sandstone Member
- Kt — Lower black shale

Cloverly Formation

- Kcv — Orthoquartzite
- Kcv — Sandstone, siltstone, shale, and other lithologies including thin orthoquartzites

Jurassic

- Jm — Morrison Formation

DH2 — Drill hole location

Unconformity

Fault, arrows indicate relative movement

Figure 4. Contact of the Cloverly (Kcv) and Morrison Formations (Jm), north end of railroad cut, Cassa area (5-foot staff for scale, left center).

The thickness of the Cloverly Formation in the area of this report varies from over 112 feet (drill hole 1, **Appendix A**) to 46 feet (drill hole 3, **Appendix A**). Love and others (1949) report a thickness of 120 to 260 feet for the Cloverly Formation north of the Cassa area. Thick sections of the Cloverly Formation reflect deposition in paleotopographic lows on the surface of the Morrison Formation.

In the Cassa area, the Cloverly Formation consists of orthoquartzite, silty sandstone, siltstone, silty claystone, and claystone. The three-part division (upper sandstone, middle shale, and lower sandstone) described in the Cloverly Formation to the north (Love and others, 1949) and east (Denson and Botinelly, 1949) is not everywhere present in the Cassa area, because the middle part of the formation here is more varied and sandier, and the lower orthoquartzite is not always present. The upper orthoquartzite may be equivalent to the Fall River Formation; the middle unit may be equivalent to the Fuson Shale; and the lower orthoquartzite, when present, may be equivalent to the Lakota Sandstone of the Inyan Kara Group in the Black Hills region.

The non-orthoquartzitic sandstones are thick to thin bedded. Planar cross-bedding and current-ripple marks are found in the medium to thin beds. All the non-orthoquartzitic sandstones exhibit channel cut-and-fill structures characteristic of deposition in a fluvial environment. The orthoquartzites, on the other hand, are massive and thick bedded and may be either fluvial or marginal marine (beach) deposits. The silica cement in the orthoquartzites in the Cloverly Formation was probably deposited from silica-rich ground water. The causes for the deposition of this silica cement in localized areas (as at Cassa) are not known.

As determined from drill cores, the measured section, and other outcrops in the Cassa area, the Cloverly here consists of an upper 15- to 26-foot-thick orthoquartzite; a middle unit of sandstones, claystones, siltstones, and other thin orthoquartzites; and a lower orthoquartzite (see **Figure 5** and **Appendix A**). The upper orthoquartzite averages about 18 feet thick; it is white in core, light yellowish white on freshly broken rocks, and has a thin (0.25 inches or less) dark brownish gray coating on weathered outcrops. A few outcrops are stained light yellow to light orange with iron oxides due to weathering. In the southeast part of the mapped area, a thick orthoquartzite is also present at the base of the Cloverly Formation (**Figure 5,** and drill hole 6, **Appendix A**). The lower orthoquartzite is white in core and white to pinkish white on freshly broken rocks. It is exposed in a railroad cut, but it is not seen as a weathered outcrop.

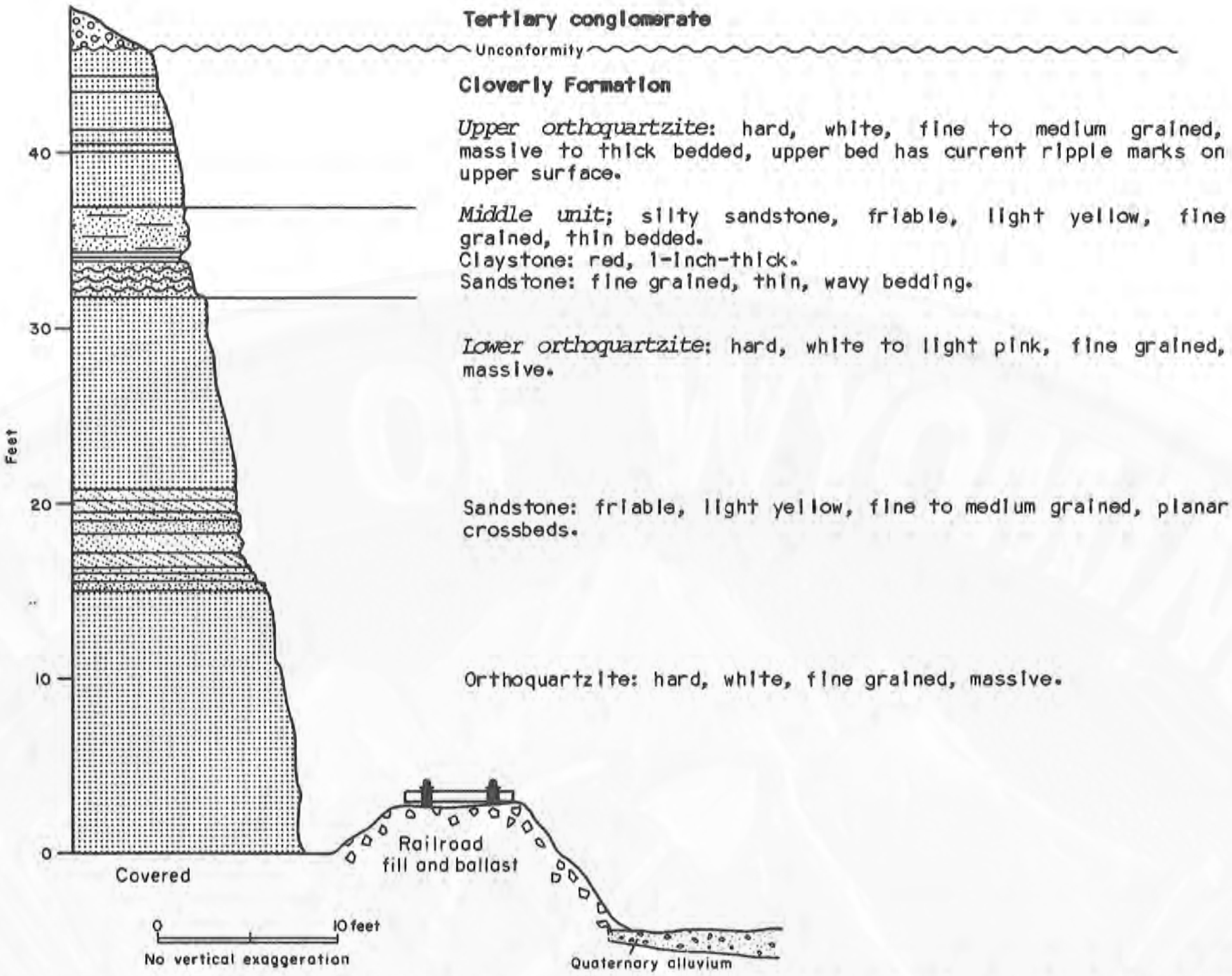


Figure 5. Measured section of Cloverly Formation in railroad cut, SW1/4SW1/4NW1/4NW1/4 sec. 36, T.29N., R.68W.

In the Cassa study area, the upper sandstone and most of the basal sandstone is orthoquartzite. The orthoquartzites in the mapped area (**Figure 2**) constitute the silica resource at Cassa.

In the northern part of the Cassa area, the hard orthoquartzite at the top of the Cloverly Formation forms the caprock of a low mesa. At Glendo Dam, 2 miles north of the study area, the upper sandstone of the Cloverly Formation is a yellow to red, friable quartz-rich sandstone. The quartz cement characteristic of the upper sandstone at Cassa is not present.

In a small canyon cut by North Bear Creek, in NE1/4 sec. 8, T.28N., R.68W., 3 miles southwest of the Cassa area, the upper part of the Cloverly Formation is also a yellow to red, friable sandstone. The top of an orthoquartzite is exposed in North Bear Creek. This orthoquartzite may be equivalent to the lower orthoquartzite at Cassa. Quartzite (orthoquartzite of this report) similar to that at Cassa occurs in the Cloverly Formation at Spanish Diggings, 12 miles north of the Cassa area. In addition, Denson and Botinelly (1949) reported that quartzite locally forms the base of the Cloverly Formation in the Hartville uplift.

An abrupt transition from white orthoquartzite to dark gray shale marks the boundary of the upper Cloverly Formation with the black shale of the overlying Cretaceous Thermopolis Shale (**Figure 6**). This boundary is exposed in the railroad cut in NW1/4SW1/4SW1/4NW1/4 sec. 36 (**Figure 6**). The Thermopolis Shale has been removed by pre-Tertiary erosion from most of the area north of and including N1/4 sec. 35, T.29N., R.68W. The upper orthoquartzite bed of the Cloverly Formation was not removed during this erosional cycle and formed a dip slope on a pre-Tertiary surface. Here, the Cloverly Formation is mostly covered by thin unconsolidated Quaternary and Tertiary sediments.

Thermopolis Shale

The Lower Cretaceous Thermopolis Shale overlies the Cloverly Formation. The formation was first named and described by Lupton (1916) for exposures near the town of Thermopolis, Wyoming. In the Cassa area, the Thermopolis Shale consists of the Muddy Sandstone Member overlying black shale.

The Muddy Sandstone Member of the Thermopolis Shale was first named and described by Hintze (1941) from oil well cuttings and cores in the Basin and Greybull oil and gas fields, Big Horn County, Wyoming. In the Cassa area, the Muddy Sandstone consists of brown to light yellow, medium-grained sandstone. It weathers to a dark brownish gray. The Muddy Sandstone grades downward into light gray shales of the lower black shale. The top of the Muddy Sandstone in the mapped area (**Figure 2**) is usually covered by Quaternary and Tertiary sediments. No younger Cretaceous rocks are present in the mapped area.

The lower black shale is 90 to 150 feet thick in the mapped area (Love and others, 1949). The upper part is well exposed in NW1/4SE1/4NW1/4 sec. 35 (**Figure 2**). In this area, the lower black shale consists of gray to light gray shale with a few 1- to 6-inch thick, brown to brownish orange, ferruginous sandstone beds. Elsewhere in the Cassa area, the lower black shale is poorly exposed since it is nonresistant. It is usually covered by colluvial material composed mostly of blocks of the overlying Muddy Sandstone Member.

Tertiary conglomerate

Deposits of boulder to cobble conglomerate containing some pebbles and sand are found at the surface along the east boundary of sec. 35 and SE1/4SW1/4

Figure 6. Contact of lower black shale of Thermopolis Shale (Kt) with upper orthoquartzite of the Cloverly Formation (Kcv) (5-foot staff for scale).

sec. 25 (**Figure 7**). The conglomerate contains boulders up to 30 inches in diameter. Most of the material is 6 inches in diameter or less. Ninety percent of the coarse material in this conglomerate is either quartzofeldspathic gneiss (45 percent) or amphibolite gneiss (45 percent). Less than 10 percent of the constituents of the conglomerate consists of felsic igneous rocks or bull quartz. Some of the feldspathic material has been epidotized.

The conglomerate is 30 feet thick or less. It is found associated with the graben in the eastern part of the mapped area (**Figure 2**). It was probably deposited in and adjacent to the graben during and immediately after formation of the graben. The probable source materials for this Tertiary conglomerate are the Precambrian rocks exposed in the Laramie Mountains, 18 miles to the east. This conglomerate could be the equivalent of the basal White River Group (Oligocene) conglomerate found in parts of eastern Wyoming (Love and others, 1980). It is overlain by Quaternary and Tertiary sediments.

Undivided Quaternary and Tertiary silt, sand, and gravel

Brownish gray to light gray, silt, sand, and minor gravel is present at the surface over much of the Cassa area. Some of these sediments can be mapped as Quaternary alluvium or colluvium and some can be mapped as the White River Group (Oligocene). All of this material was mapped as White River Group (Oligocene) by Love and others (1949). However, much of it is wind-deposited soil (loess), consisting in part of reworked White River Group, which cannot be distinguished from unreworked White River Group in grass or brush covered areas. Therefore, this material was mapped as undivided Quaternary and Tertiary silt, sand, and gravel (**Figure 2**).

The White River Group was named and described by Meek and Hayden (1857) for exposures along the White River of South Dakota, and given group status by Edwards (1941). Love and others (1949) described the unit as white to pale pink, tuffaceous, bentonitic claystone that is up to 1,800 feet thick. This unit is well exposed in bluffs 0.25 mile west of the mapped area and in the hills in the extreme northeast corner of the map area. The thickness of the White River Group, as mapped by Love and others (1949) in the Glendo area immediately north of the Cassa area, is variable due to the high relief (over 600 feet) on the surface of underlying units, upon which it rests with angular unconformity.

Figure 7. Tertiary conglomerate (foreground and left) above Cloverly Formation (Kcv), Cassa area. Large boulder (left center) is 1 foot in diameter.

The undivided Quaternary and Tertiary unit is from 0 to many feet thick in the Cassa area. In SE1/4 sec. 34 and SW1/4 sec. 35, around Twin Springs (**Figure 2**), the thickness cannot be determined from surface information. In NE1/4NE1/4SE1/4SW1/4 sec. 26 (**Figure 2**), drill hole 4 was collared in this material, but penetrated only 8 feet of it before encountering the Cloverly Formation (**Appendix A**). This material is less than 80 feet thick over the Cloverly Formation in secs. 26, 34, and 35 (**Figures 2** and **3**).

Quaternary alluvial and colluvial deposits

Quaternary alluvium, consisting of gravel, sand, silt, and clay, is found along Horseshoe Creek north of the exposure of the Cloverly Formation and along the North Platte River in sec. 36. The contact of alluvium with undivided Quaternary and Tertiary material in SE1/4 sec. 27 (**Figure 2**) is indistinct.

Quaternary colluvium, which consists mostly of large displaced blocks of sandstone and talus of the Cloverly Formation or Muddy Sandstone Member of the Thermopolis Shale is found below the resistant upper Cloverly and Muddy sandstones and usually covers the lower parts of these units and the underlying strata. Colluvium consisting of blocks of Muddy Sandstone covers all pre-Quaternary units below the Muddy Sandstone east of the North Platte River in sec. 36.

Structure

The Cloverly Formation strikes N30°E and dips southeast at about 4° in most of the mapped area (**Figure 2**). A similar dip and strike is measured on the Muddy Sandstone Member (**Figure 2**).

There are three faults mapped in the area (**Figure 2**). A fault with a strike approximately northwest-southeast and relative movement up to the southwest may be present south of Twin Springs in NW1/4NW1/4SW1/4 sec. 35. It is covered by Tertiary or Quaternary deposits. Its occurrence is inferred from the position of the Cloverly Formation in SE1/4SE1/4 sec. 34 at an elevation of 4,740 feet. There are no strike or dip changes noted in outcrops north of the inferred fault that might indicate a fold. If there were no fault, the Cloverly Formation should here be located at an elevation of 4,620 feet, as projected from dips in NE1/4NE1/4 sec. 34.

Mapping indicates that two subparallel faults bounding a small graben offset the Cloverly Formation in the east-central part of the mapped area (**Figure 2** and cross sections C-C' and D-D', **Figure 3**). The western graben-boundary fault has a maximum displacement of 30 feet, and trends N15°W. It offsets the Cloverly Formation just west of the common corner of secs. 25, 26, 35, and 36 (**Figure 8**), with relative movement up to the west. It may continue southwest of NE1/4SE1/4NE1/4 sec. 35 in the Cloverly Formation. The Muddy Sandstone is not faulted but is flexed into a monoclinal fold over the trend of the fault in the subsurface (cross section C-C', **Figure 3**).

The eastern graben-boundary fault has a displacement of 60 feet with relative movement up to the east. It trends N13°W. It offsets the Cloverly Formation in the SE1/4SW1/4SW1/4 sec. 25 (cross section D-D', **Figure 3**) and is covered by undivided Quaternary and Tertiary material to the north and by Quaternary alluvium and colluvium to the south.

The graben structure is not present in the Cloverly Formation exposed 1.5 miles north of the Cassa area on the North Platte River canyon wall near Glendo Dam. The occurrence of Tertiary conglomerate in the mapped area appears to be related to this structure. Ter-

Figure 8. Dashed line shows the approximate location of a fault displacing upper orthoquartzite of the Cloverly Formation (Kcv), NE1/4NE1/4 sec. 35, T.29N., R.68W., Cassa area. "U" on upthrown side of fault, "D" on downthrown side.

tiary conglomerate is found only within the graben or covering the boundary faults (see the section on Tertiary conglomerate, p. 10). The offset of the orthoquartzite silica rock resource in this area should be considered in mining plans.

Silica rock resource

Two orthoquartzites in the Cloverly Formation in the Cassa area constitute the silica rock resource. The upper orthoquartzite crops out in the Cassa area and was encountered in all six drill holes. The lower orthoquartzite is exposed at the site of the measured section (**Figure 5**) and along the Burlington Northern Railroad cut in sec. 36 (**Figure 2**). It was also encountered in drill hole 6. The lower thin orthoquartzite in drill hole 5 (**Appendix A**) is probably a tongue of this unit (cross section A-A', **Figure 3**). The lower orthoquartzite may extend from the railroad cut to the south, southwest, or west. The orthoquartzite found in the small canyon on north Bear Creek (sec. 8, T.28N., R.68W.), 3 miles southwest of the Cassa exposure, may be stratigraphically equivalent. The lower orthoquartzite may also be present at depth to the east, across the North Platte River. It is not exposed anywhere else in the Cassa area. The maximum extent of the lower orthoquartzite in the mapped area is shown on **Figure 2.**

Orthoquartzites are also found in other parts of the Cloverly Formation (for example, sample 61, drill hole 5, **Appendix B**), but these beds are thin and are not included in the resource calculations. However, these and other sandstones in the area may be suitable for some silica rock uses.

Quality

The upper orthoquartzite (silica rock) averages 98.33 percent SiO_2, based on the analyses for 64 drill core samples from the six holes (**Appendix B**). The lower orthoquartzite (silica rock) from drill holes 5 and 6 averages 96.19 percent SiO_2, based on the analyses for 21 core samples. The analysis of the shale break at 105 feet in drill hole 6 was not included in this calculation.

Many of the analyzed samples from both the orthoquartzites contained 99.0 percent or more SiO_2.

The upper and lower orthoquartzites are fine grained and free from coloring agents such as chromium, managanese, or large amounts of iron (**Appendix B**). They are relatively hard, especially on outcrop, and may require grinding and screening to produce high-silica mill feed.

Quantity

The estimate of the silica rock resource in the upper orthoquartzite is based on the thickness and chemical analyses of the upper orthoquartzite in drill holes 1 through 6 (**Appendix A** and B), the measured section (**Figure 5**), and the areal extent of the deposit measured from the geologic map (**Figure 2**).

The upper orthoquartzite averages 18 feet thick over an area measuring 1.25 miles (6,600 feet) by 0.75 mile (3,960 feet). There are 38,158,560 tons of high-grade (98.33 percent) silica rock in this area. An additional estimated 10,500,000 tons may be present beneath overlying units in SE1/4 sec. 35. Additional resources may be present at depth east, southeast, south, or southwest of the Cassa area.

An estimate of the quantity of the silica rock resource in the lower orthoquartzite is highly speculative since subsurface information about this unit to the south and west of the area of exposure is lacking. The maximum extent at shallow depth is an area 1 mile square. The lower orthoquartzite is 40 feet thick in drill hole 6, about 40 feet thick in the railroad cut exposure, and 15 feet thick in drill hole 5. Assuming an average thickness of 33 feet, there may be a silica rock resource of at least 34,073,600 tons in the lower orthoquartzite. Additional resources may be present in this unit at depth to the east, southeast, south, or southwest. The exposure of a lower orthoquartzite (silica rock) along North Bear Creek, 3 miles southwest, suggests that a considerable silica rock resource may be present southwest of the Cassa area at depth.

Uses of silica rock and silica sand

Silica rock or silica sand, processed to a grade of 95 percent or greater SiO_2, is the primary ingredient in the manufacture of glass and related products (fiberglass, synthetic quartz crystals, etc.). There are many varieties of glass with various uses. Glass classifications are shown in **Table 1.** High-quality glass such as optical glass, fiber optical glass, and silica used to grow quartz crystals requires the purest silica raw material. Colored glass (brown container glass, etc.) can be produced from a lower grade raw material. **Table 2** provides a list of specifications for some of the glass products listed in **Table 1.**

Other kinds of glass are being used to isolate radioactive waste (Harker and Flintoff, 1984; Ondracer and Toscano, 1984). For this kind of glass, color is not important. There are currently no exact specifications developed for this purpose since new types of glass are continually being tested. Currently, the preferred glass is a borosilicate type similar to the high-durability fiberglasses shown in **Table 2.** This use may increase in the future as technology for the isolation and storage of high-level radioactive waste develops.

Industrial sand is a classification of sand based on both physical and chem-

Table 1. Classification of glass products (after Bentzen, 1979).

Flat glass	**Other specialty glasses**
Sheet	Tableware
Float (most flat glass production)	Lead crystal
Rolled (seldom used now)	Fused silica
	Heat resistant (borosilicate) glass
Glass containers	Light bulbs (high-sodium)
Colorless	Tubing
Colored	Electronics
	Scientific and laboratory glassware
Glass fibers	Optical glass
Reinforcement filaments	Bullet-proof glass
Insulation	Other specialty glasses
Optical fibers (fiber optics)	
Fused silica fibers	

ical properties. Silica sand is classified as a type of industrial sand (U.S. Bureau of Mines, 1986). The silica rock from the Cassa deposit may be crushed and screened to produce silica sand for some industrial uses. These include foundry sand, ore of silicon metal, metallurgical flux, abrasives, and hydraulic-fracturing sand (**Table 3**). The highest priced industrial sands are used as fillers in ceramics and for hydraulic fracturing (Tepordei, 1987).

Domestic silica production

Silica sand, silica rock, or high silica industrial sand is produced in thirty-one states (**Appendix C**). Most of this production is near the industrial areas of the Midwest, Middle Atlantic states, or West Coast. The largest producer in the United States is U.S. Silica, owned by the British firm RTZ. The next largest, Unimin, is also partly foreign owned (Harben, 1987). Most domestic silica production is from quartz-rich sandstone.

The Cassa deposit is located in an area far from current silica rock or silica sand production. The nearest production is from the Dakota Group west of Pueblo, Colorado (**Appendix C**). The sand is produced by Colorado Silica Sand, Inc., for Coors, Incorporated, to make brown bottle glass at the Coors plant in Golden, Colorado. The Cassa deposit, in the Cloverly Formation, may be stratigraphically equivalent to the producing deposit in the Dakota Formation in Colorado.

A glass plant or silica rock processing plant near Cassa could supply markets in the Rocky Mountain and Great Plains states, which now require more distant shipments of finished products. The very high-grade silica rock in this deposit may also be competitive with most other domestic silica rock or silica sand sources and favor a plant that sells products throughout the United States or in world markets.

Table 2. Approximate compositions of selected glass, (weight percent) (after McLellan and Shand, 1984).

Glass designation	Use	Oxide constituents, in weight percent											
		SiO_2	Al_2O_3	B_2O_3	Na_2O	K_2O	CaO	MgO	TiO_2	ZnO	BaO	PbO	Others
Fiberglass	Low alkali lime-alumina borosilicate	55.0	14.5	7.0	0.5		21.8	0.5	0.5				0.2 Fluorine
	Soda-lime borosilicate	65.0	4.0	5.5	8.0	0.5	14.0	3.0					
	Soft soda-lime borosilicate	61.0	4.0	7.0	14.5	1.0	9.0	3.5					
	High durability lime-free soda borosilicate I	59.5	5.0	8.0	15.0				8.0				0.5 Fluorine 4.0 ZrO_2
	High durability lime-free soda	58.5	6.0	10.5	10.5	3.0	2.0			4.0	5.0		0.5 Fluorine
	High-magnesia	64.5	24.5		0.5			10.5					
Lime glasses	Light bulbs	73	1		17		5	4					
	Tempered ovenware	75	1.5		14		9.5						
	Ophthalmic lenses	68	2		8	9.5	8.5		0.5	3.5			
	Containers	66-75	0.7-7[1]		12-16	0.1-3	6-12	0.1-5			0-0.5		
	Float	73-74	0.2-0.3		13.5-15	0.2	8.7-8.9	3.6-3.8					0.07-0.13 Fe_2O_3 0.2-0.3 SO_3
	Sheet	71-73	0.5-1.5		12-15		8-10	1.5-3.5					
Barium glasses	Color TV panels	65	2		7	9	2	1			2	2	10 SrO, F^-
	Ophthalmic biofocal segments	50.5		4	11.5		5		2.5	7.5	16		3 ZrO_2
	Optical dense barium crowns	36	4	10						9	41		
Lead glasses	Neon tubing	63	1		8	6						22	
	Electronic parts	56	2		4	9						29	
	Color TV funnels	54	2		6	8	3	2				23	
	Ophthalmic biofocal segments	35	2			7.5			3.5			51	1 ZrO_2
	Optical dense flints	32			1	2						65	
	Solder sealing	3	11	12								74	
Borosilicate glasses	Chemical apparatus	81	2	13	4								
	Tungsten sealing	74	1	15	4							6	
	Kovar sealing	64	8	19	2	3					3		1 Li_2O, F^-
	Pharmaceuticals	72	6	11	7	1	1				2		
	Optical boro-silicate brown	69.5		11.5	9	7					3		
Aluminosilicate glasses	Combustion tubes	62	17	5	1		8	7					
	Resistor substrates	57	16	4			10	7			6		
	Fiberglass	64.5	24.5		0.5			10.5					

[1] Most container glasses have less than 2.3 percent Al_2O_3.

Table 3. Industrial uses of silica rock or silica sand in 1985 (after Tepordei, 1987).

End use	Quantity (short tons)	Percent of total
Glass	10,293,000	43.6
Foundry	5,143,000	21.8
Hydraulic fracturing	2,102,000	8.9
Abrasives	1,681,000	7.1
Roofing granules	403,000	1.7
Chemicals	378,000	1.6
Filtration	345,000	1.5
Traction	292,000	1.2
Metallurgical	188,000	0.8
Fillers	158,000	0.7
Ceramics	150,000	0.6
Coal washing	18,000	0.1
Other	2,446,000	10.4
Total	23,597,000	100.0

Other economic factors

The nearby location of other materials used in the manufacture of glass and convenient transportation routes enhance the suitability of the Cassa silica rock deposit for development. Large quantities of soda ash are used in glass production. Ninety-five percent of all domestic soda ash production is located 300 miles west of the Cassa deposit near Green River, Wyoming. Over half of this soda ash is used in the manufacture of glass (Kostick, 1988). Shipment of soda ash to the Cassa area may be available via the Burlington Northern Railroad/ Bonneville Transloaders, Inc., trucks, or a combination of rail/truck transportation using the Union Pacific Railroad (**Figure 1**).

Limestone and feldspar are other ingredients used in the manufacture of glass. There are deposits of both limestone and feldspar nearby. High-purity deposits of limestone are found less than 10 miles north, west, and east of the Cassa deposit (Harris and Meyer, 1986). Feldspar occurrences are found in the Laramie Mountains 30 miles west of the Cassa deposit (Harris and others, 1985), and a deposit of feldspar is located at Twin Buttes, 65 miles southwest of the Cassa deposit (Hausel, 1981) (**Figure 1**). Before 1982, feldspar was also produced from a deposit on Casper Mountain, 90 miles west of the Cassa deposit (**Figure 1**).

The Cassa deposit is adjacent to the Burlington Northern Railroad. The Cassa siding is 1 mile south of the deposit and construction of a siding at the deposit site may be feasible. Wyoming Highway 319, a paved two-lane road, adjoins the deposit on the southwest. The nearest access to Interstate Highway 25, which parallels Highway 319, is at Glendo, 5 miles north of the deposit. Interstate 25 passes within 2 miles of the deposit. The closeness of the Cassa silica rock deposit to paved all-weather roads and to rail transportation (**Figure 1**) decreases transportation costs of both raw materials and finished products. East Coast, Gulf Coast, Pacific Coast, and Midwestern markets as well as export terminals may be reached by rail shipment (**Figure 1**).

Land, water, and power resources necessary for the construction and operation of a glass plant are available in the immediate area. Industrial sites may be available at the site of the deposit or at the nearby towns of Glendo (4 miles from the deposit), Guernsey (20 miles), Wheatland (30 miles), and Douglas (35 miles) (**Figure 1**). The larger cities of Casper and Cheyenne are each about 90 miles from the deposit (**Figure 1**). The deposit is adjacent to the North Platte River and Horseshoe Creek, a perennial stream. Twin Springs in NW1/4NW1/4SW1/4 sec. 35 (**Figure 2**) supplies water for livestock all year, but may not flow enough to supply a glass plant. Several major power lines cross the deposit. These originate at a hydroelectric generating station at Glendo Dam, 1.5 miles to the north.

Summary

This report is based on surface geologic studies and 642 feet of drilling. Additional tests must be done to refine the resource estimates presented here. Close-spaced drilling is particularly necessary to delimit the lower orthoquartzite and determine its extent to the southwest. Additional studies are needed to determine marketability, mining costs, and processing techniques.

This study indicates that large amounts of a very high-grade silica rock are present in the area. Over 38 million tons of silica rock averaging 98.33 percent SiO_2 are found in the upper orthoquartzite of the Cretaceous Cloverly Formation. Because this unit is present at or near the surface, there is little overburden to remove in the mining process.

An additional 34 million tons or more of silica rock, averaging 96.19 percent percent SiO_2, may be present in the Cloverly Formation in part of the area. This additional resource is located beneath the upper silica rock, and the removal of the upper silica rock and other overburden will be necessary for production from the lower silica rock. A very large resource may be present at depth from the Cassa area to the southwest in the lower silica rock.

The silica rock in the Cassa deposit may be processed to meet specifications for glass sand. It may also be processed to meet specifications for other types of industrial sand.

The presence of nearby resources of soda ash, limestone, and feldspar enhance the economic factors favoring the local production of glass. The nearness of water, power, and transportation routes decrease the cost of producing and marketing glass made from silica rock from the Cassa deposit. Glass from the silica rock in this deposit may be produced locally for sale to markets in the United States or worldwide.

References

Bates, R.L., and Jackson, J.A., editors, 1987, Glossary of geology, third edition: American Geological Institute, Alexandria, Virginia, 788 p.

Bentzen, E.H. III, 1979, Production and processing problems of western glass sands: Colorado Geological Survey Resource Series 8, p. 63-74.

Darton, N.H., 1904, Comparison of the stratigraphy of the Black Hills, Bighorn Mountains, and Rocky Mountain Front Range: Geological Society of America Bulletin v. 15, p. 379-448.

Denson, N.M., and Botinelly, Theodore, 1949, Geology of the Hartville uplift, eastern Wyoming: U.S. Geological Survey Oil and Gas Investigations Preliminary Map 102, scale 1:48,000.

Dickson, Ted, 1984, North American silica sand: Industrial Minerals, no. 197, p. 39-45.

Edwards, A.R., 1941, Underground water resources of Chugwater Creek, Laramie River, and North Laramie River valleys, Wyoming: Geological Survey of Wyoming Bulletin 32, 32 p.

Emmons, S.E., Cross, Whitman, and Eldridge, G.H., 1896, Geology of the Denver Basin in Colorado: U.S. Geological Survey Monograph 27, 556 p.

Engineering and Mining Journal, 1987, International directory of mining and mineral processing operations 1987-1988: Engineering and Mining Journal, New York, 623 p.

Goldman, H.B., and Reining, Don, 1983, Sand and gravel, *in* Lefond, S.J., editor, Industrial minerals and rocks, 5th edition: American Institute of Mining, Metallurgical, and Petroleum Engineers, Baltimore, Maryland, p. 1151-1166.

Harben, Peter, 1987, U.S. industrial minerals - survival of the fittest: Mining Magazine, v. 156, no. 11, p. 437.

Harker, A.B., and Flintoff, J.F., 1984, Polyphase ceramic and glass-ceramic forms for immobilizing ICCP high-level nuclear waste, *in* McVay, G.L., editor, Scientific basis for nuclear waste management VII: Elsevier, New York, p. 513-520.

Harris, R.E., 1988, The Plumbago Creek silica sand deposit, Albany County, Wyoming: Geological Survey of Wyoming Report of Investigations 40, 30 p.

Harris, R.E., and Meyer, J.E., 1986, Construction materials map of Wyoming: Geological Survey of Wyoming Map Series 21, scale 1:500,000.

Harris, R.E., Hausel, W.D., and Meyer, J.E., 1985, Metallic and industrial minerals map of Wyoming: Geological Survey of Wyoming Map Series 14, scale 1:500,000.

Hausel, W.D., 1981, Updated report on the Twin Buttes feldspar-limestone-flagstone property, Albany County, Wyoming: Geological Survey of Wyoming Mineral Report 81-1 (unpublished), 5 p.

Hintze, F.F. Jr., 1941, The Basin and Greybull oil and gas fields: Geological Survey of Wyoming Bulletin 10, 62 p.

Kostick, D.S., 1988, Sodium carbonate (soda ash): U.S. Bureau of Mines Mineral Commodity Summaries 1988, p. 146-147.

Love, J.D., Denson, N.M., and Botinelly, Theodore, 1949, Geology of the Glendo area, Wyoming: U.S. Geological Survey Oil and Gas Investigations Preliminary Map 92, 2 sheets, scale 1:48,000.

Love, J.D., Christiansen, A.C., and Sever, C.K., 1980, Geologic map of the Torrington 1°x2° Quadrangle, southeastern Wyoming and western Nebraska: U.S. Geological Survey Miscellaneous Field Studies Map MF 1184, scale 1:250,000.

Lupton, C.T., 1916, Oil and gas near Basin, Big Horn County, Wyoming: U.S. Geological Survey Bulletin 621-L, p. 168.

McGookey, D.P., Haun, J.D., Hale, L.A., Goodell, H.G., McCubbin, D.G., Weimer, R.J., and Wulf, G.R., 1972, Cretaceous System, *in* Geologic atlas of the Rocky Mountain Region: Rocky Mountain Association of Geologists, Denver, Colorado, p. 190-228.

McLellan, G.W., and Shand, E.B., 1984, Glass engineering handbook: McGraw Hill, p. 1-10 and 20-24.

Meek, F.B., and Hayden, F.V., 1857, Descriptions of new species and genera of fossils collected by Dr. F.V. Hayden in Nebraska Territory; with some remarks on the Tertiary and Cretaceous formations of the Northwest: Philadelphia Academy of Natural Science Proceedings, v. 9, p. 117-148.

Ondracer, G., and Toscano, E.H., 1984, In-can hot pressing of borosilicate glass for the immobilization of high- and medium-level wastes, *in* McVay, G.L., editor, Scientific basis for nuclear waste management VII: Elsevier, New York, p. 591-596.

Pettijohn, F.J., 1949, Sedimentary rocks: Harper and Brothers, New York, 526 p.

Tepordei, V.V., 1987, Sand and gravel: U.S. Bureau of Mines Minerals Yearbook 1985, v. 1, Metals and Minerals, p. 821-835.

United States Bureau of Mines, 1986, Directory of industrial sand and gravel producers in the United States in 1985: Division of Industrial Minerals, U.S. Bureau of Mines Annual Advance Summary Supplement, 7 p.

Appendices

A. Lithologies in drill holes.

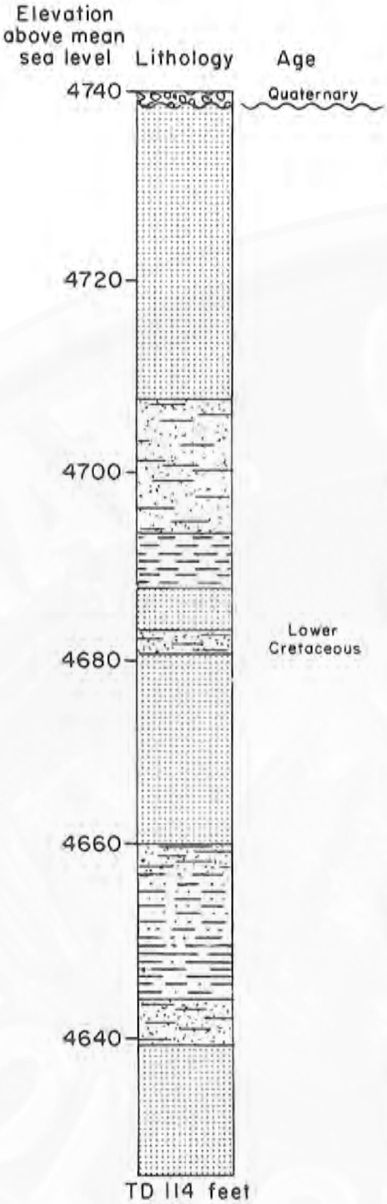
B. Whole-rock chemical analyses of cores.

C. Silica sand, silica rock, and other silica production in the United States.

Appendix A

EXPLANATION OF LITHOLOGIC SYMBOLS USED IN APPENDIX A(1-6)

A1. Lithologies in drill hole 1.



DESCRIPTION

Colluvium: composed of loose material derived from the underlying Cloverly Formation.

Cloverly Formation

Orthoquartzite: white, massive to thick bedded, fine grained.

Silty sandstone: light yellowish white, thin bedded, mostly quartz grains.

Claystone: dark reddish brown, greenish gray, and yellowish gray.

Orthoquartzite: white to very light gray, massive.

Silty sandstone: light yellowish white, thin bedded.

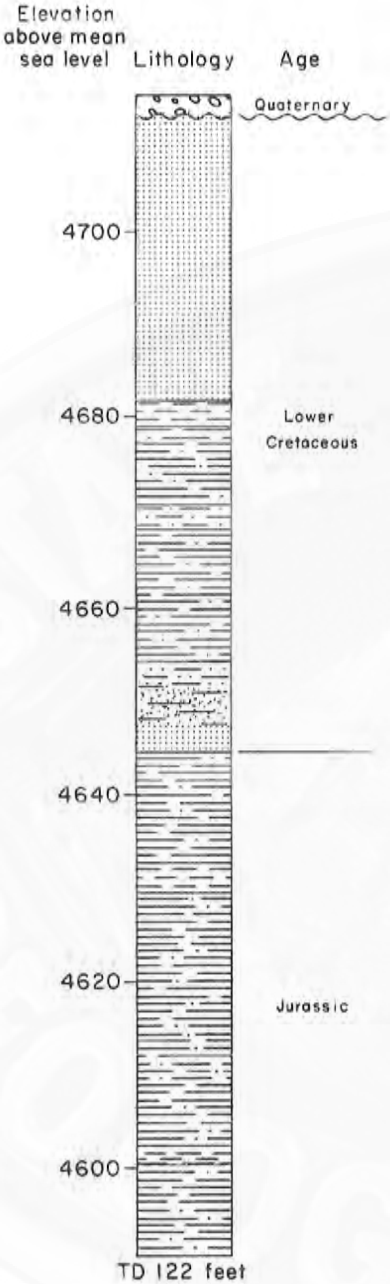
Orthoquartzite: white, massive to thick bedded, fine grained.

Silty sandstone: light yellowish white, thin bedded, grades downward into yellowish white sandy siltstone, which grades into light greenish gray silty claystone.

Silty sandstone: light yellowish white, thin bedded.

Orthoquartzite: white to light yellowish white, thick bedded, fine grained.

A2. Lithologies in drill hole 2.



DESCRIPTION

Colluvium: composed of loose material derived from the underlying Cloverly Formation.

Cloverly Formation

Orthoquartzite: white, massive to thick bedded, fine grained.

Claystone: dark reddish brown.

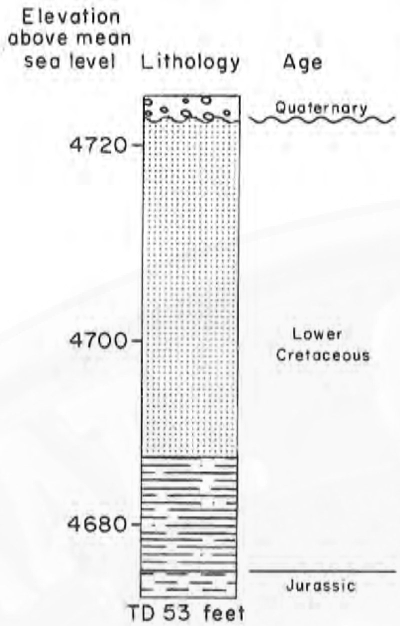
Silty claystone: dark reddish brown, greenish gray, or light yellowish gray, with an interbed of light yellowish gray siltstone.

Fining upward sequence: light yellowish white, fine-grained orthoquartzite at base, grades upward to light yellowish gray silty sandstone, grades upward into light yellowish gray sandy siltstone, grades upward into overlying silty claystone.

Morrison Formation

Silty claystone: light greenish gray, light gray, and dark reddish brown, with a few interbeds of light greenish gray or dark reddish brown claystone.

A3. Lithologies in drill hole 3.



DESCRIPTION

Colluvium: loose material derived from the underlying Cloverly Formation.

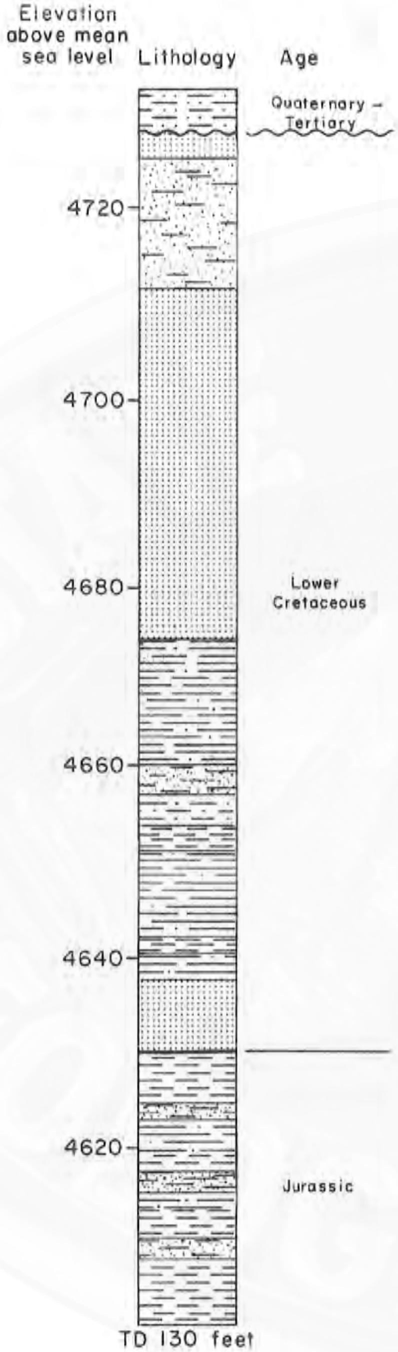
Cloverly Formation

Orthoquartzite: white, massive, fine grained.

Silty claystone: light yellowish gray, with a few dark reddish brown, pink, and greenish gray silty claystone beds.

Morrison Formation: light greenish gray claystone.

A4. Lithologies in drill hole 4.



DESCRIPTION

Undivided: sandy silt, light brown, no bedding or structures noted.

Cloverly Formation

Orthoquartzite: white, massive, fine grained, with 14 feet of light yellow, thin-bedded, silty sandstone near the top.

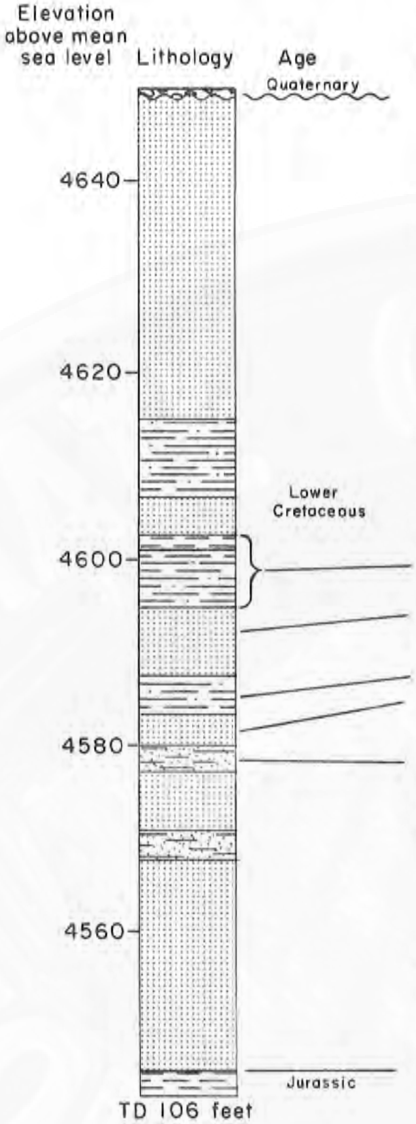
Silty claystone: dark reddish brown, light green, dark gray, and yellowish gray with beds of light yellow silty sandstone and dark reddish brown claystone.

Orthoquartzite: white, massive to thick bedded, fine grained.

Morrison Formation

Claystone: dark reddish brown, yellowish gray, and light green, with interbeds of yellowish gray to orangish gray silty claystone and fine-grained silty sandstone.

A5. Lithologies in drill hole 5.



DESCRIPTION

Colluvium: composed of loose material derived from the underlying Cloverly Formation.

Cloverly Formation

Orthoquartzite: white, massive to thick bedded, fine grained.

Silty claystone: yellowish gray to light greenish gray.

Orthoquartzite: white, thin to medium bedded, fine grained.

Silty claystone: Yellowish gray to light greenish gray with a thin dark reddish brown claystone at the top.

Orthoquarzite: white to light yellowish white, thin to medium bedded, fine grained.

Silty claystone: yellowish gray to orange gray.

Orthoquartzite: white to light yellowish white, thin to medium bedded, fine grained.

Silty sandstone: light yellowish gray, thin bedded, fine grained.

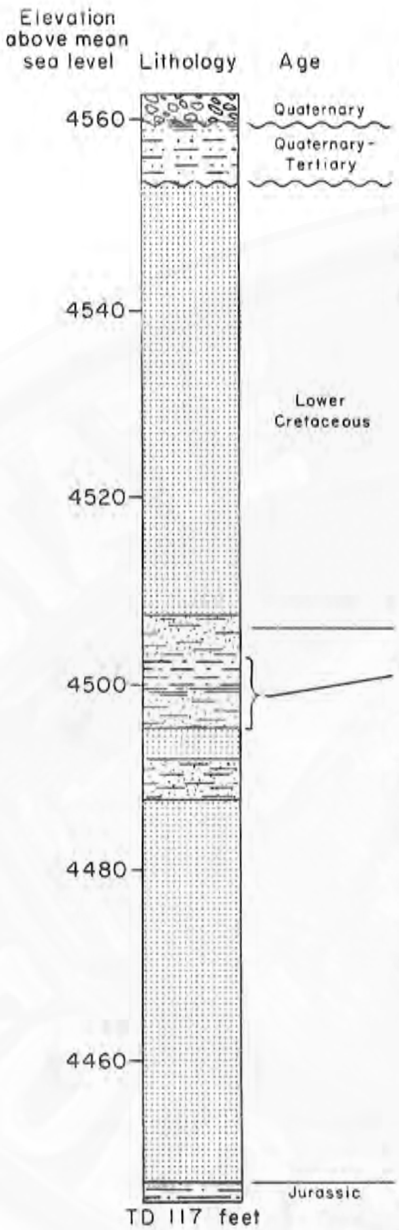
Orthoquartzite: white to light yellowish white, thin to medium bedded, fine grained.

Silty sandstone: light yellowish gray, thin bedded, fine grained.

Orthoquartzite: white to light yellowish white, thick bedded to massive, fine grained.

Morrison Formation: greenish gray claystone.

A6. Lithologies in drill hole 6.



DESCRIPTION

Colluvium: loose material derived from the overlying Muddy Sandstone.

Undivided: sandy silt, light brown, no bedding apparent.

Cloverly Formation

Orthoquartzite: white, massive to thick bedded, fine grained.

Silty sandstone: light yellow, thin bedded, fine grained.

Fining upward channel sequence: light yellow, silty sandstone at base, grading upward into light yellow siltstone, to yellowish gray silty claystone.

Orthoquartzite: white, thick bedded, fine grained.

Silty sandstone: light yellow, thin bedded, fine grained.

Orthoquartzite: white to light yellow, thick bedded to massive, fine grained.

Morrison Formation: silty claystone, light green.

Appendix B

B1. Whole-rock chemical analyses of core from drill hole 1, Cassa silica rock deposit (values in weight percent).

Sample number[1]	Al_2O_3	CaO	Fe_2O_3	K_2O	LOI[2]	MgO	MnO	Na_2O	P_2O_5	SiO_2	TiO_2	Total
9	1.38	0.04	0.12	<0.03	0.70	0.05	<0.01	0.04	<0.03	99.00[3]	0.06	101.46
12	0.92	0.04	0.56	<0.03	0.30	0.05	<0.01	0.04	0.11	99.00[3]	0.05	101.11
15	0.96	0.04	0.38	<0.03	0.60	0.06	<0.01	0.03	0.07	99.00[3]	0.06	101.24
18	0.52	0.04	0.11	0.26	0.60	0.03	<0.01	0.07	0.06	99.00[3]	0.03	100.73
21	1.18	0.03	0.12	0.32	0.50	0.05	<0.01	0.04	<0.03	99.00[3]	0.06	101.34
23	0.32	0.03	0.07	0.26	0.20	0.03	<0.01	0.06	<0.03	99.00[3]	0.03	100.04
25	0.34	0.03	0.07	0.26	0.10	0.03	<0.01	0.07	0.04	99.00[3]	0.02	99.97
27	0.81	0.05	0.19	0.26	0.30	0.06	<0.01	0.04	0.03	97.27[3]	0.04	99.06
30	0.53	0.04	0.10	0.26	0.10	0.04	<0.01	0.06	<0.03	99.00[3]	0.03	100.20
33	2.86	0.07	2.24	0.43	1.00	0.10	0.02	0.11	0.07	95.00[3]	0.14	102.04
39	9.35	0.48	1.83	1.69	5.40	1.32	<0.01	0.15	0.12	81.13	0.37	101.85
42	8.83	0.48	8.83	1.42	5.40	1.10	<0.01	0.10	0.24	75.63	0.33	102.37
45	10.61	0.62	11.24	1.36	6.20	1.19	0.13	0.12	0.18	70.20	0.42	102.27
47	11.92	0.68	2.13	1.66	6.60	1.26	<0.01	0.13	0.18	75.76	0.44	100.77
48	11.74	0.65	2.19	1.62	6.60	1.21	<0.01	0.17	0.18	76.24	0.41	101.02
51	6.83	0.25	1.68	0.80	3.50	0.53	<0.01	0.07	0.04	87.96	0.28	101.95
54	4.22	0.15	0.82	0.49	2.10	0.29	<0.01	0.07	0.17	93.01	0.19	101.52
57	5.11	0.17	3.98	0.59	3.00	0.33	<0.01	0.06	0.24	88.08	0.23	101.80
60	4.41	0.09	0.67	0.49	1.80	0.15	<0.01	0.06	0.11	93.63	0.12	101.54
63	3.99	0.12	0.72	0.48	2.60	0.23	<0.01	0.06	0.17	94.00	0.18	102.56
66	5.66	0.14	0.78	0.45	2.70	0.27	<0.01	0.05	0.11	91.95	0.20	102.32
69	3.57	0.11	0.71	0.46	2.10	0.21	<0.01	0.05	0.11	95.12	0.17	102.62
72	6.31	0.09	1.02	0.34	0.90	0.15	<0.01	0.05	0.14	92.89	0.13	102.03
75	1.79	0.06	0.26	0.44	1.80	0.09	<0.01	0.05	0.15	98.00	0.10	102.75
78	4.19	0.10	0.51	0.57	2.00	0.20	<0.01	0.06	0.14	94.39	0.19	102.36
81	4.05	0.22	1.57	0.26	4.40	0.19	0.03	0.04	0.15	90.60	0.15	101.66
90	11.28	0.15	3.25	1.03	4.40	0.63	<0.01	0.06	0.08	79.92	0.48	101.29
93	18.70	0.31	5.64	2.29	2.80	1.49	0.02	0.09	0.12	68.75	0.73	100.94
98	6.25	0.12	2.49	0.87	3.20	0.56	<0.01	0.04	<0.03	88.78	0.37	102.72
99	8.08	0.13	3.04	1.02	0.80	0.48	0.01	0.06	0.20	87.99	0.36	102.17
102	2.39	0.05	0.39	0.54	0.80	0.11	<0.01	0.04	0.09	98.00	0.14	102.56
105	2.22	0.05	0.30	0.65	0.70	0.14	<0.01	0.03	0.07	98.00	0.23	102.40
108	1.63	0.04	0.40	0.48	0.60	0.13	<0.01	0.04	<0.03	99.00	0.11	102.47
112	1.57	0.05	0.26	0.43	2.00	0.12	<0.01	0.04	0.04	97.39	0.06	101.97
114	4.12	0.11	1.27	0.72	0.30	0.55	<0.01	0.04	0.18	94.82	0.24	102.36

[1] Sample number is also the depth from the surface. See Appendix A1 for lithology and stratigraphic location of each sample.

[2] Loss on ignition.

[3] Analysis used in resource calculations for the upper orthoquartzite.

B2. Whole-rock chemical analyses of core from drill hole 2, Cassa silica rock deposit (values in weight percent).

Sample number[1]	Al_2O_3	CaO	Fe_2O_3	K_2O	LOI[2]	MgO	MnO	Na_2O	P_2O_5	SiO_2	TiO_2	Total
11	0.69	0.02	0.08	0.16	0.40	0.03	<0.01	0.04	0.10	99.00[3]	0.06	100.59
14	1.30	0.03	0.15	0.16	0.50	0.06	<0.01	0.04	0.08	99.00[3]	0.07	101.40
17	1.79	0.04	0.09	0.16	0.60	0.05	<0.01	0.03	0.12	99.00[3]	0.06	101.95
20	2.70	0.03	0.12	<0.03	1.20	0.07	<0.01	0.04	0.07	98.00[3]	0.07	102.34
23	1.33	0.03	0.21	<0.03	0.20	0.04	<0.01	0.04	0.10	99.00[3]	0.06	101.05
26	2.62	0.04	0.15	<0.03	0.90	0.07	<0.01	0.03	0.03	97.12[3]	0.12	101.12
29	2.67	0.04	0.13	<0.03	1.20	0.07	<0.01	0.02	0.18	97.30[3]	0.13	101.78
32	4.72	0.07	3.03	0.11	2.00	0.13	<0.01	0.04	0.15	91.46	0.44	102.16
35	12.52	0.48	1.80	1.01	6.10	0.83	0.04	0.06	0.15	77.87	0.68	101.54
38	9.72	0.38	1.25	0.59	5.30	0.60	<0.01	0.08	0.16	83.69	0.52	102.30
41	8.87	0.28	0.94	0.48	4.30	0.45	<0.01	0.05	0.19	86.03	0.40	102.00
44	13.29	0.52	2.65	2.44	7.10	1.68	0.01	0.08	0.23	73.32	0.56	101.88
47	10.66	0.61	2.38	1.56	6.40	1.34	<0.01	0.07	0.17	78.55	0.40	102.15
50	7.26	0.45	1.25	0.62	4.90	0.71	<0.01	0.07	0.06	83.05	0.30	98.68
53	8.36	0.53	1.41	0.44	5.20	0.75	<0.01	0.07	0.18	85.03	0.33	102.31
56	5.71	0.24	13.65	0.31	4.50	0.47	0.05	0.06	0.23	76.94	0.25	102.41
59	4.39	0.17	0.55	0.51	2.20	0.24	<0.01	0.10	0.41	89.65	0.21	98.44
62	5.23	0.19	1.03	0.41	2.70	0.33	<0.01	0.09	0.17	91.82	0.26	102.24
65	4.30	0.13	3.40	0.17	2.40	0.26	0.03	0.06	0.14	90.32	0.20	101.41
68	2.75	0.10	1.01	0.19	1.50	0.19	<0.01	0.07	0.14	95.50	0.11	101.57
71	4.55	0.16	4.76	0.51	2.70	0.37	0.01	0.08	0.14	88.33	0.20	101.81
77	6.70	0.18	0.68	0.23	2.80	0.31	<0.01	0.07	0.10	89.16	0.27	100.51
80	3.93	0.12	0.28	0.70	1.50	0.11	<0.01	0.05	0.38	92.21	0.15	99.44
82	5.26	0.08	0.31	0.14	2.30	0.13	<0.01	0.07	0.13	93.58	0.10	102.11
83	12.57	0.23	4.45	1.94	5.50	0.96	0.01	0.17	0.21	75.12	0.51	101.67
89	9.97	0.20	2.28	2.19	4.00	0.87	<0.01	0.11	0.20	78.74	0.43	99.00
104	6.02	0.14	1.34	1.10	2.50	0.53	<0.01	0.08	0.14	89.93	0.43	102.22
110	5.59	0.14	1.89	1.05	2.70	0.59	<0.01	0.09	0.12	85.96	0.51	98.65
116	10.84	0.23	1.35	0.91	4.60	0.62	<0.01	0.10	0.16	82.31	0.58	101.71
119	6.69	0.13	2.38	0.36	3.00	0.31	0.01	0.05	0.09	88.46	0.44	101.92
122	2.48	1.51	0.39	0.14	1.70	0.12	<0.01	0.05	0.04	91.39	0.17	98.00

1 Sample number is also the depth from the surface. See Appendix A1 for lithology and stratigraphic location of each sample.

2 Loss on ignition.

3 Analysis used in resource calculations for the upper orthoquartzite.

B3. Whole-rock chemical analyses of core from drill hole 3, Cassa silica rock deposit (values in weight percent).

Sample number[1]	Al_2O_3	CaO	Fe_2O_3	K_2O	LOI[2]	MgO	MnO	Na_2O	P_2O_5	SiO_2	TiO_2	Total
8	0.31	0.03	0.28	<0.03	0.30	0.03	<0.01	0.05	0.11	99.00[3]	0.03	100.18
11	0.27	0.04	0.06	<0.03	0.50	0.02	<0.01	0.07	<0.03	98.37[3]	0.02	99.42
14	0.29	0.03	0.24	<0.03	0.20	0.02	<0.01	0.06	0.05	99.00[3]	0.03	99.96
17	1.13	0.02	0.14	0.11	0.60	0.02	<0.01	0.04	0.09	99.98[3]	0.06	102.20
20	1.14	0.02	0.08	0.34	0.70	0.02	<0.01	0.03	0.07	99.00[3]	0.05	101.46
23	1.34	0.02	0.08	0.60	0.60	0.02	<0.01	0.03	0.05	96.28[3]	0.05	99.08
26	3.31	0.03	0.19	0.63	1.20	0.05	<0.01	0.05	0.09	96.15[3]	0.11	101.82
29	1.90	0.02	0.18	0.33	0.90	0.04	<0.01	0.04	0.15	96.03[3]	0.07	99.67
32	1.85	0.02	0.11	0.63	1.00	0.03	<0.01	0.03	0.11	98.43[3]	0.06	102.28
35	3.47	0.05	0.34	0.45	1.40	0.06	<0.01	0.04	0.04	96.60[3]	0.17	102.63
38	3.46	0.04	0.88	0.77	1.10	0.07	<0.01	0.06	0.16	92.74	0.28	99.57
41	27.37	0.31	1.77	1.44	11.20	0.75	<0.01	0.07	0.32	56.35	0.72	100.31
44	20.03	0.49	2.34	1.87	9.50	1.37	0.13	0.08	0.20	65.14	0.53	101.68
47	12.94	0.60	2.76	2.75	7.90	1.84	0.02	0.09	0.19	71.21	0.47	100.77
50	11.61	0.59	2.66	1.87	7.40	1.55	<0.01	0.11	0.04	76.17	0.43	102.44
53	9.92	0.57	1.98	1.23	5.50	1.03	<0.01	0.10	0.43	76.65	0.41	97.83

[1] Sample number is also the depth from the surface. See Appendix A1 for lithology and stratigraphic location of each sample.

[2] Loss on ignition.

[3] Analysis used in resource calculations for the upper orthoquartzite.

B4. Whole-rock chemical analyses of core from drill hole 4, Cassa silica rock deposit (values in weight percent).

Sample number[1]	Al_2O_3	CaO	Fe_2O_3	K_2O	LOI[2]	MgO	MnO	Na_2O	P_2O_5	SiO_2	TiO_2	Total
4	1.11	0.04	0.34	0.13	0.90	0.09	<0.01	0.02	<0.03	96.40	0.07	99.14
7	0.44	0.03	0.08	0.36	0.40	0.03	<0.01	0.06	0.08	99.00	0.02	100.51
10	8.10	0.11	1.05	1.74	2.60	0.37	<0.01	0.12	<0.03	83.89	0.96	98.98
13	9.39	0.11	0.69	1.91	2.80	0.41	<0.01	0.10	0.06	82.49	1.07	99.04
16	7.07	0.34	0.76	1.19	2.30	0.28	<0.01	0.08	0.16	86.67	0.87	99.73
19	10.85	0.11	2.19	1.59	0.40	0.45	<0.01	0.12	<0.03	82.06	0.97	98.78
21	0.46	0.02	0.07	0.29	0.20	0.02	<0.01	0.03	<0.03	99.00[3]	0.04	100.17
23	0.40	0.04	0.07	0.29	0.30	0.03	<0.01	0.04	0.08	99.00[3]	0.05	100.31
25	0.38	0.03	0.06	0.29	<0.01	0.02	<0.01	0.04	<0.03	98.21[3]	0.04	99.12
27	1.33	0.03	0.10	0.35	0.60	0.05	<0.01	0.03	<0.03	96.96[3]	0.06	99.55
29	0.88	0.03	0.06	0.25	0.50	0.03	<0.01	0.03	0.05	96.87[3]	0.06	98.77
31	1.08	0.03	0.09	0.13	0.40	0.04	<0.01	0.02	0.06	96.30[3]	0.06	98.22
33	1.11	0.04	0.60	0.29	0.50	0.04	<0.01	0.04	<0.03	98.39[3]	0.06	101.11
35	1.22	0.03	0.42	0.29	0.60	0.06	<0.01	0.08	<0.03	99.10[3]	0.09	101.93
37	1.18	0.04	0.48	0.29	0.60	0.09	<0.01	0.05	<0.03	97.80[3]	0.05	100.62
40	1.27	0.04	0.43	0.29	0.60	0.13	<0.01	0.07	0.03	97.20[3]	0.06	100.13
43	0.99	0.04	0.26	0.29	0.50	0.07	<0.01	0.19	0.07	98.67[3]	0.05	101.14
46	1.49	0.05	0.67	0.29	0.80	0.08	<0.01	0.13	<0.03	95.22[3]	0.05	98.82
49	0.48	0.04	0.31	0.29	0.40	0.04	<0.01	0.09	<0.03	97.80[3]	0.07	99.56
52	4.70	0.06	0.34	0.13	1.90	0.14	<0.01	0.05	0.07	90.51	0.48	98.39
55	4.75	0.05	0.73	0.13	1.80	0.09	0.01	0.05	<0.03	90.69	0.35	98.68
58	3.17	0.05	0.67	0.13	1.40	0.09	<0.01	0.05	0.04	93.40	0.37	99.38
61	17.29	0.42	1.30	0.13	7.80	1.09	<0.01	0.11	0.10	71.03	0.49	99.77
64	17.44	0.57	2.47	2.60	9.00	1.89	0.01	0.13	0.14	67.10	0.44	101.79
67	10.50	0.43	1.92	1.49	6.00	1.44	<0.01	0.11	0.11	75.45	0.40	97.86
70	9.68	0.45	1.81	1.11	5.70	1.27	<0.01	0.13	0.09	81.09	0.37	101.71
73	9.78	0.47	1.84	0.69	6.10	1.11	0.08	0.13	0.06	78.42	0.40	99.08
76	7.32	0.27	1.18	0.13	3.80	0.59	<0.01	0.10	<0.03	84.67	0.26	98.36
79	1.50	0.07	11.38	0.13	2.70	0.21	0.40	0.06	0.06	82.16	0.10	98.77
82	4.18	0.11	0.79	0.13	1.90	0.24	0.02	0.06	<0.03	90.91	0.20	98.57
85	10.20	0.20	1.42	0.87	4.60	0.51	<0.01	0.08	0.03	84.53	0.29	102.74
88	5.65	0.17	1.59	0.94	3.10	0.47	0.02	0.09	0.12	89.45	0.25	101.85
91	5.69	0.17	0.97	1.00	3.10	0.47	<0.01	0.08	0.09	88.14	0.25	99.97
94	3.76	0.08	0.54	0.49	1.60	0.24	<0.01	0.07	0.06	92.85	0.15	99.85
97	2.44	0.08	0.40	<0.03	1.00	0.22	<0.01	0.05	0.12	95.12	0.13	99.60
100	2.73	0.07	0.33	<0.03	1.20	0.20	<0.01	0.06	0.09	97.34	0.10	102.16
103	8.29	0.05	0.84	<0.03	3.10	0.06	<0.01	0.06	0.12	89.84	0.02	102.42
106	7.07	0.16	1.76	0.64	2.80	0.73	<0.01	0.12	0.06	85.60	0.47	99.42
109	10.27	0.14	1.51	1.12	4.10	0.60	<0.01	0.08	0.15	81.97	0.42	100.37
112	9.12	0.13	1.33	0.49	3.70	0.53	<0.01	0.08	0.14	85.18	0.47	101.18
115	11.92	0.16	1.93	0.74	4.80	0.61	<0.01	0.12	0.19	81.28	0.47	102.23
118	16.35	0.22	3.53	1.09	7.10	0.93	0.06	0.12	0.43	69.18	0.62	99.63
121	2.74	3.87	1.15	1.11	4.90	0.18	<0.01	0.07	0.16	86.74	0.11	101.04
124	18.03	0.49	4.99	2.91	7.20	2.17	0.02	0.17	0.20	64.81	0.75	101.74
130	11.28	0.50	4.61	2.22	5.50	1.29	<0.01	0.16	0.31	63.26	0.56	89.70

[1] Sample number is also the depth from the surface. See Appendix A1 for lithology and stratigraphic location of each sample.

[2] Loss on ignition.

[3] Analysis used in resource calculations for the upper orthoquartzite.

B5. Whole-rock chemical analyses of core from drill hole 5, Cassa silica rock deposit (values in weight percent).

Sample number[1]	Al_2O_3	CaO	Fe_2O_3	K_2O	LOI[2]	MgO	MnO	Na_2O	P_2O_5	SiO_2	TiO_2	Total
10	0.46	0.07	0.06	0.26	0.30	0.03	<0.01	0.03	0.07	99.00[3]	0.03	100.32
13	0.77	0.03	0.11	0.26	0.03	0.04	<0.01	0.02	0.10	99.00[3]	0.04	100.41
16	0.98	0.03	0.16	0.26	0.20	0.05	<0.01	0.03	0.10	99.00[3]	0.05	100.87
19	0.92	0.04	0.07	0.26	0.20	0.05	<0.01	0.02	0.09	99.00[3]	0.04	100.70
22	0.95	0.06	0.34	0.26	0.20	0.05	<0.01	0.01	0.04	99.00[3]	0.05	100.97
24	0.74	0.03	0.05	0.26	0.20	0.04	<0.01	0.02	0.04	99.00[3]	0.04	100.43
25	0.77	0.05	0.09	0.26	<0.01	0.04	<0.01	0.03	0.13	99.15[3]	0.04	100.58
28	0.55	0.02	0.08	0.26	1.10	0.02	<0.01	0.02	0.10	99.00[3]	0.03	101.19
31	3.07	0.06	0.17	0.32	0.90	0.15	0.03	0.04	0.16	97.00[3]	0.36	102.26
34	2.44	0.05	0.19	0.26	1.20	0.11	0.02	0.04	0.04	98.00[3]	0.24	102.59
37	12.18	0.65	2.21	1.13	6.90	0.99	0.08	0.06	0.41	76.88	0.72	102.21
40	7.53	0.38	0.83	0.26	4.10	0.50	<0.01	0.05	0.10	87.95	0.33	102.04
43	4.88	0.18	0.68	0.58	2.60	0.38	<0.01	0.04	0.13	92.21	0.29	101.98
46	1.86	0.08	0.50	0.26	1.00	0.18	<0.01	0.03	0.13	98.00	0.07	102.12
49	3.90	0.11	12.18	0.30	3.30	0.32	0.21	0.01	0.11	79.46	0.13	100.03
52	5.77	0.16	0.85	0.48	2.60	0.38	<0.01	0.03	0.13	91.36	0.22	101.99
55	2.72	0.08	0.83	0.32	1.10	0.17	<0.01	0.04	0.07	97.00	0.09	102.43
58	3.99	0.13	0.60	0.16	1.90	0.30	<0.01	0.05	0.10	95.23	0.17	102.64
61	1.63	0.07	0.19	0.16	0.90	0.14	<0.01	0.04	0.08	99.00	0.05	102.27
64	12.51	0.42	3.02	1.60	5.80	1.11	<0.01	0.06	0.17	77.05	0.58	102.33
67	4.41	0.20	0.97	0.71	1.90	0.48	<0.01	0.05	0.15	92.64	0.19	101.71
70	7.27	0.11	1.74	0.16	2.80	0.29	<0.01	0.05	0.14	88.84	0.18	101.59
73	1.88	0.07	1.12	0.34	0.80	0.23	0.01	0.05	0.05	97.50	0.10	102.15
76	2.38	0.07	0.48	0.46	1.00	0.27	<0.01	0.08	0.12	97.00	0.11	101.98
79	6.79	0.15	11.41	0.91	3.50	0.50	0.03	0.06	0.16	78.80	0.26	102.57
82	2.43	0.05	0.60	0.96	1.30	0.13	<0.01	0.07	0.10	96.56[4]	0.15	102.36
85	1.22	0.03	0.18	0.41	0.40	0.06	<0.01	0.04	0.13	99.00[4]	0.05	101.53
88	1.66	0.04	0.34	0.55	0.60	0.09	<0.01	0.06	0.13	99.00[4]	0.09	102.57
91	1.93	0.03	0.25	0.51	0.60	0.09	<0.01	0.06	0.10	96.78[4]	0.11	100.47
94	1.56	0.04	0.22	0.43	0.90	0.09	<0.01	0.04	0.05	99.00[4]	0.06	102.40
97	1.48	0.03	0.31	0.47	0.40	0.07	<0.01	0.05	0.15	99.00[4]	0.07	102.04
100	1.70	0.04	0.45	0.63	0.50	0.10	<0.01	0.05	0.10	99.00[4]	0.08	102.66
103	2.41	0.04	0.21	0.45	0.80	0.10	<0.01	0.06	0.04	95.89[4]	0.07	100.08
106	12.30	0.29	3.04	2.57	5.40	1.32	0.02	0.09	0.16	76.68	0.57	102.44

[1] Sample number is also the depth from the surface. See Appendix A1 for lithology and stratigraphic location of each sample.

[2] Loss on ignition.

[3] Analysis used in resource calculations for the upper orthoquartzite.

[4] Analysis used in resource calculations for the lower orthoquartzite.

B6. Whole-rock chemical analyses of core from drill hole 6, Cassa silica rock deposit (values in weight percent).

Sample number[1]	Al_2O_3	CaO	Fe_2O_3	K_2O	LOI[2]	MgO	MnO	Na_2O	P_2O_5	SiO_2	TiO_2	Total
9	3.60	0.11	0.54	0.44	1.80	0.13	<0.01	0.05	0.06	93.12	0.22	100.08
12	2.17	0.06	1.16	0.56	1.10	0.07	0.01	0.03	0.07	94.80	0.10	100.13
15	8.47	0.14	0.68	1.29	2.80	0.41	<0.01	0.11	0.09	85.27	0.98	100.25
18	1.08	0.05	0.80	0.44	0.50	0.04	0.01	0.07	<0.03	97.79[3]	0.07	100.88
21	0.90	0.05	0.06	0.44	0.60	0.03	<0.01	0.04	<0.03	97.16[3]	0.06	99.38
24	0.26	0.04	0.05	0.44	<0.01	0.02	<0.01	0.04	<0.03	98.81[3]	0.02	99.73
27	0.31	0.03	0.04	0.25	0.10	0.02	<0.01	0.02	<0.03	99.16[3]	0.02	99.99
30	0.28	0.03	0.03	0.44	0.20	0.02	<0.01	0.03	<0.03	98.90[3]	0.02	99.99
33	0.56	0.03	0.04	0.25	0.20	0.02	<0.01	0.01	0.12	99.00[3]	0.08	100.32
36	0.48	0.04	0.05	0.25	0.20	0.03	<0.01	<0.01	0.09	99.00[3]	0.07	100.23
39	0.35	0.04	0.06	0.44	0.30	0.04	<0.01	0.03	0.05	97.90[3]	0.03	99.25
42	0.99	0.06	0.09	0.44	0.20	0.05	<0.01	0.06	0.05	99.00[3]	0.11	101.06
45	0.55	0.03	0.06	0.34	0.30	0.03	<0.01	0.02	0.09	99.00[3]	0.06	100.49
48	0.31	0.04	0.03	0.25	0.10	0.02	<0.01	0.02	<0.03	99.00[3]	0.03	99.84
51	0.65	0.06	0.09	0.35	0.50	0.05	<0.01	0.05	0.13	98.10[3]	0.07	100.06
54	0.64	0.03	0.05	0.34	0.40	0.03	<0.01	0.01	0.07	98.15[3]	0.06	99.79
57	1.21	0.03	0.05	0.49	0.80	0.04	<0.01	0.04	0.09	97.55[3]	0.06	100.37
60	20.35	0.36	1.39	0.50	9.30	0.52	0.02	0.06	0.15	67.72	0.60	100.97
63	7.93	0.60	1.25	0.66	6.00	0.83	<0.01	0.05	<0.03	82.73	0.38	100.47
66	8.79	0.52	1.62	1.08	5.90	0.83	<0.01	0.07	0.16	81.40	0.37	100.75
69	8.77	0.32	1.30	0.99	4.40	0.67	<0.01	0.06	0.08	83.66	0.36	100.62
72	11.01	0.37	1.84	0.91	5.70	0.81	0.02	0.07	<0.03	78.11	0.40	99.27
74	6.27	0.17	0.76	0.29	2.80	0.33	<0.01	0.06	0.08	90.43	0.29	101.49
75	5.47	0.09	2.75	0.77	2.40	0.13	0.17	0.08	0.13	87.93	0.16	100.08
78	2.90	0.05	0.38	0.59	0.01	0.09	<0.01	0.04	0.06	95.79[4]	0.12	100.04
81	2.22	0.07	0.27	0.75	0.70	0.11	<0.01	0.04	<0.03	97.69[4]	0.11	102.00
84	2.36	0.04	0.28	0.25	0.80	0.11	<0.01	0.02	<0.03	95.95[4]	0.11	99.96
87	2.04	0.06	0.16	0.79	0.70	0.11	<0.01	0.05	<0.03	95.91[4]	0.09	99.95
90	3.02	0.06	0.30	0.90	1.30	0.13	<0.01	0.05	<0.03	93.17[4]	0.11	99.08
93	2.13	0.04	0.14	0.65	0.70	0.06	<0.01	0.03	<0.03	96.03[4]	0.07	99.89
96	1.81	0.08	0.22	0.80	0.90	0.14	<0.01	0.05	0.13	96.03[4]	0.09	100.26
99	1.21	0.03	0.14	0.30	0.50	0.07	<0.01	0.03	0.10	99.47[4]	0.07	101.93
102	3.77	0.13	0.51	1.21	1.80	0.39	<0.01	0.05	0.06	92.54[4]	0.25	100.72
105	6.82	0.11	0.55	1.04	3.00	0.38	<0.01	0.04	0.08	89.53	0.37	101.93
108	4.28	0.07	0.23	0.43	1.60	0.16	<0.01	0.04	<0.03	94.86[4]	0.11	101.82
111	3.97	0.05	0.17	0.43	1.40	0.11	<0.01	0.02	<0.03	92.73[4]	0.09	99.01
114	1.38	0.04	0.42	0.29	0.50	0.08	<0.01	0.05	<0.03	95.40[4]	0.04	98.24
117	4.78	0.11	0.80	0.49	2.20	0.31	<0.01	0.03	0.10	90.34[4]	0.31	99.48

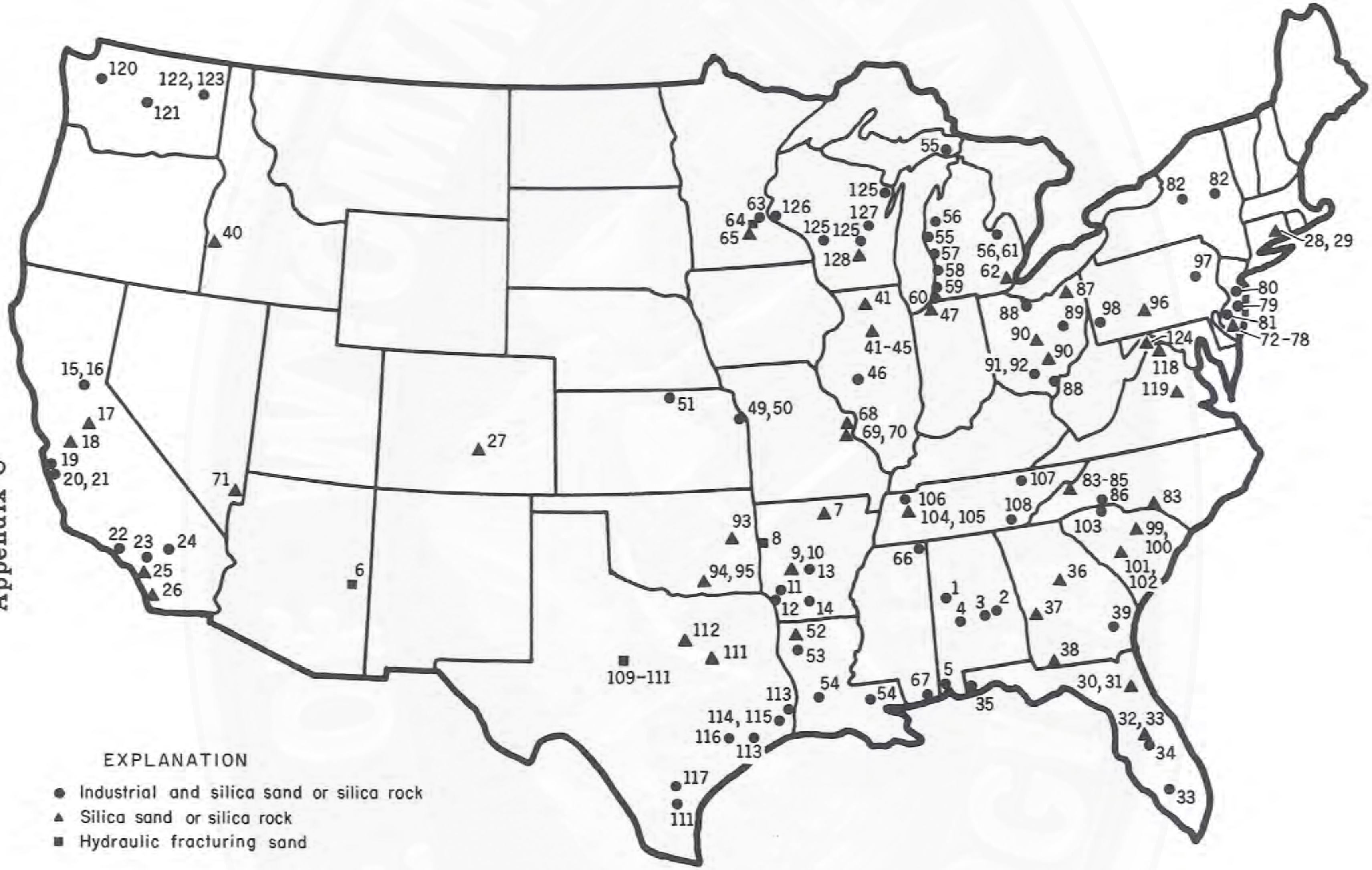
[1] Sample number is also the depth from the surface. See Appendix A1 for lithology and stratigraphic location of each sample.

[2] Loss on ignition.

[3] Analysis used in resource calculations for the upper orthoquartzite.

[4] Analysis used in resource calculations for the lower orthoquartzite.

Appendix C



Appendix C1. Location of silica sand, silica rock, and other silica production in the United States (including feldspar produced as a glass raw material and some industrial sand production that may be used for silica sand). Numbers refer to producers, Appendix C2.

Appendix C2. Glass and hydraulic fracturing sand and silica production in the United States (including feldspar produced as a glass raw material). Modified from U.S. Bureau of Mines (1986), Engineering and Mining Journal (1987), Goldman and Reining (1983), Dickson, (1984), and U.S. Bureau of Mines Minerals Yearbooks 1982-1985 (for 1981-1984), v. I, Metals and minerals, and v. II, Area reports: domestic.

Numbers refer to map symbol (Appendix C1)	Major producers and products (if known)	Number of active operations
	Alabama (foundry, silicon, ferrosilicon)	
1	The Morie Company, Inc.	1
2	Warrior Sand and Gravel Company, Inc.	1
3	R & S Materials, Inc.	2
4	Cosby-Carmichael, Inc.	1
5	Dravo Basic Materials Company, Inc.	1
	Arizona	
6	Arizona Silica Sand Company (frac)	1
	Arkansas (foundry, glass, abrasives)	
7	Silica Products Company (glass)	1
8	Ashland Oil, Inc. (probably frac)	1
9	Coleman Crystal Inc. (LASCAS)	1
10	Geomex Mine Services Inc. (LASCAS)	1
11	Ideal Basic Industries, Inc.	1
12	Gifford-Hill and Company, Inc.	1
13	Arkansas White Rock, Inc.	1
14	Turner Trucking Company	1
	California (glass, other)	
15	Pacific Silica Company	1
16	Yuba Silica Inc. (silica flour)	1
17	Owens-Illinois, Inc. (glass)	1
18	Unimin Corporation (glass)	1
19	Santa Cruz Aggregates Company	1
20	Lone Star Industries, Inc.	1
21	Monterey Sand Company, Inc.	2
22	P.W. Gillibrand Company	1
23	Gifford-Hill and Company, Inc.	1
24	Calspar Inc. (feldspar and quartz)	1
25	Ogleby-Norton (California Silica Products Co.) (feldspar-quartz sand for glass)	1
26	U.S. Silica (feldspar-quartz sand for glass)	1
	Colorado	
27	Colorado Silica Sand, Inc. (glass)	1
	Connecticut	
28	U.S. Silica (glass)	1
29	The Feldspar Corporation (feldspar for glass)	2
	Florida (glass, foundry)	
30	The Feldspar Corporation (by-product sand for glass)	1
31	Florida Rock Industries	1
32	Standard Sand and Silica Company (glass)	6
33	E.R. Jahna Industries, Inc.	2
34	Gall Silica Mining Company, Inc.	1
35	Clark Sand Company, Inc.	1
	Georgia (glass, fused silica, other)	
36	The Feldspar Corporation (feldspar for glass)	2
37	The Morie Company, Inc. (glass)	1
38	Florida Crushed Stone Company (glass?)	1
39	Satilla Sand Company, Inc.	1
	Idaho	
40	Unimin Corporation (glass, other)	1

Appendix C2 (continued).

Numbers refer to map symbol (Appendix C1)	Major producers and products (if known)	Number of active operations
	Illinois (glass, foundry, frac)	
41	Unimin Corporation (glass, frac)	3
42	U.S. Silica (glass)	1
43	Wedron Silica Company (glass, foundry, frac)	1
44	Manley Brothers of Indiana, Inc. (glass)	1
45	Treco Sales Inc.	1
46	East Side Sand Company	1
	Indiana	
47	Unimin Corporation (glass)	1
	Kansas (fiberglass, abrasive, other)	
49	List and Clark Construction Company	1
50	HUB Materials, Inc.	1
51	Alsop Sand Company, Inc.	1
	Louisiana (glass, foundry)	
52	U.S. Silica (glass)	1
53	Cobb Industrial Corporation	1
54	Mid State Sand and Gravel Company, Inc.	2
	Michigan (foundry, glass, frac)	
55	Sand Products Corporation	2
56	Sargent Sand Company	3
57	Nugent Sand Company, Inc.	2
58	Construction Aggregates Corporation	2
59	Manley Brothers of Indiana, Inc.	2
60	Unimin Corporation	1
61	Great Lakes Minerals Company	1
62	U.S. Silica (glass)	1
	Minnesota (frac, glass, foundry)	
63	Twin City Silica, Ltd.	1
64	Cornwall China Clay, Ltd. (frac)	1
65	Unimin Corporation (frac, glass)	2
	Mississippi (unknown)	
66	Tri-Sands, Inc.	1
67	Jet Sands, Inc.	1
	Missouri	
68	U.S. Silica (glass)	2
69	Unimin Corporation (glass)	1
70	Master Brothers Silica Sand Company	1
	Nevada	
71	J.R. Simplot Company (glass, other)	1
	New Jersey (glass, foundry, abrasive)	
72	The Morie Company, Inc. (glass)	4
73	Unimin Corporation (glass)	1
74	U.S. Silica (glass)	1
75	Warner Company	1
76	Owens-Illinois, Inc. (glass)	1
77	George F. Pettinos, Inc.	1
78	Whitehead Brothers Company (glass)	1
79	N.J. Pulverizing Company	1
80	South River Sand Company	1
81	Downer Silica Company	1
	New York (foundry, minor glass)	
82	Whitehead Brothers Company	2
	North Carolina	
83	Unimin Corporation (glass, high purity silica)	2
84	Indusmin Inc. (by-product silica)	1

Appendix C2 (continued).

Numbers refer to map symbol (Appendix C1)	Major producers and products (if known)	Number of active operations
85	The Feldspar Corporation (high purity silica)	1
86	KMG Minerals Inc. (by-product feldspar and silica)	1
	Ohio (foundry, glass, silica flour)	
87	Best Silica Sand Company (foundry, frac, glass)	2
88	Keener Sand and Clay Company	2
89	U.S. Silica	1
90	Ogleby-Norton (Central Silica Company) (glass, silica flour, foundry)	2
91	Southern Silica Corporation (glass)	1
92	The Parry Company	1
	Oklahoma (fiberglass, glass)	
93	Ashland Oil, Inc. (quartz-feldspar sand for frac, glass)	1
94	U.S. Silica (glass)	2
95	Mid-Continent Glass Sand Company (glass)	1
	Pennsylvania (glass, other)	
96	U.S. Silica (glass)	1
97	Alliance Sand Company	1
98	McCrady, Inc.	1
	South Carolina (fiberglass, glass, abrasive)	
99	Whitehead Brothers Company	1
100	Unimin Corporation (glass)	1
101	U.S. Silica (glass)	1
102	Columbia Silica Sand Company	1
103	Jobe Sand Company, Inc.	1
	Tennessee (glass, foundry, fused silica, other)	
104	The Morie Company, Inc. (glass?)	2
105	Tri-State Sand Company (glass?)	1
106	Murray Silica Sand Company	1
107	Caryville Sand Company	1
108	Vulcan Materials Company	1
	Texas (glass, frac, other)	
109	Ogleby-Norton (Texas Mining Company) (frac)	1
110	Vulcan Materials Company (frac)	1
111	U.S. Silica (frac, glass)	3
112	Unimin Corporation (glass)	1
113	Specialty Sand Company	2
114	Pioneer Concrete of Texas, Inc.	1
115	Barry and Barry Sand Company, Inc.	1
116	Ideal Basic Industries, Inc.	1
117	Palo Alto Silica Sand, Inc.	1
	Virginia	
118	Unimin Corporation (glass)	1
119	The Feldspar Corporation (aplite for glass)	1
	Washington (glass, ferrosilicon, other)	
120	Industrial Mineral Products, Inc.	1
121	Wenatchee Silica Products, Inc. (silicon and ferrosilicon)	1
122	Lane Mountain Silica Company (ferrosilicon?)	1
123	Northwest Alloys, Inc. (ferrosilicon)	1
	West Virginia	
124	U.S. Silica (glass)	1
	Wisconsin (foundry, glass, frac)	
125	Badger Mining Corporation (glass?)	3
126	Treco Sales Inc.	1
127	A.F. Gelhar Company, Inc.	2
128	Unimin Corporation (glass)	1

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