KAMES, ESKERS, AND THE DELUGE

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Kames and eskers do not seem to be forming in modern glacial deposits, and the origin of these features is a baffling problem for geologists. A new concept of the drift is suggested by a possible process of rock disintegration during uplift of the continents at the end of the Deluge. Expansion effects of this disintegration process can account for the formation of kames and eskers. Many of their features fit this explanation, while the same features are problematic in terms of the Glacial Theory. The concept of the formation of drift by disintegration may help solve some problems in creationist geology.

Were Kames and Eskers Formed by Ice?

Kames and eskers are familiar mounds and ridges in places where a layer of unconsolidated sand and gravel mantles the countryside. Striking examples of kames occur in the region of Kitchener, Ontario. Chikopee and Doon Hills are prominent kames. The long slopes on Chikopee Hill make it an excellent ski area in winter.

Doon Hill is a large kame near the 401 highway, with a TV tower at the summit. The Baden Hills, a few miles west of Kitchener, are a group of remarkably symmetrical kames about two hundred feet high. Radio transmission towers are mounted on the highest hill. The Baden Hills are probably the best known examples of kames in Ontario, and they have been described by Karrow as "moulin kames."[1]

Kames are often associated with, or grade into eskers. The eskers are prominent winding ridges of gravel and sand. See Figure 1. J. K. Charlesworth refers to both kames and eskers as "osar," and refers to the problem of their origin as "one of the most thorny of glaciological problems."[2] Rejecting several early hypotheses, Charlesworth wrote:

> The exclusion of all these hypotheses still leaves much room for uncertainty which research on existing glaciers has done little to dispel: modern accumulations resembling osar in appearance and structure are singularly few. The investigator is baffled at every turn[3]

Kames and eskers are thought to have been formed during the Ice Ages by deposition of debris from melting ice. Investigators have looked for ridges and mounds among the moraines of present-day glaciers, and have claimed some of these structures are eskers in the process of formation.

In 1958, J. C. Stokes reported an esker-like ridge in front of the retreating Svartisen ice cap in north Norway. Composed of sand, boulders and rock flour, the ridge was one to two meters high, and was formed in a tunnel beneath the ice. Embleton and King reported:

> In tunnels beneath the glacier, debris was found piled up against the walls, ready to form ridges as the ice melted. The process would form small unstratified esker-like ridges, similar to genuine eskers in that they form in a subglacial tunnel, but unlike them in their lack of stratification.[4]

W. V. Lewis, looking for esker-like ridges among the deposits of glaciers in the Rondane district of eastern Norway, found a ridge 120 feet in length, which he claimed was an esker.[5]

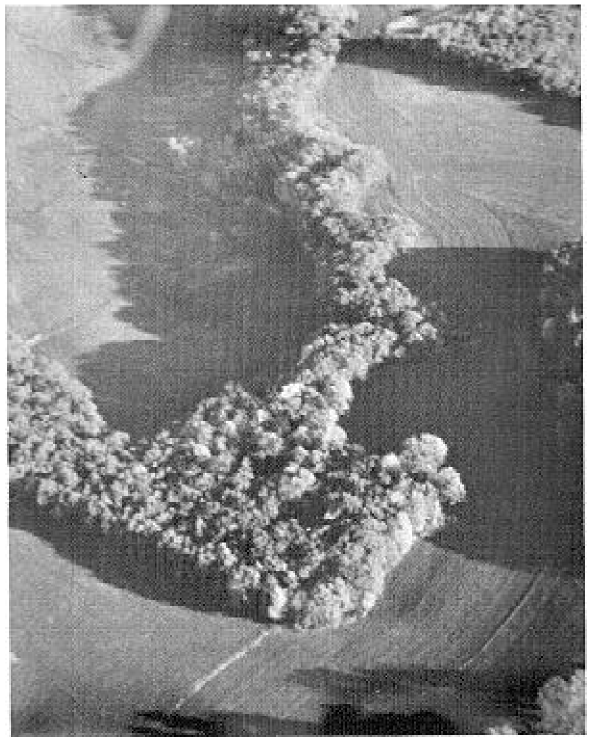

Figure 1. This is an aerial view of a typical esker, a few miles west of Baraboo, Wisconsin. Because of the rugged topography of the esker, it remains wooded, although the surrounding country is intensively cultivated.

When such reports are considered in view of the scale of many eskers, there seems to be hardly any comparison. Eskers in Maine extend 150 miles in length.[6] Those in Finland are even longer, and are elevated 80 meters above the surrounding drift. J. J. Donner reported:

> Many parts of Finland are crossed by long continuous eskers or broken series of esker ridges . . . The well-developed eskers in central Finland reach up to 40 m - 60 m, in some places 80 m, above their surroundings; and their material consists of well-sorted glaciofluvial material.[7]

Modern glacial deposits which have been identified as eskers do not seem to have the internal structure of typical kames and eskers of the drift. The presence of cross stratification has not been reported. Although streams flowing from glaciers do form moraine ridges, e.g. at Breidamerkurjökull, Iceland,[8] it is doubtful that true kames and eskers are actually formed by glaciers at the present time.

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A New Concept of the Drift

The glacial theory of the drift would lead geologists to expect kames and eskers would be in the process of formation in glaciers and ice-sheets at the present time. The difficulty in finding comparable structures in the process of formation is only one of many problems in the glacial theory.

Many creationists remain unconvinced that there really was an Ice Age, and that the Glacial Theory is the correct interpretation of the drift phenomena. Some objections to the theory have been cited in a recent article.[9]

It is incumbent on those who object to the Glacial Theory to suggest an alternative explanation of the drift. This article outlines a mechanism of kame and esker formation, in the context of the Noachian Deluge rather than Ice Ages.

A new concept of the drift is suggested by a possible geologic effect of uplift of the continents at the end of the deluge. Rapid release of pressure caused disintegration of surface rocks, forming the pattern of cross stratification in the sand of the drift. A proposed mechanism of shattering was described in another article.[10]

In this new interpretation, the drift is the product of a disintegration of surface rocks during elevation of the continents at the end of the Noachian Flood. This disintegration affected rocks of various types, and the composition of the drift would thus reflect that of the original surface rocks.

Both igneous and sedimentary rocks are found mantled with drift. Along the border of the Canadian Shield in Ontario, a change in the composition of the drift is apparent, reflecting the change in the kind of bedrock present below. This is typical of the drift in other regions, and is what we would expect if the drift originated by disintegration.

So that this new concept of the drift can be considered in historical perspective, earlier creationist thinking about the drift is reviewed.

Creationist Thinking on the Drift

The earliest geologists were creationists, and the problems they tried to solve were much the same as those creationists face today.

French paleontologist Georges Cuvier supposed the drift was the deposit of the Noachian Flood. This view was also upheld by William Buckland, who cited evidence from bones found in caves and the drift of England.

Charles Lyell favored the iceberg theory of the drift, which to many appeared to fit in with the Noachian Flood. However these views were replaced by the Glacial Theory beginning about 1840, and the Geologic Time Scale became "frozen" in about the form in which it is presented today.

Creationist geologist George McCready Price spearheaded the attack on the doctrine of uniformitarianism in the present century. He denied that the flood could have followed the Ice Age, an interpretation favored by George Frederick Wright. Price has written:

> Of one thing I am certain: the Flood was not due to the melting of a great continental ice-cap. The theory of an "ice-age" was invented as a sort of mental buffer, an intellectual shock absorber, in order to make the transition from the fossil world to the modern condition of things seem less abrupt, less catastrophic,—and this after almost all the fossils had already been strung out in a long series reaching back almost to the dawn of eternity . . . when we adopt correct scientific methods of studying the rocky record for the world as a whole, we shall cease to be troubled with any "glacial nightmare." Certainly we shall not invoke the melting of this imaginary ice-cap to explain the Flood. Several other explanations are more probable.[11]

Following the views of George McCready Price, Alfred Rehwinkel in his book, *The Flood*, devoted a chapter to objections to the glacial theory. He suggested that the drift had been deposited by currents of the deluge rather than ice-sheets.[12]

Both the iceberg theory and the idea of diluvial currents distributing the drift encounter difficulty with the fact of the similar composition of the drift and the underlying rocks. There seems to be no reason for this correspondence, unless it has been formed from the rocks below.

While the drift is similar in composition to the rocks below, it differs greatly in its unconsolidated condition and structure. To many creationists it seems that if the deluge was responsible for the "solid" sedimentary rocks, the drift above must be attributed to some other kind of action.

Ice-sheets, it is claimed, are capable of eroding bedrock and depositing debris similar in composition above it when the ice melts away.

Byron Nelson in *The Deluge Story in Stone* accepted the Ice Age interpretation of the drift.[13] Whitcomb and Morris supported this view, with some reservations, in *The Genesis Flood*.[14].

Adoption of the Glacial Theory means all the problems and weaknesses of this theory are included in a creationist framework of geology. Many additional problems are created.

For example, condensing the duration of the Glacial Period from about a million years to say, about 2,000 years involves a reduction by a factor of 500.

R. F. Flint has documented the required amount of transport of drift by motion of the ice-sheets: as a typical example, he noted: "Stones from Ontario have been carried as much as 1,000 km to positions in Missouri."[15]

A creationist view of the Ice Age, presumably, would require this amount of movement in about 2,000 years. The ice-sheet would thus have to move at the speed of above five feet per day. This exceeds the rate of flow of many mountain glaciers on steep slopes, but there is no downhill gradient aiding the movement of ice towards the south. In fact, glacialists believe the weight of the ice in Northern Ontario may have depressed the crust of the earth by about 1,000 feet or so, and the ice would then have to flow *uphill* to Missouri!

At present, some creationists believe in a short, rather catastrophic Ice Age following the deluge, and others, probably a minority, attempt to explain the drift and its landforms in terms of currents of the Flood.

Kames, eskers, and other features are explained as giant ripples or deposits of violent torrents. John Cunningham has suggested that this point of view succeeds "at least as well as does the ice age hypothesis."[16]

However, currents of the Flood would likely have deposited the erratic boulders and gravel *underneath* the finer sediments, rather than on top. The drift seems to be out of its proper sequence, in this diluvial theory.

The proposed disintegration theory explains the formation of the drift in place, and does not involve long transport of innumerable rounded boulders and erratics. The material would be in proper position on the surface. And similarity to the bedrock is what would be expected in a process of rock disintegration.

In some regions the thickness of drift is of the order of thousands of feet, and this indeed involves problems for any transportation theory, either by ice or water.

Kames and Eskers: Expansion Effects

It is clear that the Glacial Theory is not altogether satisfactory as the final answer to problems posed by the drift, and there is much to be desired in the alternative diluvial theory as well.

In the theory of disintegration due to release of pressure as the origin of the drift, the kames and eskers may be quite neatly explained as the effects of expansion. During disintegration, it is likely that some expansion would occur, causing limited movement within the drift.

Lateral expansion over a wide area could result in quite a considerable mass of drift being pushed across the bedrock, striating the surface. Consider a possible effect of expansion during the disintegration of bedrock, amounting to 4% increase in volume. Suppose the surface rocks were disintegrated to a depth of 100 feet. Then the resulting vertical uplift would be four feet.

But the lateral effects of the expansion must also be accommodated. In an area of one mile radius, the drift would tend to be pushed into the surrounding area, so that the radius of the region it covered would be increased by more than 100 feet.

Of course, friction and resistance from surrounding drift, also expanding, would limit lateral movement. In places, then, it is to be expected that mounds and ridges would be pushed up. It is suggested that kames and eskers have resulted from such movements, caused by expansion during rock disintegration at the time of the Deluge.

Some Familiar Analogies

A common phenomenon caused by expansion of water upon freezing provides an analogy. Ice cubes formed in a rigid metal tray often have surfaces pushed up into conical mounds. These may be quite pointed, and the little mounds of ice resemble some kames composed of drift.

A variety of mounds and ridges of ice may be produced by freezing water in shallow trays with rigid walls. Though on a much smaller scale, it seems that the principles causing the formation of mounds and ridges in such experiments would also apply during a shattering and disintegration of rocks on a much greater scale.

Ice forms on the surface of water, and tends to expand laterally. The restriction of lateral movement by the rigid walls of the container results in upheaval of the surface. In some lakes, pressure ridges analogous to eskers may be formed due to similar causes.

In the theory of rock disintegration, shattering would have proceeded from the surface downwards. A layer of sand and gravel expanding over the original volume would have been produced. This mantle of drift would behave much like the freezing water in a rigid tray, and where movement was restricted laterally, mounds and ridges would be pushed up. These would resemble the structures formed in surfaces of ice freezing under various kinds of restricted conditions.

An example showing the considerable pressure that may result from expansion of water during freezing, is familiar to some unfortunate people: failure to add antifreeze to a car engine cooling system has resulted in many a cracked engine block.

Another analogy with the effect of expansion during a disintegration origin of the drift is provided by a cake baking in an oven. The surface of a cake may be formed into mounds and ridges, because as the cake batter is heated, little bubbles of carbon dioxide are formed, and the cake expands in conditions restricted laterally by the walls of the baking pan.

Signs of Uplift in Kames and Eskers

The internal structure of kames and eskers provides evidence for a disintegration-expansion theory of origin. The material comprising kames and eskers is sand and gravel, and the pattern of cross stratification is evident in the sand.

The reality of a disintegration origin of cross stratification could be given strong support from direct experiments involving the rapid release of pressure on rocks. Such experiments on the nature of cross stratification present a major challenge to creationist scientists today.

The structure of kames and eskers indicates upthrust from below, as anticlinal structures are commonly present. This has often been interpreted as the effect of melting of side-walls of ice. The sides of eskers are supposed to have slumped. Flint described the feature, observed in many eskers in Connecticut:

> Transverse sections of every esker suitably exposed in eastern Connecticut, as well as sections of scores of eskers described from other localities, invariably exhibit irregular bedding paralleling the side-slopes of the esker. This bedding is definitely attributable to slump attendant upon the melting away of the retaining walls of the ice. Slumps made by artificial excavations on Connecticut eskers kept under observation develop a structure identical with the above. The side-slopes, controlled thus by the angle of rest of the material involved, range in 20 of these eskers from 18° to 30°, with an average of about 20°.[17]

Other glacial geologists have interpreted anticlinal structures within eskers as evidence that the eskers have been thrust up by pressure from below. It has been supposed that eskers are compressional features, that were pushed up by the weight of the ice on either side.[18]

In terms of the disintegration-expansion hypothesis, the anticlinal structure of kames and eskers is due to the warping of the drift by upthrust, associated with lateral pressures of the drift on either side of the kame or esker. Kames are formed when the stress is radial, and eskers occur along the intersection of two opposing bodies of drift.

Some eskers contain several successive anticlinal structures of piled-up drift. These are referred to as "multiple eskers."[19]

The strata some tens of feet below eskers may show no signs of disturbance, and these eskers may have formed before the plane of rock disintegration had penetrated to the level of these undisturbed layers.

Conceivably the shattering process would have proceeded from the top downwards, in successive stages, forming cross stratified sand and gravel. There would likely have been movement, in some cases, before the underlying rock disintegrated. This would result in a low profile, well defined esker, with greatly disturbed material at the surface. The underlying drift would remain intact.

Conversely, expansion and movement of underlying drift might cause uplift of undisturbed layers of drift, resulting in a large, wide esker ridge. The disturbed strata would be deep below the esker.

Evidence for Disturbance

Eskers are often hummocky and irregular. The drift within eskers is often faulted and distorted. This distortion would result from stresses built up due to expansion during formation of the drift by disintegration.

Some sections of eskers may have the pattern of cross stratification in the sand obliterated due to movements, and material without stratification is described as "till."

An interesting feature of some eskers in Denmark is the presence of vertical "clay walls." This feature is described by Hansen:

> The horizontal sequences of gravel and sand in the eskers are in Denmark called alpha-layers, and they form the so-called piled-up eskers. Another group of eskers is characterised by a central vertical clay wall (moraine clay), flanked by steeply dipping, cross-bedded gravel and sand. These sequences of gravel and sand are called beta-layers, and together with the clay wall they form a clay-wall or a squeezed-up esker. Sometimes a combination of a clay wall and beta-layers occurs in the lower part of an esker, and horizontal alpha-layers may be present in the upper part of the same esker.[20]

This mysterious "clay-wall" may represent a disintegration feature, where a vertical crack or fault was present in bedrock. Vertical structures known as clastic dikes are not uncommon in the drift.

Some movement both vertically and horizontally within eskers might be expected in the disintegration-expansion hypothesis. An indication of vertical movement associated with eskers and kames is the fact that the height of the drift on either side of eskers may vary considerably. The writer has seen variations in the elevation of drift on either side of eskers near West Montrose and a few miles east of Mount Forest, Ontario. The differences are commonly about 50 feet. See Figure 2.

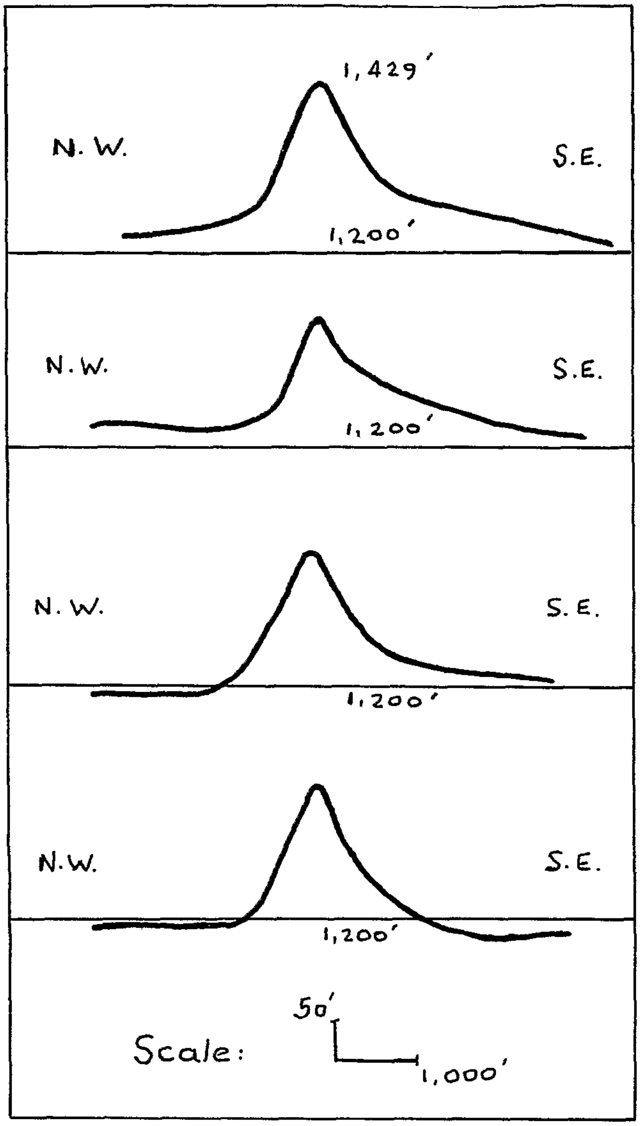

Figure 2. These are some profiles of the Baden Hills, mentioned in the text. The chain of peaks shown here extends for about 1,100 yards. The one shown at the top is the most easterly; the one at the bottom the most westerly. Note that the land to the south-east of the hills is raised more than that to the north-west. The significance of this inequality is discussed in the text.

Similar differences in elevation of the drift occur in the vicinity of kames. Depressions such as kettles are common near kames and eskers.

Embleton and King illustrated cross profiles of an esker near Reflection Lake, Baffin Island. The length of the esker under study was about 800 meters. An average difference in elevation of the drift on either side of the esker, from 20 profiles, is nearly five meters.[21]

Vertical movements due to expansion may have caused such differences in the height of the drift on either side of kames and eskers, but variations in the level of the drift would not be expected if eskers had simply been let down on the surface of the drift from melting ice-sheets.

According to the disintegration-expansion theory, the tops of eskers were contorted and faulted by movements during their uplift, but some of this evidence for disturbance might have been mistaken for frost effects. For example, while describing the internal structure of an esker in Norfolk, England, R. C. West wrote: "The uppermost parts of the esker gravels are much disturbed by cryoturbation."[22]

Composition of Eskers

The idea of disintegration and expansion causing eskers would lead one to expect that the eskers would resemble the content of the drift and bedrock in the immediate vicinity.

The glacial river hypothesis, on the other hand, would require that there was much movement of the drift along the course of the esker, in the river flowing within the ice-sheet.

In fact the gravel within eskers does not seem to have been transported to the extent which would be expected if the eskers were the deposits of glacial rivers.

Chapman and Putnam stated that the longest esker in Southern Ontario stretches from Biddy Lake, near Colborne, to beyond Beaver Lake. That esker crosses the edge of the Canadian Shield, and it is thought that the direction of flow of the glacial stream which produced the esker was from the northeast to the southwest. Thus, it is to be expected that Precambrian rocks would be present within the esker for a considerable distance south of the Shield boundary, that had travelled within the glacial river. Observations do not support the glacial interpretation. Chapman and Putnam reported:

> The stream that laid down this gravel flowed to the west crossing the limestone border at Beaver Lake. On examining this gravel in the esker we were surprised to learn that, although not one limestone pebble could be found north of it, the gravel a scant mile or two over the boundary was approximately three-quarters limestone.[23]

The content of the esker gravel changed abruptly over the border between the limestone and the Canadian Shield. This does not confirm the hypothesis of a river in the ice-sheet having formed the esker, but it does support the idea of disintegration, and the esker resulting from uplift due to expansion during the formation of the drift.

The composition of the drift in some areas may not resemble the bedrock below, if the surface rocks which were disintegrated overlaid rocks of another type. In such cases the drift may seem to have been transported.

Boulders within kames and eskers may be portions of original bedrock left intact, as for example masses of bedrock within an esker in Southern Alberta reported by A. MacS. Stalker.[24]

Several erratic boulders of granitic rock occur on the slopes of the Baden Hill kames near Kitchener, Ontario. One such boulder was partly disintegrated in such a way that a gradual transition from rock to sand occurred, and the sand was continuous with the sand comprising the kame. It seems that such disintegrated boulders could hardly have been carried great distances by ice-sheets.

According to the disintegration explanation, erratics of varying composition in kames and eskers would have a concretionary origin, and some chemical segregation occurred within the rocks disintegrated during rapid release of pressure.

Striations on Boulders and Bedrock

Striations on boulders in the drift have long been cited as evidence for the action of moving ice, but movements of the drift due to expansion would also cause grooves and scratches on boulders. These are not found on all the boulders, and seem to be limited to definite horizons.

Similarly striations on bedrock underlying the drift would be expected as an effect of disintegration. Ron Plewman, engineer at the Canada Crushed Stone plant near Dundas, Ontario, told me of some observations on these striations a few years ago. At this limestone quarry, a layer of drift several feet thick must be removed before quarrying. As the drift cover was excavated, long striations were found on the surface of the limestone. Further excavations invariably located a large boulder resting on bedrock at the terminus of the groove in the limestone.

In the disintegration theory, eskers were pushed up where movement of the drift occurred in opposite directions. Striations on bedrock might provide direct evidence that such movement has occurred in the vicinity of eskers. The direction of these striations would indicate that direction of movements of the drift during disintegration.

In the vicinity of eskers the drift is often quite thick, but in Finland, it has been scraped off in some areas and the direction of the striations near the eskers was observed. It was found that these marks were almost at right angles to the line of the esker.[25]

This is direct evidence that movement normal to an esker has occurred in the drift nearby. The direction of the striations suggests that bodies of drift on either side of the esker pushed against one another, resulting in the esker being pushed up along the zone of intersection.

Glacial Hypothesis Inadequate

Many well known features of kames and eskers seem to fit the disintegration explanation of the drift, rather than the idea of glacial rivers having caused them.

Eskers are sinuous ridges which trend up and down slopes across the countryside. The up-and-down trend would be expected from a disintegration origin, but is difficult to explain in terms of glacial deposition.

The size of eskers does not decrease towards the supposed source, as would be expected if they were caused by rivers. If the river were very far above the base of the ice-sheet, it is difficult to see how the eroded chunks of bedrock could have become part of the esker. What would cause these rocks to rise through the ice?

It seems that rivers flowing within crevasses in an Ice Age glacier would freeze in winter, and would be unlikely to reform at the same place year after year and continue to build eskers.

The pattern of cross stratification within eskers is continuous with the drift of the vicinity, and no boundary exists below eskers or kames indicating they have been let down on previously deposited drift.

The direction of inclination of the cross-strata within eskers does not conform with the inferred direction of the glacial stream, or with the axis of eskers. Investigators studying the pattern of cross stratification within an esker in Scotland concluded the river that formed it flowed sideways, across the axis of the esker![26]

Tributary eskers occur which are just as prominent as the main esker. Eskers may end abruptly, and begin again further on in the same course. Some eskers, called "beaded eskers," consist of a series of isolated mounds. All this is quite unlike glacial river deposits.

In the glacial hypothesis of kames and eskers, there is no obvious relationship between the size of an esker and the thickness of the drift in the vicinity. Eskers ought to occur resting on bedrock, in fact.

However, there seems to be a very definite relationship between the drift thickness and the size of eskers and kames. In the region of Kitchener, Ontario there are several prominent kames, and the drift reaches 400 feet in thickness. In the theory of disintegration, eskers and kames would not occur where no drift layer was present.

When the concept of glacial rivers depositing kames and eskers is considered, two fundamental contradictions emerge. First, evidence that the ice overrode and eroded bedrock contradicts evidence that the ice overrode the surface of the drift. Second, drumlins in the vicinity of eskers are explained by movement of the ice, and the presence of eskers crossing the line of flow proves ice-motion was impossible. If the ice moved, why were these eskers not obliterated?

Conclusions

The idea of rocks disintegrating due to rapid release of pressure provides a new way of looking at the drift and associated landforms. In harmony with this concept, a mechanism exists for the creation of kames and eskers during uplift of the continents from the depths of the Deluge. Kames and eskers were formed due to effects of expansion of the drift, during disintegration.

Thus the drift phenomena can be considered as an effect of a world wide Flood having much more general geologic effects. As George McCready Price suggested, "the Drift *is not a prime event in itself*; it becomes only a *minor* event in the much larger problem."[27]

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