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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA
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By

A. MacS. Stalker

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
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Preface

The presence of large blocks of quartzite resting on the thick glacial drift and bedrock along the foothills of southern Alberta was first reported in 1863 and these blocks were then recognized as glacial erratics. Various observers have put forward conflicting hypotheses as to their origin and mode of emplacement.

The author of this report has made a systematic study of these erratics from the International Border northward to the latitude of Edmonton. As a result of this study some conclusions have been reached as to the probable origin of the erratics, the mode of transportation, and the relationships of the Cordilleran and Laurentide ice-sheets at this stage.

GEORGE HANSON,
Director, Geological Survey of Canada

OTTAWA, January 13, 1956

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THE ERRATICS TRAIN, FOOTHILLS OF ALBERTA

Introduction

Large blocks of quartzite and pebbly quartzite, scattered along a narrow belt in the foothills of southwestern Alberta and the adjacent plains, have attracted considerable attention ever since their first discovery. The largest and best known of these is 'Big Rock', just north of the highway to Turner Valley at a point 5 miles west of Okotoks. It is easily accessible and has proved quite a tourist attraction, with several hundred people stopping to examine it each year. It has a mass of about 18,000 tons. Other blocks, though smaller and less accessible, have also attracted attention and have added to the speculation regarding their origin. Several of the blocks are outstanding enough to form landmarks, and a few have been named. These include, besides 'Big Rock', the Glenwoodville erratic (section 29, township 5, range 26, west fourth meridian), and the Beddington erratic (section 26, township 25, range 1, west fifth meridian).

In 1952 the writer undertook the study of these 'boulders' with a view to solving the mystery of their origin and the manner of their emplacement. It was generally assumed at that time that they were erratics brought eastward by Cordilleran ice, by valley glaciers, or by ice-rafting, from the Rocky Mountains 50 or more miles to the west. It was hoped that the general direction of ice movement from the mountains could be determined by means of these characteristic erratics, and that the eastern limit of Cordilleran glaciation might also be defined. The problems connected with the erratics were soon found to be more complex than previously thought, and doubt arose as to whether the blocks did represent eastward movement of mountain ice. Dr. Wickenden, of the Geological Survey of Canada, who had previously studied many of the blocks, had noted (oral communication) that they seemed to be missing farther west, nearer the Rocky Mountains, and suggested that they might consist of a fairly narrow belt along the foothills, and that they might be connected with Laurentide glaciation. Wickenden also reported blocks of similar type rock south of Magrath, in a region where they had not been recorded previously. As the importance of the blocks to the interpretation of the glacial history of the region was realized, the study of their occurrence was continued in the field seasons of 1953 and 1954.

Previous Work

The occurrence and character of the large erratics have generally been noted as a sideline to other work and hence there are all too few references to them in the literature. They were first mentioned by Dr. Hector, geologist of the Palliser exploration of British North America, who states (Palliser *et al.* 1863, p. 221)[1]: ". . . at 3,700 feet above the sea, and 50 miles from the Rocky Mountains, there occur a very extraordinary group of

[1] Names and dates in parentheses are those of references cited at the end of this report.

blocks of granite, resting on a high plateau formed of sandstone strata. These blocks are of great size, one having been estimated to weigh 250 tons. Although lying in a line, miles apart, they seem to consist of the same rock, viz., a mixture of quartz and red feldspar, the latter predominating, with only faint traces of mica disseminated in very minute flakes. They present smooth surfaces, although, in general, they are rhomboidal in form. Some of them are cracked into several pieces, which are quite detached, but are evidently parts of the same block. If these blocks were derived from the granite belt to the east, as I believe all the erratics of the prairies have been, they must have travelled at least 400 miles. From the fact, however, that they are beyond the western verge of the drift, and the boulders were found, as a rule, to diminish in size in that direction, it may be that the presence of these blocks is due to very different agencies, different at least in the time of their occurrence".

Though Hector referred to the erratics as 'granite', he undoubtedly was referring to the numerous erratics of siliceous sandstone and quartzitic conglomerate north-northwest of Calgary, which have some resemblance to granite. The exact location cannot be determined from the general map accompanying the report, but the erratics mentioned were probably those bordering Beddington Creek or others near MacPherson Coulee, or possibly those in townships 26 and 27, range 29, west of the fourth meridian, which lie on a high sandstone plateau.

The boulders also aroused the interest of G. M. Dawson who states (1885, pp. 148c and 149c): "Very large boulders were noted in a few places in the district. A remarkable group of these, composed of Huronian quartzites, occurs near the lower part of the Waterton River, and it is notable generally that some of the heaviest boulders are found not far from the western limit of the Laurentian and Huronian drifts. One of these erratics is 42×40×20 feet, a second 40×30×22, and both are partly buried in the soil. The height of this point was not exactly determined, but must lie between 3,200 and 3,300 feet. In common with all the larger boulders of the district these are surrounded by a shallow, saucer-like depression, caused by the pawing of the buffalo, and their angles are worn quite smooth and glossy by the rubbing of these animals upon them".

Williams and Dwyer (1930, p. 76) report that the boulders in the southwest quarter of section 29, township 5, range 26, west fourth meridian at about 3,550 feet elevation are probably the ones referred to by Dawson. They further report (p. 102): "Another huge boulder occurs near the Springridge-Brocket trail about 4 miles southeast of Brocket. The quartzite is very angular and in shape quite unlike boulders from the east. The rock seems identical with the Cambrian quartzites of Waterton Lakes and Windermere regions, and moreover a boulder of conglomerate about 8 feet in diameter, apparently belonging to the Blairmore formation, was found 4 miles east and 1 mile south of Brocket at about 3,800 feet in elevation. It seems, therefore, that these huge blocks have come from the Rocky Mountains, carried on the ice of the mountain glaciers, which locally overlapped the morainal deposits of the continental ice".

The boulder referred to the Blairmore formation is undoubtedly of a different type than the other erratics, which definitely did not come from this formation. Williams and Dwyer continue: "Along the banks of Willow

creek west of Stavely and Claresholm are a number of angular boulders 2 to 3 feet in diameter, which were quite unlike erratics from the east and were probably derived from the Rocky Mountains. A very large boulder of the same character was found in the Porcupine Hills at an elevation of 3,450 feet in sec. 8, tp. 14, range 28, W.4th mer. It was roughly tetrahedral in shape with sides 20 feet long".

Hume (1931, pp. 267-268) mentions these erratics in discussing overthrust faulting in Alberta, and suggests that such faulting may have brought them from the west. He says the blocks are suggestive of rocks known in the mountains to the west and states: "These blocks must have been transported long distances from the west. It is difficult to understand, if ice was the transporting agency, why the blocks would not be broken up and strewn over a wide area. The size of the blocks and their occurrence along a line which in a rough way parallels the foothills belt therefore suggests erosion remnants of a fault plate which at one time covered the entire foothills in this area".

Hume's figure 6 illustrates Big Rock west of Okotoks. Hume later discarded the possibility of the blocks being fault plate remnants (*see* Rutherford 1941, p. 120).

Allan (1939, 1942, and 1943), in summarizing geology for Alberta soil survey reports, assumes that mountain or alpine glaciation brought the erratics to their present positions, and uses them to determine eastward extent of such glaciation. He states (1939, p. 94): "The most easterly extension of these glaciers is not yet known but large boulders of quartzitic sandstone from the mountains were observed at an elevation of about 3,500 feet above sea-level, between the Belly and Waterton Rivers, four miles northeast of Glenwoodville in the southwest corner of section 29, township 5, range 26, W.4th meridian. This boulder is 25 feet high, 50 feet long and about 35 feet wide above the surface. Other smaller boulders of similar quartzitic sandstone were observed about 12 miles north of Cardston in the Blood Indian reserve".

Allan (1942, p. 113), also states: "The large boulder known as the 'Big Rock', on the north side of the highway, 8 miles west of Okotoks in section 21, township 20, range 1, has been deposited there by the mountain glaciers. It consists of quartzitic sandstone. Other smaller boulders of the same kind occur to the south in range 1 and farther west around Longview".

Allan (1943, p. 121) also states: "Rock debris from the mountain ice-sheets is distributed as far east as the fifth meridian at Calgary. Large glacial erratics and smaller glacial boulders of quartzitic sandstone were observed by the writer from the southeast corner of the Banff sheet at Calgary, north through the centre of range 1, across MacPherson coulee to the top of township 28, three miles west of Crossfield; in a northwesterly direction to Cremona and north to the Little Red Deer river at Elkton in township 31, range 4, west of the fifth meridian. In some places the drift is thin and the boulders are close to bedrock.

"The largest glacial erratic observed in this map-area is the Beddington boulder which occurs close to Nose Creek on the east side of the Canadian Pacific Railway, in legal subdivision 9[1], section 26, township 25, range 1,

[1]Note. This boulder lies in legal subdivision 11.

west of the fifth meridian, five miles north of Calgary. This erratic consists of quartzitic sandstone, with rose and opalescent quartz grains, well-bedded and possibly derived from Lower Cambrian strata within the Rocky Mountains to the west. This glacial boulder measures 24 feet long, 23 feet wide and 15 feet high above the surface of the ground. The depression in which the boulder occurs is eight feet deep and has been formed by wind action and by the tread of animals rubbing against the rock. Other boulders of similar quartzitic sandstone were observed by the writer in a number of places in townships 25, 26, 27, 28, range 1 and in townships 28, 29 and 30, ranges 2, 4 and 5 respectively."

Illustrations of the Glenwoodville erratic (Allan 1939, Plate 4, figure 1) and the Beddington erratic (Allan 1943, Plate 4, figure 1) are contained in these reports.

Atwood (1940, p. 270, Figure 133) describes Big Rock, which he states is the largest known erratic in North America, as being 80 feet long, by 40 feet wide, by 30 feet high. The writer believes that Atwood refers only to the larger of the two main blocks forming this erratic, for if the blocks were reassembled into one, which seems logical from their disposition, it would measure 135 feet by 60 feet by 30 feet.

Rutherford (1941, pp. 119-123) summarizes previous literature and lists the more important of the erratics then known. He suggests that the transportation and distribution of the boulders are related to the ponding of waters in front of the Keewatin ice-sheet, the erratics being ice-rafted to their present positions, and hence not directly related to the main Cordilleran glaciation. He mentions that they occur within an area containing Keewatin drift. He states (p. 122): "In the opinion of the writer, these large erratics all came from the Waterton Lakes district. They apparently were transported a short distance by mountain glaciers, but their chief mode of transportation was by floating ice in bodies of water impounded in front of the retreating Keewatin ice. They moved eastward and north for distances up to 125 miles. Their sizes and shapes seem to preclude any long distance movement within moving ice".

Rutherford points out that the largest of the erratics (Big Rock) would float if enclosed in 5,500,000 cubic feet of ice. He further states: "The distribution with respect to elevation and topography is significant and indicates that the movement of such boulders only occurred for a comparatively short time. Apparently, when the ice front had retreated some distance eastward and northward, there were no lakes extending from the ice front to the points near the front range at Waterton. There may have been some slight movement to lower levels after their deposition from the ice, but the surface features at the sites of most of the large boulders are gently undulating".

Horberg (1954, p. 1118) agrees that ice-rafting seems the best explanation for certain large boulders present in the southwestern part of the province. The boulders to which he refers, in part at least, belong to the erratics presently being discussed.

Distribution

The present study has revealed the occurrence of great numbers of these quartzite and pebbly quartzite erratics, particularly of medium-size ones (5 to 25 feet in diameter), and greatly extended their range. They

no longer appear as local isolated blocks of similar type rock, but as an erratics train, generally only a few miles wide, stretching for 350 miles along the foothills and into the plains. The most important extensions of the train made by the present study are to the north and to the southeast, and they probably extend beyond the limits of the area examined. In addition, many more erratics have been found in the neighbourhood of those previously known.

The erratics train as shown on the map is not continuous but has large gaps. These gaps represent, in the main, areas that have not been studied or in which the erratics may be buried under lake deposits. Where till plains occurred along the trend of the erratics train, and at elevations at which it was thought the erratics should occur, they were invariably found.

The studies were not carried north of township 53, about the latitude of Edmonton. Farther northward, study of the boulders would require increasingly more time as there are few roads and the country is thickly forested, but it is hoped that others will be on the lookout for similar blocks and will record them. Those erratics mapped west of Edmonton represent a quick survey along highways, where clearing of the trees has made them more easily observable. No mapping was done from township 50 southward as far as Rocky Mountain House, where quick study under similar conditions revealed those shown on the map. T. Peters of the Dominion Soil Survey located many of the blocks in townships 36, 37, and 38 before the writer visited them. The gaps in the erratic belt in townships 33, 34, and 35, and also in townships 8, 9, 10, are partly due to lack of thorough examination in these regions, but mostly due to extensive lake deposits that may have buried the blocks. Gaps southeast of Magrath as far as Coutts may represent destruction of the train by overriding later ice. The other gaps represent areas that were not studied. Further mapping should close most of the gaps and extend the train northwestward, perhaps into British Columbia.

Description

The erratics were first reported in the open plains and foothills of the southwestern part of the province, where many of the larger blocks are visible for several miles. In the wooded country north of township 31 they are less noticeable. It was the large size of many of the blocks that first attracted attention, and this is their outstanding feature. During many seasons mapping farther east on the plains the largest boulder of other rock type seen by the writer was 18 feet in greatest dimension, and erratics longer than 10 feet are rare. However in Table I are listed thirty-four blocks of this erratics train that are 20 or more feet long, and of these ten are more than 30 feet long. The great bulk of the blocks are more than 2 feet in largest dimension and most of the smaller fragments lie near larger blocks off which they may have broken.

Another characteristic that early drew attention to the large erratics was their lithology, which contrasts markedly with the other boulder erratics. The rock is very uniform in character over the entire length of the belt studied. The writer classifies the rock as quartzite and pebbly quartzite. The blocks are generally referred to in the literature as quartzites or as being quartzitic, and in the first record of the blocks it was called a granite. Though some of the massive blocks do give the impression of a

coarse-grained granite, the rock is clearly sedimentary. It consists mostly of fine pebble conglomerate and coarse, massive to bedded quartzite, cross-bedding being commonly displayed. The coarse quartzite and conglomeratic horizons are commonly separated by a siltstone or shaly bed, $\frac{1}{4}$ to 1 inch wide. Quartz veins of about the same thickness also occur in a few of the blocks. The rock commonly breaks along these beds or partings and along the veins. The pebbles in the conglomerate are rounded to sub-angular, and most are between $\frac{1}{4}$ and $\frac{3}{4}$ inch in length, though cobbles as long as 5 inches are present in a few of the blocks. These pebbles consist largely of quartzite and chert. The pebbles and grains are well cemented so that the rock commonly breaks across them. The rock is hard and tough, and readily distinguishable from other types of sandstone and conglomerate boulders derived from the nearby foothills. From a short distance the rock has a light grey, pink, or a purplish appearance.

Despite the hardness of the rock, the blocks are very susceptible to frost action. They split readily along the thin silt beds and along joints, and the various pieces soon separate. It is said that one major break in Big Rock is separating at the rate of nearly an inch a year, but the accuracy of this statement is difficult to assess. At the moment this crack (trending west and dipping steeply) is about $3\frac{1}{2}$ feet wide on the average, measured at the joint plane 3 feet below the surface of the rock. The blocks rarely show significant weathering aside from frost action. The prominent exfoliation on one side of a 40-foot long block in section 29, township 12, range 28, west of the fourth meridian probably occurred largely before the erratic was brought to its present position.

Most of the blocks are angular in shape and rectangular in outline. They can thus be listed by length, breadth, and height (*see* Table I). The bedding in most of the blocks is horizontal, or nearly so, and the blocks are therefore flat-topped. Where the blocks are on edge and the beds dip steeply the blocks tend to be pointed or ridged. Frost action has split many of the larger blocks into two or more pieces, and the cracks now range in width from an inch to several feet or the pieces may be scattered at various angles of repose. The various pieces generally retain their relative positions, and could be refitted to form the original block. This splitting is very evident in Big Rock (section 21, township 20, range 1, west fifth meridian), where each of the blocks has undergone successive splittings. It is probable that local groups of moderate-size erratics were carried to near their present positions as single large blocks, perhaps as large as Big Rock, and were broken and scattered during grounding and final emplacement.

No glacial striæ were discovered during careful examination of many of the blocks and it seems probable that none was produced during transportation of the blocks to their present positions. The known erratics of the train are listed in Table I, in a general sequence from south to north. These are beyond doubt only a small part of the total number of blocks, but represent all examined up to the present. One quarter section which lies athwart a branch of the main train was examined thoroughly and this explains the large number of erratics listed for the southeast quarter of section 22, township 26, range 29, west fourth meridian. Though this is one of the regions in which the erratics are most abundant, many other districts have nearly as many. Moreover it is unlikely that all on the surface in this quarter section were noted, and still others may be buried. This quarter section

indicates the number that would be revealed by complete mapping of the erratics train, and the amount of rock of this type moved. Elsewhere most of the erratics listed are those that were encountered in the normal course of mapping the surficial materials, no special efforts having been made to find them.

Whenever possible the dimensions and weight of the individual boulders are given. These were measured or estimated in the field, and allowance was made for the width of cracks between pieces of what were obviously single blocks originally. In estimating weights 150 pounds per cubic foot was used for the density. In many cases there are discrepancies in the dimensions of erratics recorded by various observers. This is largely a result of the difficulty of estimating the size of the irregular-shaped or non-rectangular blocks. The dimensions given in Table I for most of these erratics are those taken during the present study. Elevations were estimated from maps of various accuracies and different contour intervals, but most of the elevations given should be within 50 feet of the true figure. A few elevations were found by Paulin barometer, and the accuracy in these cases is probably of about that order.

Features of the Erratics Train

The present study has revealed several features of the erratics train that were not previously known. It is narrow relative to its length and rarely widens or fans out. The map gives an impression of a train wider than it is in reality, as a whole section of land is blocked in though but a single erratic may occur on the train side of the section. The widening indicated north of Calgary is caused by a separate branch of the train east of the main string of blocks.

The study has also revealed a general constancy in average size and in concentration of the erratics along the length of the train, except perhaps in the southeastern part. The apparent increases in number of erratics locally, as in townships 12 and 26, are in the regions most studied and further mapping may well show that the concentration is more uniform.

The erratics train lies near what is generally regarded as the approximate zone of contact of the Laurentide and Cordilleran ice-sheets, but stones of certain types found in the drift for some distance to the west of the chain of erratics indicate that the area was occupied at least once by Laurentide ice. Locations of some of these stones are shown on the accompanying map. The writer believes that, although Cordilleran ice either as valley glaciers or piedmont glaciers may have overriden at an earlier period much of the area now covered by the train, at the time of distribution and emplacement of the erratics, in the south at least, Cordilleran ice lay appreciably farther west.

The erratics end abruptly on the east but are numerous right up to this line. In contrast, on the west, in all districts examined there is a gradual decrease in number until none is present. Elevation seems to control their eastern limit, though there is a steady change in the elevation of this limit over a considerable distance longitudinally. The eastern edge of the train is not thoroughly enough mapped to indicate accurately the overall change. However, from the United States border northward to west of Claresholm the elevation of the eastern margin is about 3,400 feet. There is a northward

rise from there to about 3,550 feet near Calgary[1] and 3,600 feet in townships 31 and 32 (further mapping may lower this latter figure). Northward from there the elevation of the eastern margin, though based on only a few blocks, seems to lower again, to about 3,550 feet in townships 36 to 40, and perhaps as low as 3,100 feet in townships 50 to 53. The western boundary of the erratics is less definite, but it also may be controlled by elevation. In general the highest erratics, most of which are near the western edge of the train, are 400 to 500 feet higher than the lowest erratics to the east.

The relation between elevation and distribution of the erratics is strikingly demonstrated northeast of Calgary. The lowest members of the boulder train in these townships are at an elevation of about 3,550 feet. Northeast of Calgary, and separated by low land from the main mass of high land to the west, is a broad ridge that rises to an altitude of about 3,700 feet and which is mostly higher than 3,500 feet. A branch or offshoot of the boulder train, separated from the main band by the low land, lies on this ridge, with blocks as low as 3,550 feet. The erratics are thickly strewn over an area 15 miles long and ½ mile wide, but are absent in the neighbouring areas. This branch was given more study than any other part of the boulder train, and its location seems to have been entirely controlled by the elevation of the hill, which rises to that of the main erratics train in these townships. Further mapping may reveal additional local branches.

Another feature of the boulder train, as shown by the map, is that its eastern border is not influenced by adjacent passes in the mountains to the west, through which valley glaciers once flowed. There is no apparent eastward expansion or lobing of the train opposite the chief of these passes, the Bow valley, or any of the others. Furthermore the map does not reveal any increased westward range of the erratics opposite these passes, as might be expected if the erratics had been brought down them.

Depressions and Polishing

Most of the erratics lie in shallow, normally circular, depressions, 1 foot to 8 feet deep with a diameter generally two to four times the length of the erratic. On slopes the depressions may be present only on the upslope side of the erratics, but on fairly level ground the depressions completely surround them. There are no outlets or cuts in the rims of these depressions, as would be expected if they had been caused by running water, but rather they commonly contain shallow ponds. The rims do not rise above the general level of the surrounding country. The depressions have been ascribed to the action of buffalos in pawing up the soil material and carrying it off on their coats when they congregated near these boulders, and to wind action carrying off the loosened material. This is a good explanation of most cases, but in a few instances it does not seem probable. This is particularly evident in the case of the depression surrounding the large erratic in the northwest quarter of section 22, township 25, range 1, west fifth meridian, where sections of the block are undermined in a manner

[1] There are a few exceptions, such as the several erratics in an old spillway of the Bow River, that may have slumped or been carried to their present low position subsequent to their original deposition, and the one marking the former position of Fort Calgary, which may have been brought to its present low position for use as a marker.

that could not possibly have been done by buffalos. A similar situation exists in the case of several other large blocks. In addition, noticeable principally in the Blood Indian Reserve but also elsewhere, similar depressions 1 foot to 2 feet deep occur in the otherwise level surface of the plain. It was discovered by digging that these depressions commonly occur above buried erratics, and in many instances the bottom of the depression is formed by the boulder. It is difficult to see how buffalos could be responsible for forming depressions in which there was no boulder showing above the surface to attract them.

B. G. Craig, of the Geological Survey of Canada, has investigated similar depressions in Saskatchewan, though much larger relative to the size of the boulders they surround than the ones seen in Alberta. He too concludes (oral communication) that some of the depressions could not be the work of buffalos, partly because of their large diameter. He also describes one depression that contains so many small, rounded boulders that buffalos certainly would have avoided the vicinity. Many of the depressions around erratics in Alberta also contain rounded stones, other than those placed there during clearing of nearby fields. Craig suggests that frost and wind action together may be responsible for forming many of the depressions.

Wind is not believed to have played a large role in forming the depressions seen in Alberta. The depressions are similar on the sides of the blocks facing and away from the prevailing winds, and show the same characteristics even where protected from the full force of the wind by hills or other obstacles. It is also difficult to see how the wind could be responsible for the depressions above the buried erratics on the Blood Indian Reserve mentioned above.

Several factors undoubtedly contributed to the development of the depressions around the larger erratics. The lack of outlets indicates that water was not an important factor. Frost action may in some cases have initiated the depressions or loosened the material surrounding the blocks for removal by other agents. They may also have been partly formed when the erratics were emplaced and the ice was still present. However later buffalo wallowing, or a combination of wind action and buffalo wallowing, seems requisite in many cases. Removal of the finer material by such means would concentrate the coarser cobble and boulder size material, as commonly seen in the depressions. No large depressions were noted around the few erratics observed in wooded areas, where the buffalos generally did not range, but too few such erratics have been examined to permit drawing any conclusions as to differences in the depressions outside the former buffalo range. Furthermore those so situated are also somewhat sheltered from the wind.

Normally the large erratics of the train and other large boulders in the region are remarkably well polished to a height of 5 feet or so on their corners and to a lesser extent on their sides. The localization of the polish indicates that it is principally the result of buffalos having rubbed their sandy hides against the rocks, though wind may have been partly responsible. Commonly there is a somewhat oily stain in these polished areas.

Source and Transportation of the Erratics

The source of the erratics is not known. Williams and Dwyer (1930) mention Cambrian quartzites in the Windermere and Waterton regions of southeastern British Columbia and southwestern Alberta as being more or less identical in type, and inferred that the erratics came from the Rocky Mountains. Rutherford (1941) gives his opinion that all the then known erratics came from the Waterton Lakes area. Allan (1939) states that they came from the mountains to the west, and (1943) that they are possibly derived from Lower Cambrian strata within the Rocky Mountains, and (1942) that Big Rock was deposited by mountain glaciers. Hume (1931) says the erratics are suggestive of rocks known in the mountains to the west, and that these blocks must have been transported long distances from the west. Hector (1863) and Dawson (1885) thought they had been brought from the northeast.

Rock exactly similar to that contained in the erratics is rare in mapped regions of the mountains to the west, but it is present in the Windermere and Cranbrook regions of British Columbia. Rock somewhat suggestive of the quartzite conglomerate is found elsewhere in the mountains and could also be present in unmapped regions farther north. Similar rock is present in the Precambrian Shield, more particularly in the Great Slave, Nonacho, and Snare groups, all of Proterozoic age and all in the neighbourhood of Great Slave Lake and Lake Athabasca. (Oral communications, J. F. Henderson and C. S. Lord, Geological Survey, Canada.) Similar rock may also be present elsewhere in the Shield. The source of the erratics cannot at present be determined by lithology, though several possible sources can be eliminated.

As mentioned above, Laurentide ice overrode the area of the boulder train, and some of the more westerly occurrences of crystalline erratics brought by it are shown on the map. Stones from the Rocky Mountains are distributed everywhere in the region of the boulder train, but most of them were carried eastward by rivers and streams. Large boulders and angular blocks of western origin are confined chiefly to the country west of the boulder train. It is not possible to determine from the drift whether the erratics originated in the western mountains or in the Shield.

Three methods of transportation have been suggested for the blocks and boulders: glaciers (either Cordilleran or Laurentide), ice-rafting on glacially-dammed lakes, and overthrusting. The overthrusting theory was later discarded by its author (*see above*). A fourth possibility is that the erratics were river-transported to their present sites. This is denied, however, by the distribution of the erratics, both areally and vertically, by the lack of other alluvial deposits, by the enormous size of several of the blocks, their angularity, and the lack of evidence of river valleys or of suitable gradients near many of the blocks. Rutherford (1941), in advocating ice-rafting as the method of transportation of the erratics, inferred that a single, large lake was present rather than a number of small lakes, and this was necessary if there was but a single source for the erratics. The train has since been extended from the few erratics known by Rutherford to a string of them several hundred miles long. There is a general absence of the lake deposits that would be expected from such a large body of water, and it is extremely improbable that a single lake several hundred miles long was

ever contained by ice in this region. There is also a lack of the shore features and run-off channels that would be expected from such a large lake. Ice-rafting as a method of transportation of the erratics thus seems to be eliminated. It therefore seems necessary to accept the hypothesis that the erratics were carried to their present positions by glaciers.

Certain features of the erratics train have been responsible for the persistent search for means other than glaciers for bringing the blocks to their present positions. It was felt that such large blocks of rock could not have been carried far by ice without being broken up, somewhat rounded, and occasionally striated. The direction in which the blocks must have been carried did not always agree with what was thought to be the direction of ice movement. The chief difficulty was, however, the long distances the boulders must have been moved by the glaciers, and the gradients through which they must have been brought. To come from any possible source in the Precambrian Shield would have entailed not only a journey of 500 to 800 miles, but also a rise in elevation of 2,500 feet or more. The blocks, if derived from such a source, were quarried at the base of the glacier, and the writer knows of no method by which such blocks could subsequently be raised to or near to the surface of the ice-sheet. It is difficult to conceive of such large blocks being carried near the base of a glacier for such great distances and being raised 2,500 feet without being broken up or grounded during the journey. It should be remembered, however, that smaller boulders of granite, gneiss, and schist that could have come only from the Shield are scattered throughout most of the area, and have undergone a journey nearly as long. A few of these boulders are 10 feet long or more, but are generally much more rounded and are commonly striated. To have been brought eastward from the mountains by valley glaciers would, had there been a source for the erratics at every pass, have entailed journeys of 50 to 150 miles for the blocks. Valley glaciers could have quarried the rock from the valley sides and received the boulders directly on their surfaces. Moreover there would have been a downhill gradient while in the valley. The present distribution of the boulders would, however, have required lateral spreading of the ice parallel to the boulder train upon reaching the foothills with the gradient largely lost or even reversed. Had only valley glaciers been present the erratics would have been deposited in lobes opposite the valleys. It seems logical to conclude therefore that mountain glaciation alone could not have effected the present distribution of the boulders. The known directions of ice movement make the sources suggested earlier, Waterton Lakes, Cranbrook, or Windermere districts, unlikely. Regardless of the source of the erratics Laurentide ice was necessary to effect their distribution in a narrow belt controlled on the east by elevation. Only Laurentide ice lying to the east could have forced the mountain ice to spread laterally north or south and prevented the valley glaciers from flowing into low lands farther east and spreading the erratics in lobate fans opposite one or more valleys.

The large size of many of the erratics and the absence of striæ indicate that the blocks were carried on or near the surface of the transporting glacier. This would prevent them from being striated by the large amounts of material carried near the bottom of the ice, and lessen the danger of their grounding prematurely in low country. Only if they were carried some distance from the base of the ice-sheet, and not irregularly through it,

could elevation have had such strong control over their distribution. The difficulty of raising such blocks to the surface of a glacier, if they were quarried near its base, without rounding and striation, indicates that the blocks were originally received by the transporting glacier upon or near its surface. This is not possible if the source were in the western parts of the Precambrian Shield with its generally low altitudes, but it is possible with mountain ice flowing down passes in the mountains and quarrying rock from the valley walls. No other source seems possible. A mountain source also entails a shorter journey than the long, uphill movement from the Shield.

The transportation and distribution of the erratics would thus seem to be effected by the Cordilleran glacier supplying the blocks and the Laurentide glacier controlling their distribution. The mountain ice carrying the blocks flowed eastward down one or more valleys to the proximity of the Laurentide ice, and there locally spread over the surface of the southward-flowing Laurentide glacier, or joined with this glacier and was diverted south along its margin. It is more probable that the valley glaciers joined with the larger ice-sheet and that they flowed southward together. There would be some mixing of ice, but most of the mountain ice would be retained near the western margin of this combined ice-sheet, and constitute most of the ice there. The scattered crystalline boulders of Precambrian Shield origin present west of the erratics train either represent deposits from earlier glaciers or minor mixing of the Cordilleran and Laurentide ice during this stage. The erratics from the west would be carried southward near the surface of this combined ice-sheet, and strung out for a long distance near its margin. The blocks would ground as they were carried towards the higher land and the thinner ice of the ice margin or be deposited as the ice stagnated and melted.

Though the actual source of the erratics is not known, its position can be suggested, and certain of its characteristics inferred. It must have been near a large pass in the mountains to the west that, during one of the glacial stages, contained a valley glacier with a large volume of fairly rapidly flowing ice. A bed of the characteristic pebbly quartzite must have been present high enough on the main or tributary valley walls for the glacier to undermine and quarry it in large blocks and to carry them on its surface. This pebbly conglomerate bed must have been not less than 30 feet thick, the thickness of Big Rock, and probably was much thicker. Such a valley is not at present known, but some can be eliminated. As the last Laurentide ice evidently flowed southward in southwestern Alberta, and as the eastern margin of the erratics train seems progressively lower from Calgary southward, the Waterton region, the Oldman valley, and the Highwood valley are effectively eliminated. In the Bow valley and the North Saskatchewan valley (west of Rocky Mountain House), erratics seem to be absent west of the well-defined train, and do not continue westward as might be expected if they were brought down these valleys. The valleys farther north have not been examined, and the source of the erratics is evidently in one of them. There is at present no reason to assume that the erratics originated in more than one pass.

Time of Deposition

The deposition of the blocks is connected with the last major glaciation of the region. The erratics, with their great susceptibility to frost action, could not have withstood much of the severe climate that would be associated with subsequent glaciations. The present rapid rate of disintegration, and their fresh appearance, indicates that the blocks are not of pre-Wisconsin age. Also a later Laurentide glacier would undoubtedly have destroyed any part of the erratics train it overran, and small fragments would be common in the drift. Such fragments have not been noticed except in the southeastern part of the train, between Magrath and Coutts. There large blocks are generally absent on the surface and small, somewhat rounded, boulders of the quartzitic conglomerate occur in the drift. This section of the train seems to have been overrun by late Wisconsin ice. Similarly later valley glaciers would have destroyed or disturbed the distribution of the erratics train opposite the valleys. Thus, except in the southeast, no later ice-sheet has advanced from either east or west as far as the erratics train and it is unlikely that the erratics ever extended farther eastward.

The erratics train presumably was deposited during the Wisconsin stage. It either represents the highest level of Wisconsin Laurentide ice or at least of 'late' Wisconsin ice; for otherwise, higher trains of this type rock would be expected. Disposition of the erratics ended when southward flow of the ice ceased or when, through retreat of either or both Cordilleran and Laurentide glaciers, the connection between the two ice-sheets was broken opposite the source of the erratics. If this connection had continued as the Laurentide ice lowered there would presumably be other trains of these erratics marking successive positions of the Laurentide ice at lower elevations.

The erratics, deposited near the margin of the Laurentide ice-sheet, roughly mark the surface of this ice-sheet at the time of their deposition. Thus, assuming that directions of ice movement and other factors, such as exposure of the quartzitic conglomerate bed remained much the same in the various Wisconsin sub-stages, and if the maxima of the valley and Laurentide glaciations were contemporaneous or if the maxima of the valley glaciers were slightly earlier, the erratics mark approximately the highest elevation reached by Laurentide ice during the entire Wisconsin stage. If, however, the maximum of valley glaciation was later than that of the Laurentide ice-sheet, the erratics chain may represent just a stage during the lowering of the Laurentide glacier. If, again, the direction of Laurentide ice movement differed in the various Wisconsin substages, but that of the valley glacier remained the same, the erratics train could represent any substage that had the necessary direction of ice-flow.

Other Considerations

The pebbly quartzite erratics occur up to elevations of about 4,100 feet, and the ice that distributed them probably rose a few hundred feet higher. Dawson (1885, p. 148c), however, reported Laurentide stones as high as 5,280 feet and the writer has seen boulders from the Precambrian Shield higher than 5,400 feet in the Porcupine Hills west of Claresholm. This indicates that at least one Laurentide ice-sheet reached an altitude

1,000 feet or so higher than did the one that deposited the quartzite erratics, and was therefore about 1,000 feet thicker. If the glacier that deposited the erratics does represent the maximum extent of Wisconsin ice in the region, as the writer believes, then one of the pre-Wisconsin Laurentide glaciers was much stronger, thicker, and more severe than the Wisconsin.

The last large glacier in the region, evidently the one that distributed the erratics, flowed southward or south-southeastward in southwestern Alberta. This is indicated by ice-flow features such as drumlins, flutings, and grooves. The erratics therefore represent a lateral deposit by this ice-sheet. The margin of the ice-sheet in this area was determined chiefly by the westward rise of land, rather than by a westward drop of the surface of the ice towards its margin. The contribution of ice from the mountains to the west may even have caused a local westward rise in the surface towards the ice margin. The altitude of the erratics thus would be roughly the same as that of the surface of the former ice-sheet for some distance eastward except where sufficient ice was received from the west to have forced the ice carrying the erratics eastward over low land, where it deposited the erratics upon melting. The erratics train, being parallel to the direction of ice flow and roughly representing the top of the former ice-sheet for some distance eastward, should represent approximately the profile of this glacier at its maximum extent and parallel to its direction of flow south of Calgary, where little ice was received from the west. If sufficient erratics were mapped it should be possible to determine the general gradient of the surface of this former glacier. It has already been noted that the altitude of the lowest erratics falls about 150 feet between Calgary and Claresholm. Furthermore the maximum thickness of the ice that distributed the erratics can be determined within several hundred feet, for perhaps 100 miles to the east, by comparing the elevation at any particular point with the altitude of the erratics to the west of that point. For this purpose the altitude of the erratics of the eastern margin of the train should be used, as this is fairly definite and easily mapped, but some amount, perhaps 600 feet, must be added to this altitude to compensate for the difference in elevation between that of the eastern margin of the train and the highest erratics, plus the thickness of the ice necessary to carry these highest erratics to their present position.

The abundance of the erratics and the strong southward flow of ice that was largely of mountain origin indicate that the Laurentide glacier in Alberta received more ice from the western mountains than was previously thought. Most of this mountain ice must have come from west of Calgary and farther north, for south of Calgary the Laurentide and Cordilleran glaciers seem to have been largely unconnected in Wisconsin time. The ice so added may have been enough to have exerted the pressure that gave the southerly or southeasterly flow of ice indicated by many features in west-central Saskatchewan and central Alberta.

Most of the problem raised by these erratics can only be solved by increased knowledge of their distribution and by careful mapping of the eastern margin of the train, for as yet only a small proportion of the erratics are mapped. Extension of the mapping northward is most desirable, and it is hoped that observers working in regions farther north along the trend of the erratics train will supply information.

Conclusion

The pebbly quartzite erratics train of southwestern Alberta is the result of a unique and short-lived set of circumstances. The writer believes that a bed of well jointed quartzite and pebbly quartzite that could be quarried in large blocks by a glacier was the prime factor. The bed was in such a position that an eastward-flowing valley glacier in the Rocky Mountains north of Calgary received large blocks of the quartzite on its surface. Southward-flowing Laurentide ice present to the east, and with its western margin more or less controlled by the westward rise of land, deflected the flow of the mountain ice that was carrying the blocks, and diverted it southward along the margin of the Laurentide ice, or else received and carried the blocks of quartzite itself. The transporting glacier then distributed these blocks in a belt several hundred miles long, and within a range of elevation controlled by the approximate surface of the Laurentide ice. This glacier was presumably of Wisconsin age. No subsequent glacier has been strong enough to overrun the area of the erratics train except at its southernmost end. The various factors necessary for the formation of the erratics train were present during only one of the glaciations of the area, and then only for a relatively short time at the maximum or during the retreat of this ice-sheet. Only one large erratics train of this type rock was formed in southwestern Alberta.

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TABLE I

List of Known Quartzitic Conglomerate Erratics in Western Alberta

Source of Information (1)	Location of Boulder (Listed by Township from South to North) ¼ Section		Township	Range	Meridian	Dimension of Block (in feet) (2)			Elevation (in feet) (approximate) (3)	Estimated Weight (in tons) (4)	Remarks
S	SW	3	1	15	4				3525		1 small block.
S	NW	4	1	15	4	1	by 10	by 4	3450	15	Also 2 smaller blocks.
S	NW(?)	4(?)	1	15	4	6	6	6	3475	6	Also 2 blocks 5 feet long.
S	NW	5	1	15	4	9	3	2	3475		Also 15 blocks up to 4 feet long.
S	NE	7	1	15	4	6	5	2	3475		Also 15 blocks up to 5 feet long.
S	SE	18	1	15	4	8	5	2	3450		Also 2 blocks 4 feet long.
S	NE	25	1	20	4				3825		2 small blocks.
S	NE	12	2	17	4	6	4	1	3575		
S	NW	2	2	18	4	4	4	2	3725		
S	SW	1	3	17	4				3600		1 small block.
S	SW	2	3	17	4				3725		1 small block.
S	NW	25	3	22	4	6	4	3	3750		
S	NW	7	4	18	4	2	1	1	3625		Several smaller blocks.
S	SE	28	4	20	4	2	1	1	3700		
S	SW	5	4	24	4	3	3	3	3725		
S	SE	5	4	24	4	6	4	3	3725		
S	NW	23	4	24	4	3	2	1	3650		
S	NE	26	4	24	4	2	2	1	3625		
						3	2	1	3625		
S		3	4	25	4	7	5	3	3675		Also 3 smaller blocks.
S	N	28	4	26	4	20	15	13	3575		(On side) Also about 20 smaller blocks.
						20	15	6	3575		
						8	8	6	3575		
S		35	4	26	4				3500		1 block.
ARS	SW	29	5	26	4	—	35	15	3550	2,578	Isosceles triangle 35 feet to a side. (Glenwoodville Erratic). Other smaller blocks nearby.
DW						40	30	22	3550		
						42	40	20	3550		
AR	(SW part)		5	25	4	20	20	8	3600	264	

RW	(N part)		6	28	4				3600–3700		
S	NE	32	7	27	4				3375		1 block, unexamined.
S	SW	31	10	27	4				3325		1 block, unexamined.
S	NE	25	10	28	4				3550		1 block, unexamined.
S	NW	26	10	28	4				3850		1 large block unexamined.
S	NE	35	10	28	4	8			3600		Scattered blocks up to 8 feet long.
S	all	36	10	28	4				3300–3600		Many blocks.
S	all	6	11	27	4				3350–3600		Many blocks.
S	SE	1	11	28	4				3550–3650		Many blocks.
S	SW	24	11	28	4				3350		1 block, unexamined.
S	NW,NE	27	11	28	4				3350–3450		Several blocks.
S	SE	34	11	28	4				3400		Several blocks.
S	SE,SW	35	11	28	4				3425		Several blocks.
S	NW	35	11	28	4	18	15	10	3425	120	Ridge-topped, bedding nearly vertical.
S	SE	16	12	28	4	11	10	4	3650	20	Several large blocks nearby.
S	SE	1	12	28	4	28	14	9	3325	250	Bedding nearly vertical.
S	SE,SW	2	12	28	4	10			3425		Several blocks up to 10 feet long.
S	NE,NW	10	12	28	4	5			3425–3475		Several blocks up to 5 feet long.
S	SE,SW	15	12	28	4	5			3425–3525		Several blocks up to 5 feet long.
S	SE,NE	29	12	28	4	40	35	13	3750–3950	500	Bedding nearly vertical; one side weathered; split into three parts; also smaller pieces nearby.
S	NE	21	12	28	4	10?			3500		1 block, unexamined.
S	NW	21	12	28	4				3600–3700		
S	NW	23	12	28	4				3350		Several hundred blocks up to 4 feet long.
S	NW	24	12	28	4				3325		
S	SW	26	12	28	4				3350		Ridged.
S	SW	25	12	28	4	20	16	8	3325	110	Several hundred blocks up to 8 feet long.
						9	6	4	3325	13	
						6	5	1	3325		
						9	6	4	3325	10	
						8	5	3	3325	6	
						11	9	4	3325	22	In two pieces.
S	SE	27	12	29	4	10	10	5	3400–3500		
S	NW	35	12	28	4				3425		Many blocks, a few of them large.
S	SE,NE	4	13	28	4				3600–3700		Many blocks.
S	W	8	13	28	4				4000		Several blocks.
S	NE,SE	9	13	28	4				3550–3650		Many blocks.
S	E	18	13	28	4				4000		Several blocks, of moderate size.
S	SE	19	13	28	4	13	6	3	3800–4000	9	Other blocks nearby.
S	NE	20	13	28	4				3650–3750		Several blocks up to 10 feet long.
S	NW,SE	20	13	28	4				3700–3800		Several blocks.

TABLE I—*Continued*

List of Known Quartzitic Conglomerate Erratics in Western Alberta—Continued

Source of Information (1)	Location of Boulder (Listed by Township from South to North) ¼ Section	Township	Range	Meridian	Dimension of Block (in feet) (2)			Elevation (in feet) (approximate) (3)	Estimated Weight (in tons) (4)	Remarks
S	NW 21	13	28	4				3600		1 block.
S	SW 32	13	28	4	8	6	3	3700	7	
S	NE,SE 33	13	28	4				3475		Many blocks up to 10 feet long.
S	SE 4	14	28	4	15	10	7	3525	65	Bedding on edge.
					14	9	3	3525	9	Many blocks nearby.
					12	6	4	3525	20	
WR	8	14	28	4	20			3450		Tetrahedral, 20 feet to a side.
S	SE 9	14	28	4	50	13	4	3600	160	In 3 pieces.
					22	15	5	3600	110	Other blocks up to 10 feet long nearby.
					8	8	3	3600		
					20	10	10	3600	75	
					13	11	10	3600	60	In 2 pieces. Pointed; bedding on edge, the composing pebbles are as large as 5 inches.
					10	7	6	3600	25	Bedding on edge.
S	NE 9	14	28	4	4	4	3	3600		Two similar pieces.
S	SW,SE 16	14	28	4	4	4	3	3600		Several similar pieces.
S	NE,SE 31	14	28	4				3800–4000		Several blocks.
S	NW,SW 32	14	28	4				3700–3800		Several blocks.
S	NW 16	15	28	4				3825		Small blocks.
S	NE 17	15	28	4				3875		Small blocks.
S	SW 36	15	29	4	25	13	10	3850–4100	100	
S	NW 36	15	29	4	25	21	15	3750	675	In 2 main pieces.
					32	21	15	3750	700	In 2 main pieces.
					16	13	8	3750	60	
					15	12	5	3750	25	
					18	10	7	3750	90	
					14	10	6	3750	35	Ridged.
S	SW 1	16	29	4	9	7	4	3750	14	
S	SE 2	16	29	4	15	7	5	3750	45	Ridged. Others up to 10 feet long.

						11	10	4	3750	15	
S	SE	4	16	29	4	8	8	5	3700	13	
S	NE	4	16	29	4				3725		One moderate size block.
S	SE	9	16	29	4	26	26	10	4000	400	In about 6 main pieces.
S	NE	9	16	29	4	11			3800		One block about 11 feet long.
S	NE,SE	10	16	29	4	8			3600-3800		Others nearby.
S	SW	10	16	29	4	20	20	18	4000	400	In 2 main pieces. Other smaller blocks nearby.
S	SW	14	16	29	4				3600		Several blocks up to 3 feet long.
S	SE	15	16	29	4	5	4	2	3650		
S	N	17	16	29	4	8	5	4	3800		
S	NE	18	16	29	4				3875		One block.
S	SW	9	16	29	4				3800		1 large block.
S	SE	24	16	30	4	12	8	3	3800		Other blocks up to 7 feet long.
						13	4	2	3800		
						18	9	5	3800	20	
S	NW	21	17	1	5	8	4	3	3900		
S	NW	22	17	1	5				3800		1 block.
S	SW	28	17	1	5				3900		1 block.
S	SW	29	17	1	5				4000		Many blocks up to 5 feet long.
S	SE	30	17	1	5	18	16	4	4000	40	Also several hundred blocks greater than 2 feet long.
						14	8	4	4000	25	
						13	13	4	4000	22	
						15	5	4	4000	15	Ridged.
						17	10	2	4000	15	
						10	9	4	4000	15	
						10	10	4	4000	15	In 2 pieces.
						16	10	1	4000	12	
S	SW	30	17	1	5	16	12	7	4100	85	
S	NW	32	17	1	5	4	3	2	3800		
S	NE	34	17	1	5				3750		1 block, unexamined.
S	NW	18	17	2	5	11	9	3	3900		
S	SW	3	18	1	5				3750		1 block, unexamined.
S	NW	19	18	1	5				3950		1 large block.
S	SW	30	18	1	5	14	10	9	4000	35	Several smaller blocks nearby.
						15	11	3	4000	22	
						14	8	2	4000		
						10	4	3	4000	5	
S	SE	31	18	1	5				3975		1 block.
S	NW	34	18	1	5	12	12	7	3775	17	
S	SE	24	18	2	5	35	25	7	3950	280	In 2 pieces.

TABLE I—*Continued*

List of Known Quartzitic Conglomerate Erratics in Western Alberta—Continued

Source of Information (1)	Location of Boulder (Listed by Township from South to North) ¼ Section	Township	Range	Meridian	Dimension of Block (in feet) (2)			Elevation (in feet) (approximate) (3)	Estimated Weight (in tons) (4)	Remarks
					14	9	4	3950	18	
					14	8	2	3950	10	
S	SE 26	19	1	5				3800		1 block.
S	NW 15	20	1	5				3775		One large block.
S	N 16	20	1	5				3775		Scattered blocks.
ARS	SE 21	20	1	5	135	60	30	3750	18,000	The 'Big Rock'. Originally one block, now in several pieces.
S	SW 36	21	1	5	23	15	8	3650	75	
					10	10	5	3650	20	
					22	12	8	3650		Ridged.
S	SW 4	22	1	5				3600		Several blocks up to 15 feet long.
S	NE 13	22	1	5				3275		In glacial spillway.
S	SW 36	22	1	5	11	9	5	3400		In glacial spillway.
S	NW 36	22	1	5	13	10	5	3325		In glacial spillway.
S	SW 11	22	2	5	3	3	2	3800		
S	NE 35	22	2	5	5	4	3	3800		
R	NE 24	22	3	5				3850		
S	SW 14	24	1	5				3400–3425		Boulder marking site of Fort Calgary at C.N.R. freight office Boulder probably placed here by man.
S	SW(?) 9	25	1	5	24	13	10	3850		Pointed top.
S	NW 9	25	1	5	16			3950		
S	NE 19	25	1	5				3650		Several moderate size blocks.
S	NW,SW 20	25	1	5	17	8	4	3650		Also about 50 blocks up to 8 feet long.
					9	8	5	3650		
					11	10	4	3650		
S	NW 22	25	1	5	31	23	11	3650	500	
S	NE 22	25	1	5				3500		Several blocks.
AS	NW 26	25	1	5	24	23	15	3525	250	'Beddington Erratic'. Rises to a point.
S	NE 26	25	1	5				3500		One block.

S	NW	28	25	1	5				3675	Several blocks.
S	SE	30	25	1	5				3625	Several medium size blocks.
S	SW	36	25	1	5	10			3525	In two pieces.
S	NE	33	25	2	5				4125	One block.
S	N	34	25	2	5				4025	Several blocks.
S	N	35	25	2	5				4000	Many blocks.
S	NW	14	26	29	4	8	6	3	3575	Also about 25 smaller blocks.
S	SW	15	26	29	4	17	9	6	3575	In 2 pieces. Other blocks to 6 feet long.
S	SE	15	26	29	4	14	9	4	3575	Also five blocks between 4 and 7 feet long.
						15	6	4	3575	
						17	11	3	3575	
						8	8	3	3575	
						10	8	2	3575	
S	SE	22	26	29	4	6	4	4	3575	
S	NW	23	26	29	4	32	19	13	3600	Pointed. Several others nearby beside those described (see below).
						26	12	6	3600	
						24	10	3	3600	
						15	12	6	3600	Pointed.
						23	7	5	3600	
						18	13	7	3600	
						16	9	6	3600	
						18	7	3	3600	
						14	9	8	3600	Pointed.
						14	8	4	3600	Pointed.
						14	12	7	3600	Pointed.
						13	10	3	3600	
						15	8	3	3600	
						12	10	4	3600	
						11	8	4	3600	
						8	5	2	3600	
						5	3	2	3600	
						9	7	3	3600	
						6	5	2	3600	
						9	8	4	3600	
						8	7	6	3600	
						8	5	4	3600	
						8	4	2	3600	
						6	3	1	3600	
						6	2	2	3600	
						5	4	2	3600	
						9	4	3	3600	

TABLE I—*Continued*

List of Known Quartzitic Conglomerate Erratics in Western Alberta—Continued

Source of Information (1)	Location of Boulder (Listed by Township from South to North) ¼ Section	Township	Range	Meridian	Dimension of Block (in feet) (2)			Elevation (in feet) (approximate) (3)	Estimated Weight (in tons) (4)	Remarks
					7	5	3	3600		Pointed.
					6	2	1	3600		Pointed.
					5	3	2	3600		Pointed.
S	NW 26	26	29	4	12	7	4	3625		Other blocks nearby.
S	SE(?) 26	26	29	4	11	8	4	3625		
S	NE 27	26	29	4	15	15	8	3625		
S	NW 8	26	1	5				3750		One block.
S	NE 10	26	1	5				3650		Several blocks.
S	SE 18	26	1	5				3850		Several blocks.
S	SE 27	26	1	5				3650		One block.
S	NW 28	26	1	5	3			3750		Several blocks up to 3 feet long.
S	NE 8	26	2	5				3950		Several blocks.
S	NW 9	26	2	5				3950		One block.
S	NE 11	26	2	5				3600–3800		Many blocks.
S	NE,NW 12	26	2	5				3600		Many blocks.
S	SW,SE 13	26	2	5				3600		Many blocks.
S	NE,SE 14	26	2	5	22	13	8	3700–3800		Rises to a point. Also several hundred additional blocks up to 25 feet long.
					11	11	4	3700		
S	NE 23	26	2	5				3850		Numerous blocks up to 5 feet long.
S	NE,NW 24	26	2	5				3850–3950		Numerous blocks up to 5 feet long.
S	SE,SW 25	26	2	5				3850		Numerous blocks up to 5 feet long.
S	SE 26	26	2	5				3850		Numerous blocks up to 5 feet long.
S	SW 36	26	2	5				4000		One large block.
S	SW,NE 1	27	29	4				3625		Several large blocks.
S	NW 12	27	29	4	12	8	6	3675		Several large blocks.
S	SW 13	27	29	4	35	18	8	3700		Several large blocks.
S	NW 13	27	29	4				3700		One large block.
S	SE 14	27	29	4	40	23	12	3700		In two pieces.
					10	7	1	3700		Several other blocks.

S	SE	14	27	29	4	9	7	5	3700		
						20	20	8	3700		
						20	9	6	3700		
						6	4	3	3700		
S	NE	14	27	29	4	15	10	9	3700		
S	SW	24	27	29	4				3700		One large block.
S	NE	26	27	29	4				3675		Several moderate size blocks.
S	NE	34	27	29	4				3675		One block.
S	NW	35	27	29	4				3675		One block.
S	N	20	27	1	5				3775		Several blocks.
S	SW	30	27	1	5				3825		One block.
S	SE	3	28	29	4				3675		One block.
S	N	10	28	1	5	8			3550–3700		Several dozen blocks up to 8 feet long.
S	NW	11	28	1	5				3550		Several blocks.
S	SW	16	28	1	5	25	20	14	3800		Other large blocks nearby.
S	SE	16	28	1	5	18	10	8	3800		Pointed.
S	NW	13	29	3	5				3650		One block.
S	SW	24	29	3	5				3650		One block.
S	NE	22	29	4	5				4000		Several blocks.
S	SW	23	29	4	5	18			3950		Several blocks up to 18 feet long.
S	NW	23	29	4	5	10	10	10	3950		
						8	8	5	3950		
S	SE	27	29	4	5				4000		One block.
S	NE	9	31	4	5				3750		One block.
S	NE	10	31	4	5				3800		Scattered blocks, some large.
S	NE	11	31	4	5				3725		Scattered blocks, some large.
S	SW	14	31	4	5				3800		Scattered blocks, some large.
S	S	15	31	4	5				3800		Scattered blocks, some large.
S	NW	15	31	4	5	8	6	5	3750		Also a dozen smaller blocks.
S	SW	17	31	4	5	4	4	2	3800		
S	NW	31	32	4	5	3	3	1	3700		Other blocks nearby.
S	NE	36	32	7	5	5	4	3	3975		
S	NE	17	36	5	5	16	15	10		45	
S	SW	18	37	6	5	12	12	6			Several blocks up to 16 feet long.
S	NE	7	37	6	5						Scattered blocks.
S	E	24	37	7	5						Scattered blocks.
S	S	17(?)	38	8	5				3500–3800		Two blocks up to 4 feet long.
S	NW(?)	5(?)	40	9	5						Eight blocks up to 8 feet long. Exact location uncertain.
S	SW(?)	8(?)	40	9	5	15	10	4	3525		Several dozen blocks up to 15 feet long. On highway 15½ miles west of Rocky Mountain House.

TABLE I—*Concluded*

List of Known Quartzitic Conglomerate Erratics in Western Alberta—Concluded

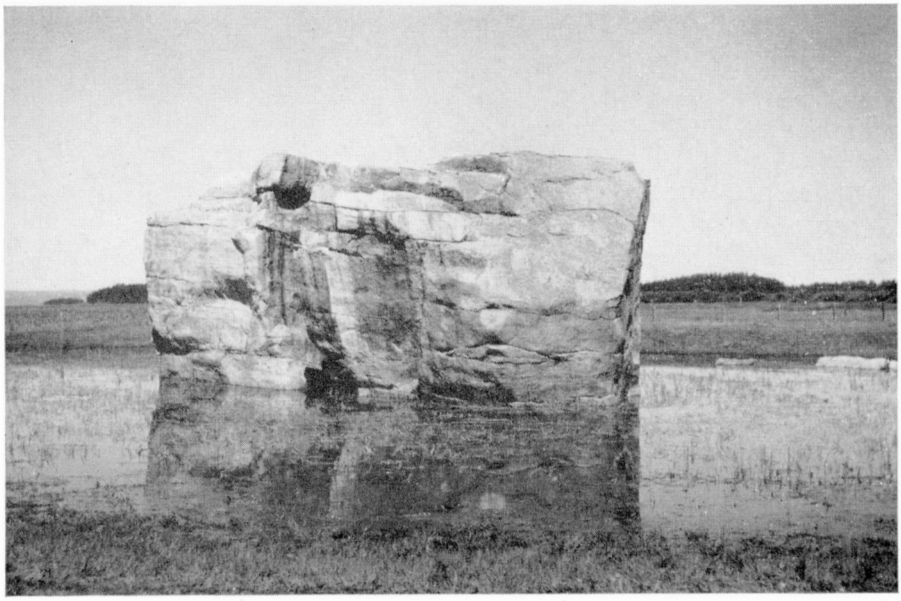
Source of Information (1)	Location of Boulder (Listed by Township from South to North) ¼ Section	Township	Range	Meridian	Dimension of Block (in feet) (2)			Elevation (in feet) (approximate) (3)	Estimated Weight (in tons) (4)	Remarks
S	26(?)	40	10	5				3550		Several blocks, 19½ miles west of Rocky Mountain House.
S	27, 28, 34	50	20	5				3100–3400		Many blocks up to 8 feet long.
S	16	51	19	5	1	1	1	3100		Other blocks present.
S	6, 7	51	19	5	5	4	3	3100		
					10	6	4	3100		
					4	3	2	3100		
					6	5	4	3100		
					5	4	4	3100		
					4	4	4	3100		
S	5	52	18	5				3100–3400		Several blocks up to 2 feet long.
S	32	52	18	5				3100		Several blocks up to 1 foot long.
S	35	52	20	5	4	4	4	3100		
S	4	53	18	5				3100		Several blocks up to 3 feet long.
S	18(?)	53	18	5	3	3	3	3100		Smaller blocks also present.
S	13	53	19	5				3100		Several small blocks.

(1) Sources of information:—D—Dawson, 1885. W—Williams and Dwyer, 1930. A—Allan (as given in Rutherford 1941). R—Rutherford, 1941. S—Stalker.

(2) As most of the blocks are angular and roughly rectangular their approximate length, breadth, and height can be listed. Dimensions are for the part of the blocks above ground only.

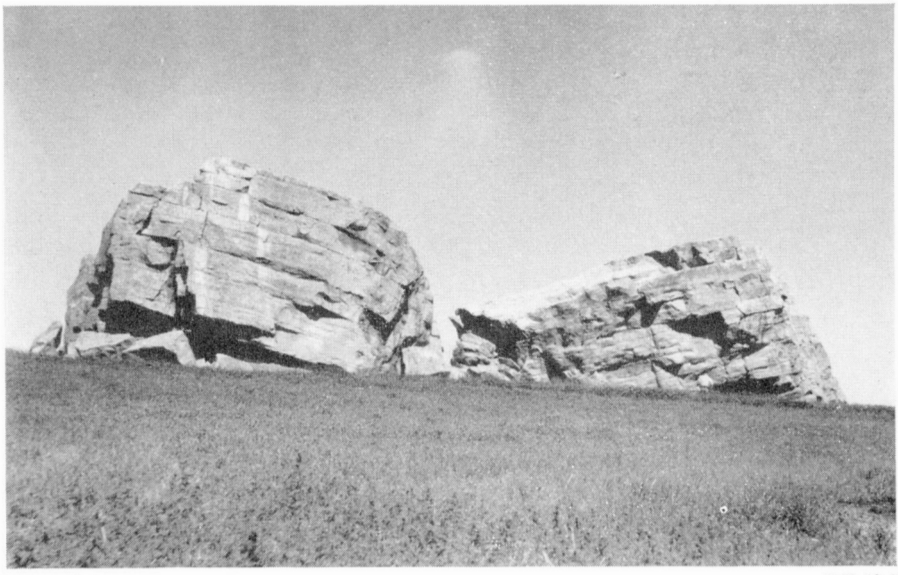
(3) Most elevations are estimated from maps. Those in townships 38 to 40 were found by Paulin barometer.

(4) All weights from the present study were estimated in the field, and refer only to the part of the block above ground.



1952 10–3

A. Pebbly quartzite erratic, July 1952. SE. ¼ sec. 14, tp. 27, rge. 29, W. 4th mer. Dimensions 40x23x12 feet. Note other small blocks nearby and shallow depression containing water.



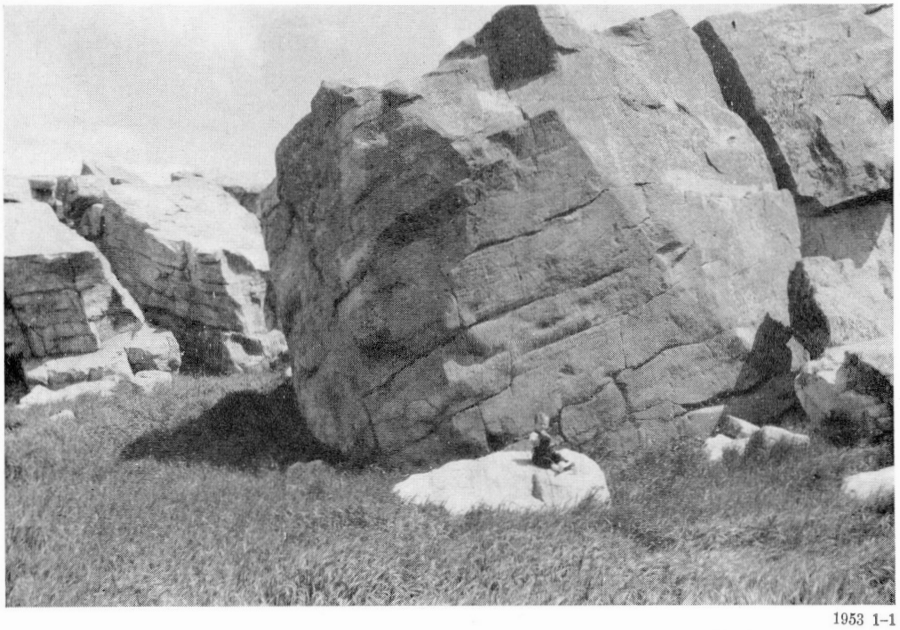
1952 10–6

B. "Big Rock", July 1952. SE. ¼ sec. 21, tp. 20, rge. 1, W. 5th mer. Dimensions 135x60x30 feet; 18,000 tons. Brought to location as single block, since split into several blocks. Note person in front of block.

PLATE II

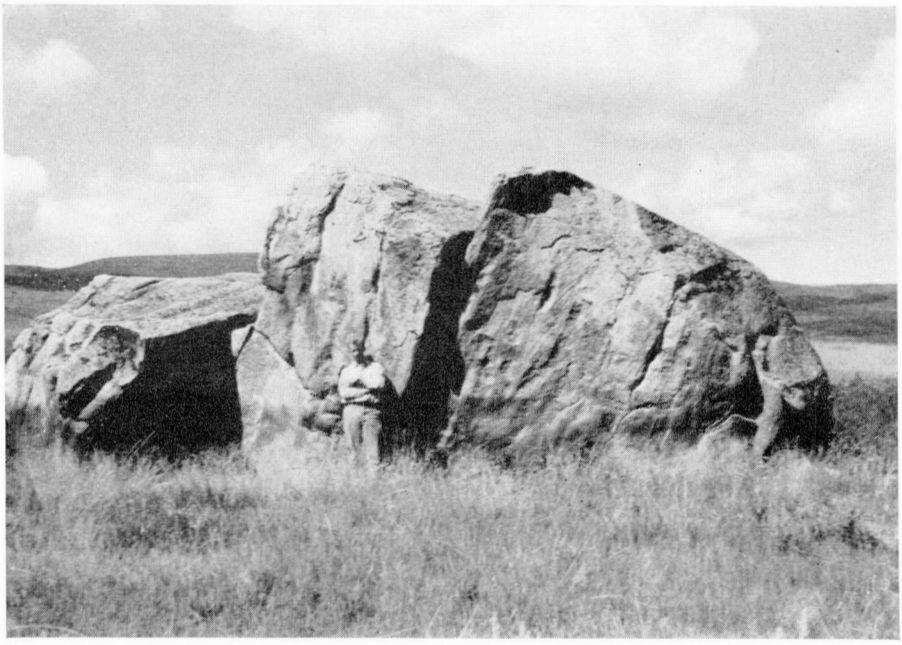
1952 5-1

A. Pebbly quartzite erratic, June 1952. NW. ¼ sec. 22, tp. 25, rge. 1, W. 5th mer. Dimensions 31x23x11 feet; 500 tons. Note surrounding depression, which is about 7 feet deep, and undermining of block.



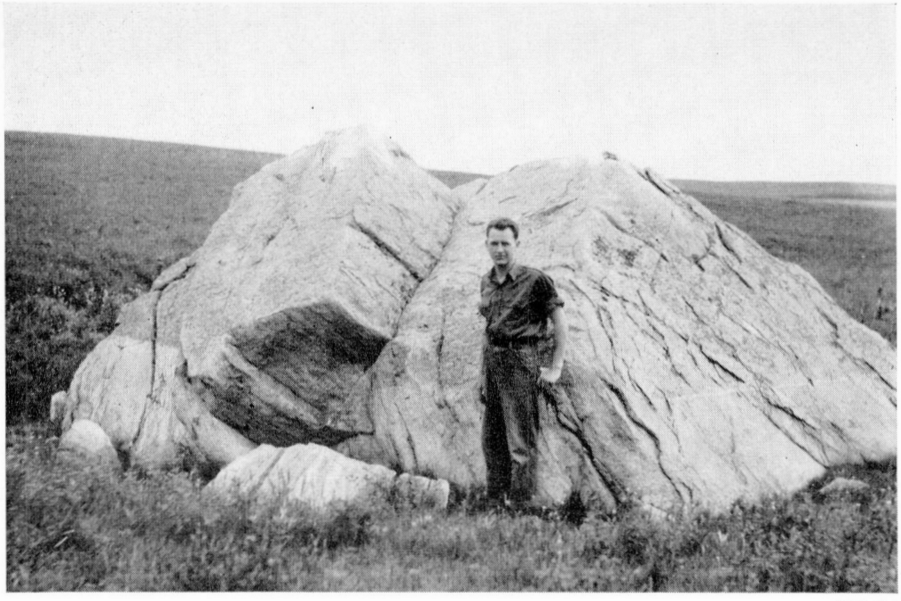
1953 1-1

B. Splitting in "Big Rock", June 1953. SE. ¼ sec. 21, tp. 20, rge. 1, W. 5th mer. This fracturing has mostly occurred since deposition of the whole block.



1954 4–6

A. Pebbly quartzite erratic, August 1954. SE. $\frac{1}{4}$ sec. 29, tp. 12, rge. 28, W. 4th mer. Dimensions 40x35x13 feet. The block has been split into three pieces since deposition. Note the shallow depression surrounding the block.



1952 5–6

B. Pebbly quartzite erratic, June 1952. SE. $\frac{1}{4}$ sec. 14, tp. 26, rge. 2, W. 5th mer. Dimensions 22x13x8 feet. The block lies in a shallow depression, its depth being clearly portrayed by the 'waterline' on the rock.