Variation in Cambrian Conglomerate Layers Exposed in Parfreys Glen, Wisconsin

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ABSTRACT

Six measured stratigraphic sections and seismic refraction survey show the distribution and variation of Cambrian conglomerate units in Parfreys Glen and the configuration of the underlying Precambrian quartzite surface beneath the glen. The conglomerate units fall into four groups designated A, B, C, and D, in ascending order. Clast long axis measurements in units A and B range from 13 to 18 cm and units A and B have similar thicknesses and lateral continuity. Maximum clasts in units C and D have long axes ranging from 20 to 130 cm; these units show much greater variation in lateral continuity and thickness than do units A and B. The seismic refraction survey reveals that the Cambrian sediments in Parfreys Glen were deposited in a pre-existing valley which formed a cove in the Cambrian shoreline. The modern glen is off-center to the west in the ancient valley.

INTRODUCTION

Remarkable exposures of quartzite conglomerate interbedded with sandstone have been used to interpret the depositional environment and depositional mechanism for Cambrian sediment exposed in the Baraboo area. The sediment accumulated on the flank of the Baraboo Quartzite hills, the remains of a nearly east-west trending Precambrian syncline. Dott proposed that the Cambrian depositional environment was shallow marine, surrounding islands of resistant Precambrian quartzite (Dalziel and Dott, 1970; Dott, 1974; Dott and Byers, 1980). *Skolithos* are rare to absent in sandstones interbedded with the Parfreys Glen conglomerate, but their presence in comparable stratigraphic positions in other exposures in the region, as well as above the uppermost Parfreys Glen conglomerate, is strong evidence for shallow marine conditions. Further evidence for shallow marine conditions comes from the Cambrian Tunnel City Formation and Trempealeau Group, which contain marine invertebrate fossils, glauconite and algal stromatolites elsewhere in the Baraboo area (Dalziel and Dott, 1970).

Dott (1974, 1983); Dott and Dalziel, (1970); and Byers (1980) proposed a storm deposit origin for Parfreys Glen conglomerates and other similar deposits near Baraboo and the rounding of cobbles and boulders was attributed to storm waves and currents. However, the evidence supporting the storm deposit mechanism is based on the inferred shallow marine setting of the conglomerates, and the occurrence of coarse, rounded conglomerate in thin, sharply-bounded layers. The purpose of this paper is to describe the conglomerates in Parfreys Glen, including their lateral and vertical extent and variations, and to evaluate the storm deposit mechanism.

METHODS

Surface Methods—Conglomerates

Six sites for stratigraphic measurement and description were selected along the entire length of exposure (fig. 1). All sections were located on a pace-and-compass map of the trail and stream in Parfreys Glen. Layers were correlated from one section to another by walking contacts and by correlating several stratigraphic levels from one side of the stream to the other (fig. 2).

Within each conglomerate layer, several groups of cobbles were measured and a most-common size range and maximum clast size were recorded for each. Where exposure and accessibility permitted, guadrates for clast long-axis measurement were selected randomly. The observer looked away from the glen wall, stepped two paces along exposure (away from a measured section, parallel to the cliff

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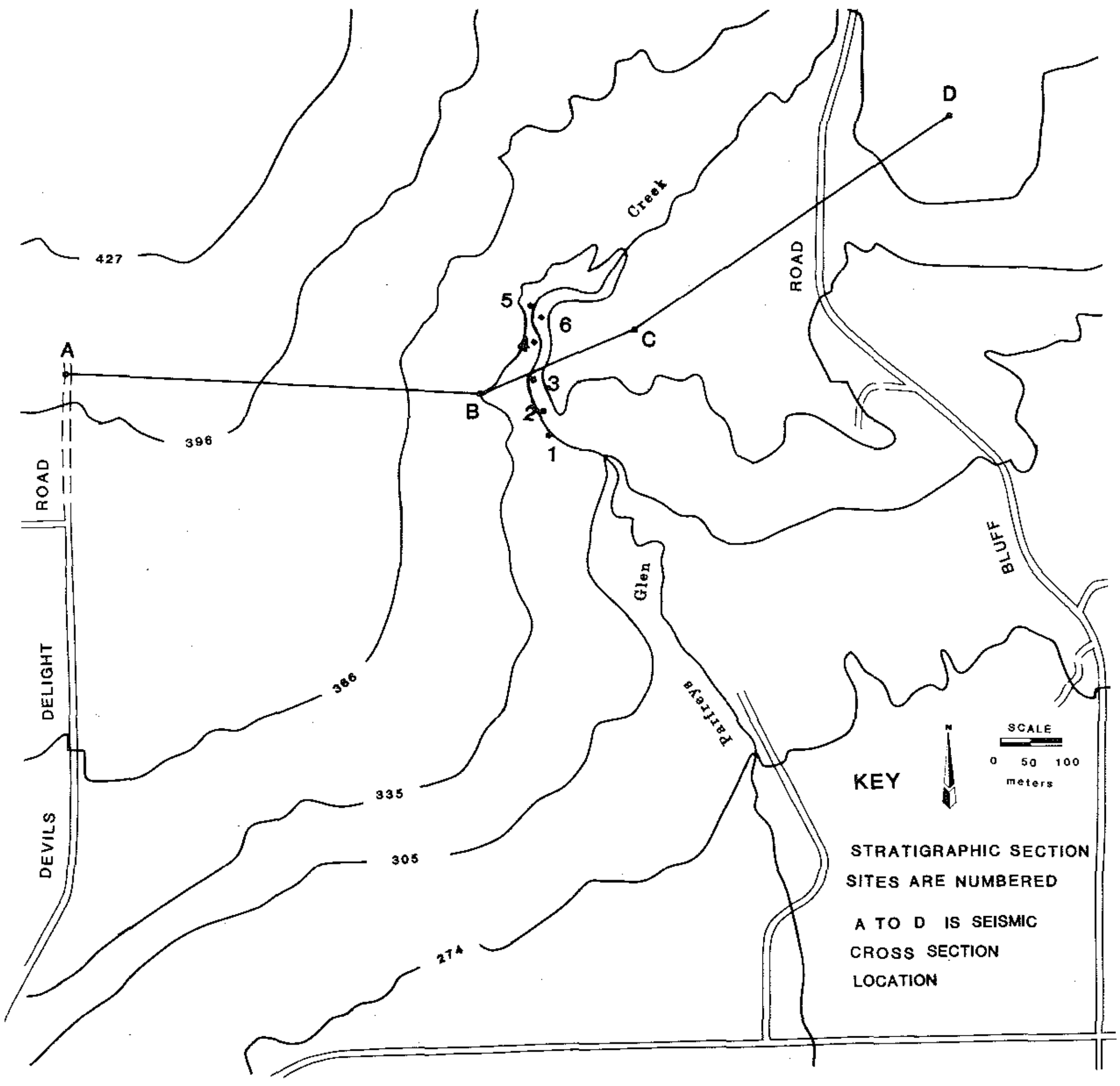

Figure 1. Location map of stratigraphic sections and seismic cross section in Parfreys Glen, Wisconsin. Surface elevations in meters above sea level, contour interval is 30 meters.

face) and extended her arm to mark the right edge of a 40 x 42 centimeter rectangle. Mean clast size was calculated for the lower two units by measuring all clast long axes which lay within the rectangle. Exposures of upper units did not permit the random sampling technique, because the majority were on inaccessible cliff faces.

Other properties, such as angularity of clasts, orientation, type of matrix, and matrix or clast support were described as the sections were measured.

Subsurface Methods — Seismic Refraction

The relief and position of the contact between Precambrian Baraboo Quartzite and Cambrian sedimentary rock was mapped using shallow seismic refraction. Contact elevation was determined by use of a Bison 1570C signal enhancement seismograph with one geophone. Seismic waves were generated with a sledge hammer. Seismic profiles were done in 21 locations in and near the glen (fig. 3). Seventeen profiles were reversed; difficult working conditions prevented reversal at four sites.

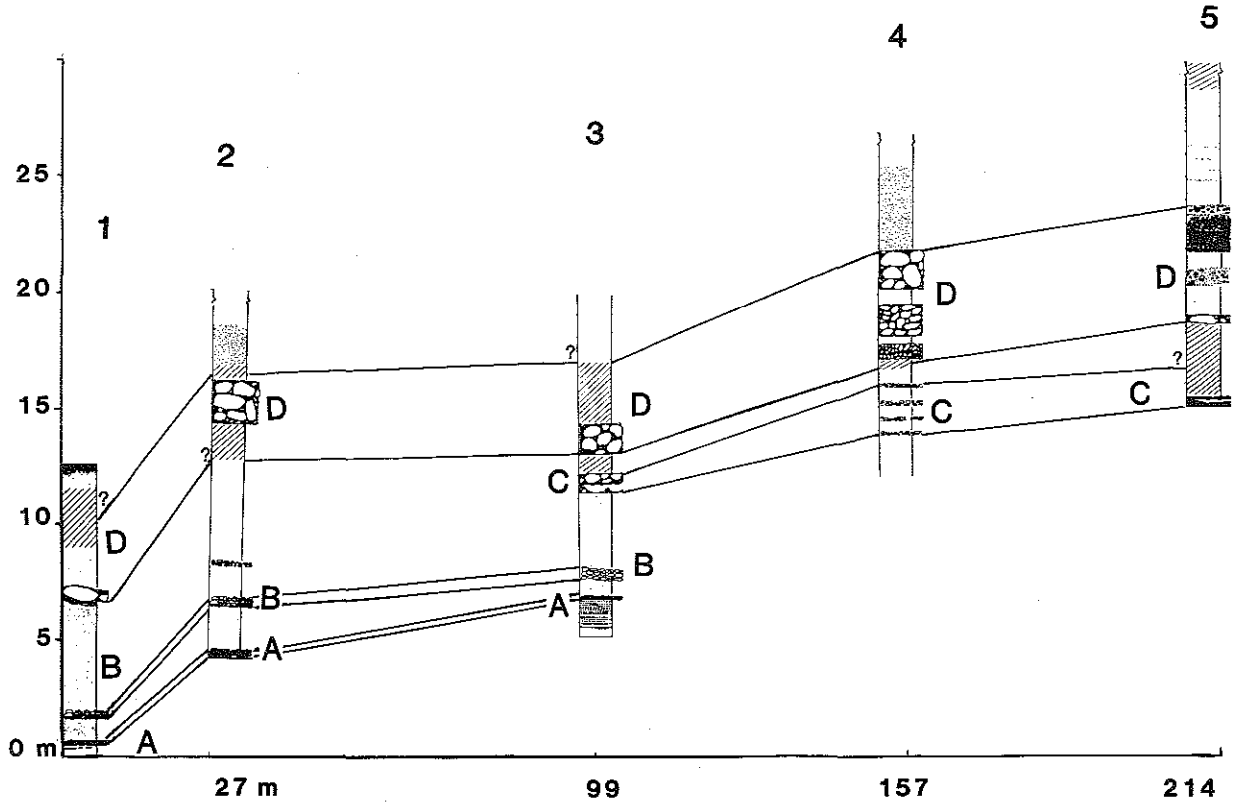

Figure 2. Stratigraphic sections 1 to 5 in Parfreys Glen, shown from south to north (left to right). (Also see fig. 1).

Two additional profiles, for the purpose of determining the seismic velocity of the quartzite and sandstone rather than to find depths, were located where there was no doubt as to the underlying material. A profile to determine the seismic velocity of the quartzite was done on an exposure near the north end of Devils Lake, and another to find the seismic velocity of the sandstone was located at the top of the bluff on the east side of Parfreys Glen. The profile lines were 50 to 100 meters long, with data points spaced at five or ten meter intervals.

In many cases the number of hammer hits required for a data point was fairly close to one tenth the number of meters between the impact point and the geophone. For example, four to six hammer hits might be required at a point 40 meters from the geohone. Since the seismograph is signal-enhancing, the seismic wave forms from the numerous impacts at each location are electronically accumulated and displayed as a single wave form. In most cases the data were not difficult to take. There were distinct differences in the seismic characteristics of the units and the stratigraphically lower units had successively higher seismic velocities so there were no blind zones. Seismic refraction, however, will reveal the depth only to layer boundaries which are distinct in terms of seismic qualities, but may or may not coincide with stratigraphic boundaries. For example, if the Baraboo Quartzite in a particular location has a weathered zone on its upper surface, the weathered zone may have seismic qualities similar to the overlying sandstone and thus be indistinguishable from it. The seismic discontinuity would be deeper than the actual depth of the quartzite-sandstone interface. We observed little chemical weathering of the quartzite in the study area, so any such error is minor.

The primary difficulties encountered in Parfreys Glen involved working conditions. In some places slopes were too steep to work on, and running water prevented reversing one profile in a streambed. A reasonable estimate of the accuracy of the soundings in Parfreys Glen would be plus or minus ten to fifteen percent. The seismic travel-time graphs resulting from the field work were interpreted using a FORTRAN computer program by Mooney (1980) and a short BASIC program by Vick (unpublished) based on formulae from the same volume.

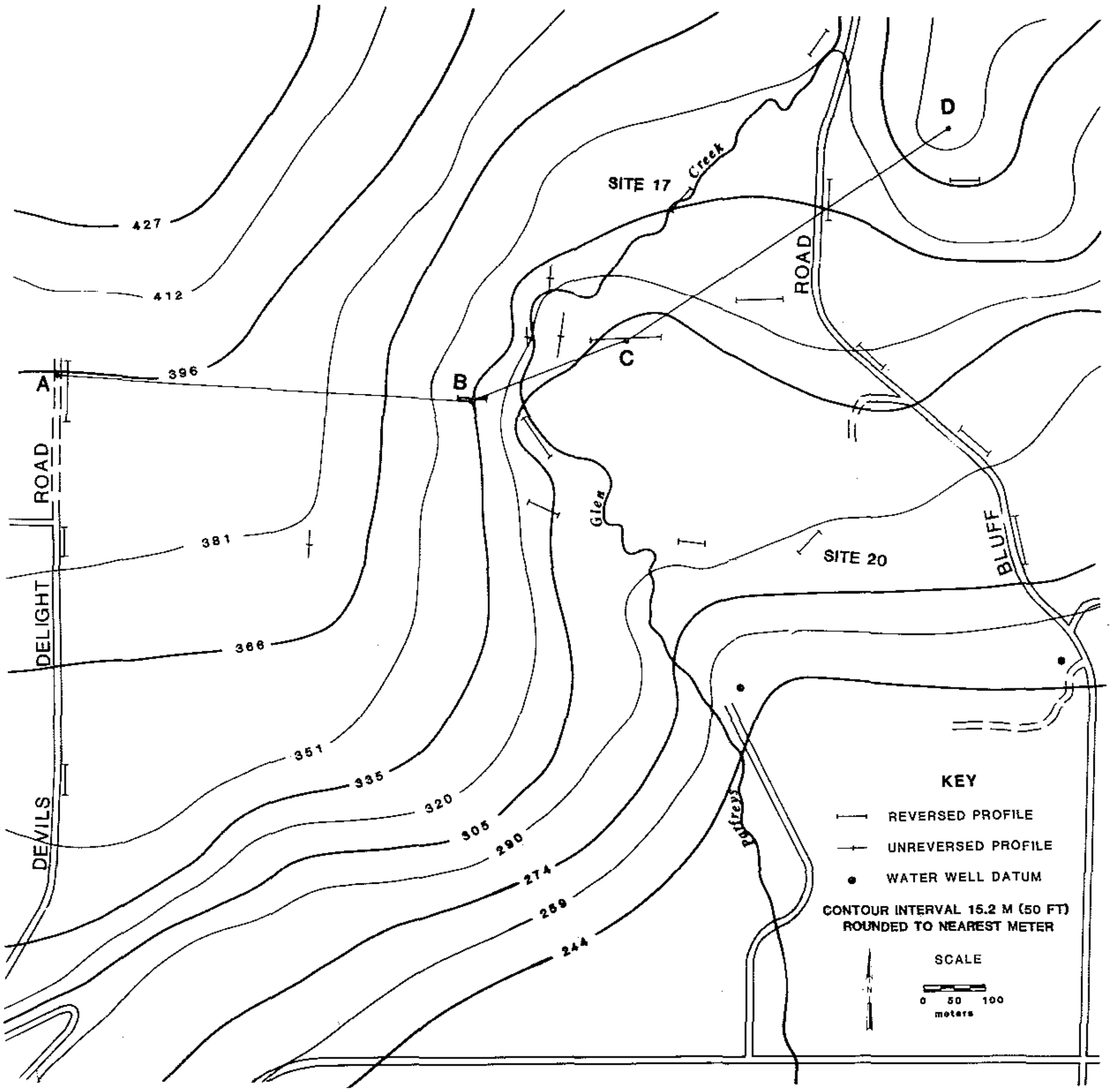

Figure 3. Precambrian Baraboo Quartzite surface map in Parfreys Glen area as determined by seismic refraction survey.

SEDIMENTOLOGY

Four conglomerate units (labelled A through D) can be distinguished in Parfreys Glen. The lower units, A and B, consist of a single layer each, while the two upper units, C and D, consist of multiple and discontinuous conglomerate layers.

Persistent Units A and B

Units A and B consist of pebbles and cobbles in a quartzarenite matrix. They share such similarities as sorting, layer thickness, matrix type and continuity. Most unit A clasts range from 4-7 cm (table 1). The clasts in Unit B are only slightly larger than those in unit A (table 1). It is possible to trace units A and B in the field over the entire range of exposure.

Clasts in units A and B range in shape from equant to disc-shaped and clasts in unit A are notably more angular than those in unit B. In general, the clasts support each other and are oriented with the long axes nearly horizontal (parallel to bedding planes). Dott and Byers (1980) found that most clasts in the glen dipped less than 20 degrees. Their data indicate a weak maximum of a-b planes dipping

Table 1. Clast size ranges, and conglomerate matrix descriptions

UNIT	SECTION	MAXIMUM CLAST SIZE (in centimeters)	COMMON SIZE RANGE (in centimeters)	UNIT THICKNESS* (in meters)		MATRIX
A	1	13	4-7	0.25		sandy
A	2	14	5-8	0.20		sandy
A	3	18	5-7	0.25		sandy
B	1	15	8	0.40		sandy
B	2	16	5-12	0.50		sandy
B	3	18	3-8	0.55		sandy
C (?)	3	20	–	0.90		pebbly
C-1—C-4	4	58	8-18	2.30		pebbly
C-1	5	25	–	0.45		pebbly
C-1—C-5	6	30	3-8	3.20		pebbly
D	1	100	40	0.55	(exposed)	pebble & sand
D	2	100	30	2.00		pebbly
D	3	30	–	2.20		pebbly
D-1—D-3	4	100	30	4.80		pebbly
D-1—D-3	5	130	5-7: 30	4.90		pebble & sand
D-1—D-11	6	15	1-7	8.80		pebble & sand

**Unit thicknesses for C and D include sandstone lenses; A and B do not.*

UNIT	MEAN CLAST SIZE (LONG AXIS)**	NUMBER OF MEASUREMENTS	MINIMUM; MAXIMUM	STANDARD DEVIATION	VARIANCE
A	4.7 (cm)	48	1.5; 13.0	+2.43	5.92
B	5.8	49	1.5; 23.0	+3.88	15.03

***Exposures and accessibility permitted random sampling technique for Units A & B only. Quadrate height was determined by thickness of conglomerate unit; quadrate width was the multiple needed to bring the area to 1680 square cm. e.g. (40x42 cm).*

toward the north.

The two lower conglomerate units show lateral continuity. For example, there is a layer of pebbles, one pebble thick, that appears below unit A at both sections 1 and 2. Thicknesses of units A and B remain uniform at approximately 0.20 m and 0.50 m, respectively. Unit B consists of two discrete cobble layers at section 2 and onc cobble layer elsewhere. Upstream from section 3 (figs. 1,2), units A and B are not exposed. The two upperunits, C and D, show considerably more variation over short distances (a few meters) than do units A and B.

Laterally Discontinuous Units C and D

With the exception of one layer in unit D, these layers cannot be traced laterally. Because of their discontinuity, they were correlated by stratigraphic position only. Other differences from units A and B exist. These upper units vary widely in sorting, layer thickness and matrix constituents.

Units C and D consist of layers of pebbles, cobbles and boulders. Pebble matrices packed between boulders are interbedded with discontinuous sandstone lenses and pebble layers. In both units C and D, the clasts and pebble matrix consist solely of Baraboo Quartzite, indicating a single source. Many of the clasts are oriented with the long axis parallel to bedding (nearly horizontal), but in a few places, long axes of clasts dip northeast. Previous work has also shown westward dipping clast orientations in some beds (Dott and Byers, 1980). As in unit B, most of the clasts in units C and D are rounded. Dott (1970) found rounded clasts up to 1.3 m in diameter, although the largest clasts in comparable conglomer-

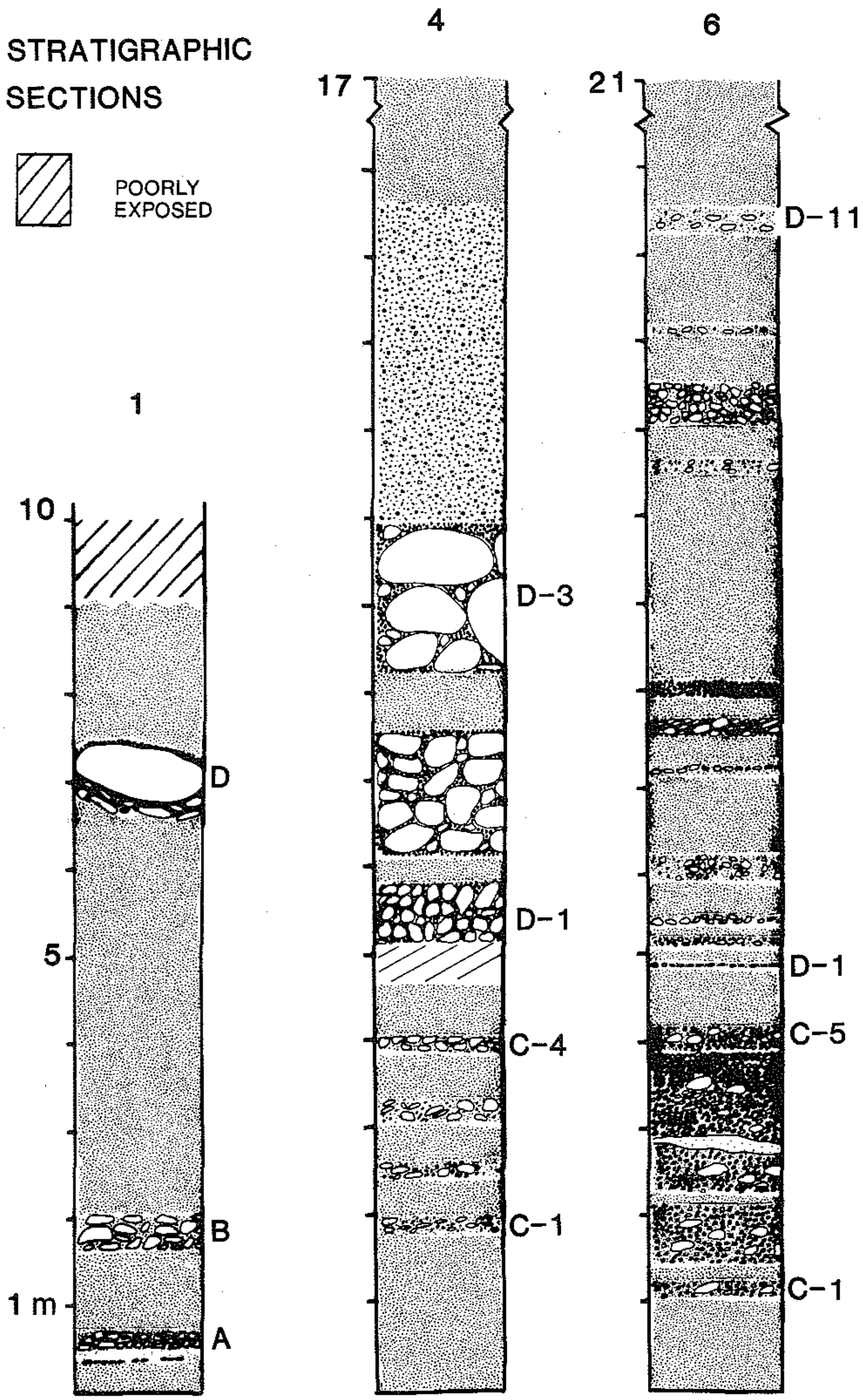

Figure 4. Stratigraphic sections 1, 4 and 6 (fig. 1) show some of the extreme size variations in clasts within Parfreys Glen.

ates on the flanks of the Baraboo hills are up to 3.0 m in diameter.

Unit C is the most enigmatic of the units exposed in Parfreys Glen, because it is not exposed in some areas where units A, B and D are present and it changes character over short distances. At the stratigraphic interval near section 3, unit C is only one cobble in thickness. Over a distance of 86 meters, unit C increases in thickness to 3.2 m at section 6, where it consists of as many as 5 layers of gravel and cobbles separated by sandstones, with maximum clast size of 15 cm. Twenty-four meters away at section 4, maximum clast size is 58 cm and the unit contains four poorly-sorted cobble layers with a pebbly matrix separated by sand lenses (figs. 2,4).

One layer in unit D is distinctive in all sections measured in Parfreys Glen. The bed contains an unsorted mixture of pebbles, cobbles, and boulders up to 1.5 m in diameter. The variability in clast size is most apparent at section 1, where the maximum clast is 1 m in diameter, whereas most clasts have long axis measurements of 40 cm or less.

Unit D is exposed at many points throughout the glen, but its strata change in thickness and character over the length of exposure. At section 1, the distinctive poorly-sorted layer is 55 cm thick, and at section 2, at least two m thick. In the lower part of the glen (sections 1, 2 and 3), this bed is the only exposure of unit D. Unit D contains numerous conglomerates at least four m thick separated by sandstones at sections 4, 5 and 6 (figs. 1, 2 and 4). These conglomerates extend only a short distance along the exposures in the glen, and the bed exposed in the downstream sections (1, 2 and 3) is the only continuous one. The largest and most numerous grouping of exposed boulders is at section 4 (fig. 2).

Summary of Sedimentological Features

The four conglomerate units recognized in Parfreys Glen differ in their main features (table 1). The upper units C and D show wide variations in thickness, number of individual clast layers, and average and maximum size of clasts over the length of exposure. Units C and D are also characterized by pebbly matrices, larger average clast sizes, more variable sizes within layers and some non-horizontal clast orientations. The lower units (A and B) are much less variable. Units A and B have sandy matrices, smaller average clast sizes, and generally horizontal clast orientations.

Paleocurrents

Information on paleocurrents indicated by trough and tabular cross-bedding orientations in Parfreys Glen was collected by Dott and Byers (1980). They discovered a strong unimodal dip toward the east and southeast with a smaller number of measurements dipping to the south-southwest. Judging from the diagram in Dott and Byers (1980), these measurements were taken from sandstones within units here designated as A, B, and C. In the sandstone above unit D, axes of trough cross-strata dip east-northeast and west-southwest, whereas tabular cross-strata in the same sandstone show modal dips to the east-southeast, south east and north-northeast (Dott and Byers, 1980). These data may mean that the transport directions changed radically between the deposition of the conglomerate layers and the overlying sandstone.

Limited observations of pebble orientations within the conglomerate layers tend to confirm the findings of Dott and Byers (1980) who concluded that most pebbles were oriented with the ab plane nearly horizontal. However, they found that clasts in unit D dipped gently west. Imbrication in the few exposures examined in this study consists of north-dipping clasts indicating flow to the south.

SEISMIC REFRACTION RESULTS

A seismic refraction survey determined the three dimensional geometry of the deposits and provided enough information to refine paleogeographic interpretation at Parfreys Glen. The materials present in Parfreys Glen fell into three seismic units: 1) an unconsolidated surficial layer up to a few meters thick, including weathered sandstone, alluvium, colluvium and glacial materials. This layer conducted seismic waves at velocities from 309 to 744 meters per second, with an average of 416 meters per second with a standard deviation of 102 meters per second (table 2). In only one case was the velocity higher than 600 meters per second. 2) An intermediate layer of sandstone was present in about half of the traverses, mostly in the central part of the area between the creek and Bluff Road (fig. 3) where it was up to 122 feet (37.2 meters) thick. It conducted seismic waves at velocities form 634 to 1866 meters per second, with an average of 1156 meters per second with a standard deviation of 381 meters per second. 3) The Baraboo Quartzite conducted seismic waves at velocities of or greater than 2185 meters per

Table 2. Seismic refraction: velocity measurements and depths to sandstone and quartzite (Depths to contacts in meters, velocities in meters per second)

SITE	SURFICIAL VELOCITY	DEPTH OF CONTACT	SANDSTONE VELOCITY	DEPTH OF CONTACT	QUARTZITE VELOCITY
1	383	2.0	634	7.6	3005
2	443	–	–	10.2	2552
3	–	–	1111	1.8	3750
4*	360	3.3	1192	(Lower contact not found)	
5	744	4.8	1866	21.8	4234
6	366	–	–	3.7	3664
7*	(See footnote)				
8	462	–	–	12.8	2636
9	377	–	–	6.1	2185
10	371	4.4	888	16.8	4872
11	395	3.0	794	17.7	2534
12	406	–	–	6.1	3000
13	333	–	–	3.4	4250
14	359	2.9	951	12.8	3574
15	577	–	–	3.7	4245
16	–	–	1381	4.9	3737
17	385	2.1	1857	7.1	4000
18	376	6.1	783	37.2	3966
19	335	3.5	1138	10.5	4805
20	370	3.8	1094	15.2	3548
21	433	6.1	1342	22.7	2987
22	509	–	–	5.3	5956
23	309	–	–	2.4	2334

**Seismic sounding done only to find a typical velocity for a rock unit (sounding #4: sandstone in Parfreys Glen; sounding #7: quartzite near Elephant Rocks in Devils Lake State Park).*

second with an average of 3641 meters per second with a standard deviation of 964 meters per second. There was no overlap in velocities between the sandstone and the quartzite and nowhere in the study area did the quartzite outcrop at the surface.

In about half of the seismic profile locations the interface between the quartzite and the overlying material was smooth and clearly visible on the travel-time graphs, as in figure 5. In other cases the boundary was topographically irregular or at a considerable angle to the modern ground surface, making the graphs more difficult to interpret, as in figure 6. In no case were the results impossible to use. The graphs which show a break in slope for the quartzite indicate irregularities in the floor of the ancient valley. Examples of irregularities include the ledges and knobs like those found on the hills in Devils Lake State Park and the sand-filled joint openings and joint slopes in La Rue Quarry.

The quartzite surface represents a wide, gentle valley or cove, (fig. 3). The valley measures at least 0.8 km in length from north to south, surrounded by steeper slopes on the southwest and northeast and ranges in width from 0.1 to 0.7 km. The valley in the quartzite surface trends southwest in the northern part of the area and southeast south of section A-D (fig. 3). Although this valley trends parallel to the trend of the modern stream in Parfreys Glen, the difference between the SSE direction of the modern stream and the SE trend of the older valley is important in explaining the SE trend of paleocurrents recorded in the sediments.

The ancient valley under Parfreys Glen is generally broad and flat-floored. Its average gradient is about nine percent, although there is a gentler-sloping area of about four percent near the lower part of the glen. The steepest-sloping part of the ancient valley is between the lower part of Parfreys Glen and the abandoned Parfreys Glen Park water well (NW 1/4, SW 1/4, Section 23, T 11 N, R 7 E) where the slope reached 15 percent.

The modern stream is displaced to the west relative to the axis of the ancient valley or cove in the quartzite surface (fig. 7). As a result, only sediments deposited in the western part of the old valley can be studied in detail in the walls of Parfreys Glen. Section A-D (fig. 7) shows that the stream has cut through most of the sediments in the western part of the sediment package. On the sides of the ancient valley, Phanerozoic sediments, including Cambrian sandstone and conglomerates and Pleistocene sediments, are less than 15 m thick. The axis part of the ancient valley, east of Parfreys Glen, is covered by a sediment package which is twice as thick as on the valley sides. Paleozoic sandstone and drift reaches a thickness of at least 37.2 m at point C (figs. 1, 3, 7). Evidence from wells in the vicinity of Bluff Road and at the mouth of Parfreys Glen indicates that conglomerate layers are found throughout the west-to-east extent of the Paleozoic sediment package and are not confined solely to the western flank.

South and east of the study area the Phanerozoic sedimentary blanket again thickens as the quartzite surface dips off into the uncharted depths of the subsurface. Near the Parfreys Glen Park water well (location given above), well log data shows that the quartzite is more than 30 meters below the surface. Driller's reports on water wells at Devils Head Lodge on the east side of the ancient valley indicate that near the barn at the base of the South Range on Bluff Road (NE 1/4, SW 1/4, Section 23) the quartzite is 58 m below the present topographic surface. It drops off to more than 80 m below the surface at an irrigation well in the SW 1/4 of Section 23 (east of Bluff Road, fig. 3). The ground surface south and east of the study area is nearly level.

INTERPRETATION AND DISCUSSION

The results of the seismic survey indicate that some of the boulders exposed in the glen may actually be quite close to their source area. They may have become rounded within a short transport distance, since the glen runs along the base of a high quartzite slope. During the Cambrian this slope was the west wall of a nearly kilometer-wide valley. The height of the hillside west of the glen is more than 150 meters from the floor of the glen. The hill must have been at least as high and steep when the sandstone was deposited as it is now. It is conceivable

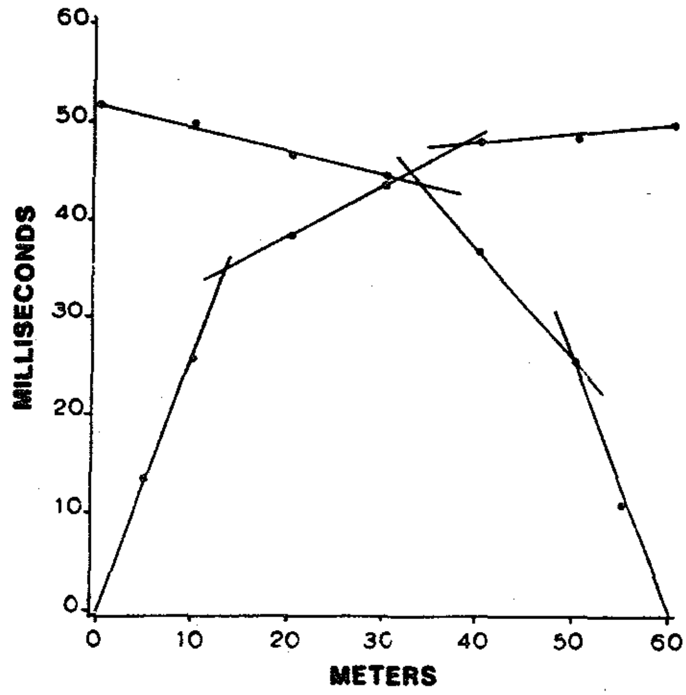

Figure 5. Site 20. Example of a travel-time graph displaying a close fit of points on the line segments. A change in slope indicates that wave speed changed, because the wave entered a different material (e.g. from sandstone to Quartzite).

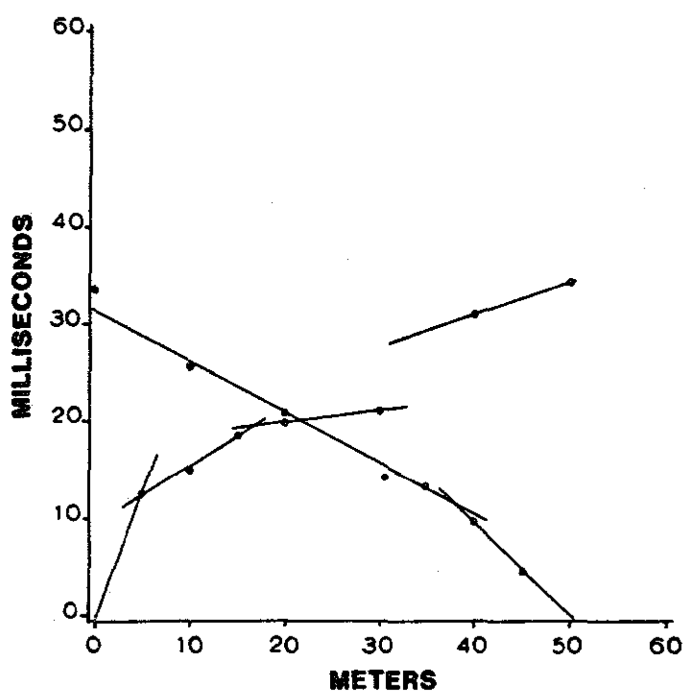

Figure 6. Site 17. Example of a seismic travel-time graph which was difficult to interpret. There is probably a ledge in the quartzite surface here; see Figure 3 for site location.

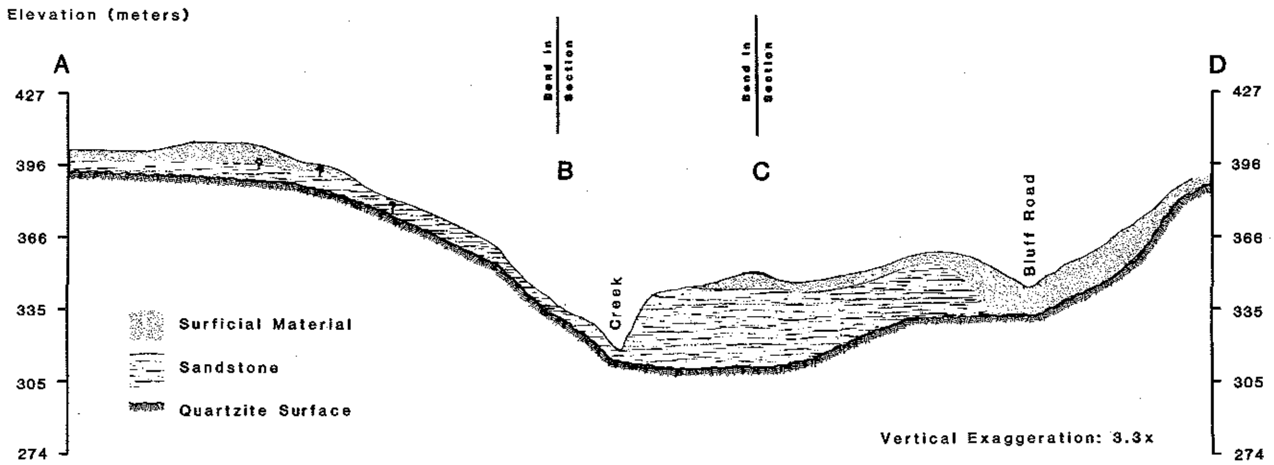

Figure 7. Seismic cross section A-B-C-D, showing Precambrian Baraboo Quartzite surface, upper Cambrian sandstone and conglomerate, and surficial material.

that the boulders in the conglomerates of Parfreys Glen could have weathered from topographic irregularities on the hills above the glen and washed down to be deposited with little lateral transport. The proximity of the glen to the hillside may also help explain the apparent eastward aspect to the dip of the conglomerate layers as sketched by Dott and Byers (1980). The Cambrian sediments may be draped into the Precambrian valley, dipping toward the valley center along the margins but dipping parallel to the valley axis in the center.

The vertical changes in the conglomerate layers exposed in Parfreys Glen indicate a coarsening upward sequence truncated and topped by a fine sandstone above the uppermost conglomerate. In individual sections, such as 1 and 2, where units A, B, and D are exposed, unit D is thicker, has larger clasts and a pebbly matrix. Unit B has a larger maximum and average clast size than unit A (fig. 2). The general upward increase in conglomerate layer thickness, proportion of pebbly layers to sand layers, and pebbly matrix indicates either increased proximity to the source of the quartzite clasts as might be caused by a prograding shoreline (Davis, 1983), or increased strength of the transporting and depositional mechanism (such as stronger storms or more extreme river floods). Furthermore, this coarsening upward developed despite the filling of the pre-existing valley by at least 25 m of sediment by the time unit D was deposited.

The lateral increase in clast-sorting from north to south (observed within individual units) suggests that most of the sediment moved down the axis of the pre-existing valley. The paleocurrent measurements recorded by Dott and Byers (1980) in the stratigraphic intervals of units A, B, and C also support the general pattern of sediment movement down the axis of the pre-existing valley with smaller amounts of sediment moving down the valley walls toward the axis.

Sedimentologic features of conglomerate units A and B support the hypothesis that these are storm deposits. The layers are uniformly thick over the extent of their exposure in the glen and contain uniformly-sized clasts. Both layers are laterally continuous. The horizontal orientations of the clasts in this unit is a feature that can be produced by storm surges moving away from cliffs and shorelines onto the nearshore (Kreisa, 1981). These layers seem to be widely distributed, uniform records of single storm events with a matrix that has filtered between the clasts after deposition.

The major difference between units A and B is the angularity of the clasts in unit A. The angular clasts probably were locally derived and did not undergo much transport before deposition. The more rounded clasts in unit B, however, indicate abrasion during transport. The disc-shapes common among these clasts suggest that they were worked on a beach prior to offshore deposition during a storm (Dobkins and Folk, 1970).

Sedimentological characteristics of units C and D are less consistent with a marine storm wave mechanism. Storm waves generally have the capacity to sort and winnow clasts of different sizes, yet the conglomerate layers in unit D are unsorted and many retain this unsorted character throughout the exposure (see unit D at section 1, fig. 2). Furthermore, the discontinuous layers within units C and D, many of which extend only a short distance down the glen, are inconsistent with a storm wave mechanism, which could be expected to spread cobbles over a wider area (Clifton, 1973).

Another problem with the storm deposit hypothesis is the paleogeographic environment. For much of the time represented by these deposits, there was a cove at this site which may have protected the area from storm waves generated further off-shore by refraction and attenuation of waves around the headlands (Leeder, 1982). Many (but not all) waves attenuate while passing over shallow shelves (Ritter, 1986).

An alternative is that of a stream moving into the shallow marine depositional basin from the north down the axis of the ancient basin. The conglomerates exposed in the Narrows section of Parfreys Glen (near sections 4 and 5, fig. 2) resemble deposits found in proximal braided stream environments (Miall, 1977). The unsorted nature of the conglomerate layers in units C and D, and the lateral variations in thickness and clast size over short distances are characteristics of proximal stream deposits. Dott and Byers (1980) have suggested that stream-deposited clasts would not be as rounded as those in Parfreys Glen. The rounding of the clasts could be explained by abrasion as well as transport in a stream (Schumm and Stevens, 1973).

Many of the cobble layers in units C and D have a pebbly matrix also composed of Baraboo Quartzite. Since clasts and pebble matrix have a uniform source, there is no problem explaining the discontinuous sandstone layers which may contain far-travelled sand grains. All quartzite clasts and pebbles may have come down the paleo-valley axis. As quartzite clasts and pebbles were transported down the valley axis, previously deposited sand layers may have been reworked as streams in flood carried cobbles onto the sands.

CONCLUSIONS

This study of the Cambrian conglomerate layers in Parfreys Glen and the underlying Baraboo quartzite shows that Cambrian sedimentary rock is at least 37.2 m thick in the thickest area and no more than 15 m beneath Parfreys Glen. There are important vertical and lateral variations within and between conglomerate layers exposed in Parfreys Glen. The lower units, A and B, and specific conglomerate layers within unit C have sedimentological features which indicate a storm deposit origin. Parts of unit C and most of unit D, however, may have been deposited by streams in flood that rounded the clasts by abrasion and transport and deposited them in a shoreline embayment.

The presence of larger clasts in upper layers indicates that larger clasts were transported into the cove at the time represented by unit D. Either the shoreline had prograded into the cove (if these are storm deposits) or the water depth decreased, allowing streams to transport material further into the basin.

The deposits in Parfreys Glen have been cited as examples of episodic sedimentation by Dott (1983). This study indicates that two kinds of episodic mechanisms (marine storms and floods) acted in the Cambrian cove at Parfreys Glen.

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