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A FIELD REPORT ON THE ALASKA EARTHQUAKES OF APRIL 7, 1958

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ABSTRACT

The Alaska earthquake at 0530 on April 7, 1958 (150° WMT) was the largest (Richter scale 7–7½) of a series of shocks centered in an area near Huslia, Alaska. The field epicenter located at 65° 45′N, 155° 45′W lies in the Koyukuk Basin where arrested sand dune deposits cover a part of the near-level alluvium deposited by the Koyukuk River. Extensive fracturing occurred in the lake and river ice in the epicentral area and the sand dune deposits were heavily fissured. The most severe damage occurred in a zone approximately 10 miles wide by 40 miles long trending northeast from Huslia. Associated with the sand dunes in this zone were large deposits of silt and sand which flowed to the surface from the alluvium beneath the dunes. Because of the distinctive characteristics of these flows they have been termed *sand flows* to distinguish them from mud flows and sand blows. Associated with the sand flows were surface collapses resulting in near-conical pits as much as 30 feet deep and up to 120 feet in diameter. The earthquakes caused little monetary damage, although the main shock registered a Modified Mercalli intensity V or more over an area in excess of 100,000 square miles.

Introduction

Approximately once each decade since 1900 a major earthquake has occurred in Interior Alaska (St. Amand, 1948). The latest event in this apparent cycle occurred at 0530 on April 7, 1958 (150° WMT) when most persons within 250 miles of Huslia, Alaska were awakened by ground motion or earth noises. The 150 residents of Huslia felt nearly continuous ground motion for the next two hours and intermittently throughout the day. Severe aftershocks occurred at approximately 1300 and 1600 the same day and several times during the next week. A weak foreshock had been felt at Huslia within a few minutes of exactly a week prior to the main shock. Huslia is the only populated town near the epicenter, the area being otherwise unhabited. There are no roads, so travel is accomplished by river boat in summer, by dog team in winter, and by airplane the year around.

The field epicenter of the main shock (Richter magnitude 7–7½) was located approximately 30 miles northeast of Huslia at 155° 45′ W, 65° 45′ N. (See figure 1). This point is in the Cretaceous Koyukuk Basin where the present surface consists of Quaternary sediment deposited primarily by a lessening in gradient of the Koyukuk River. Overlying the stream deposits at the field epicenter is a near-continuous zone of arrested sand dunes up to 10 miles wide and trending northeast

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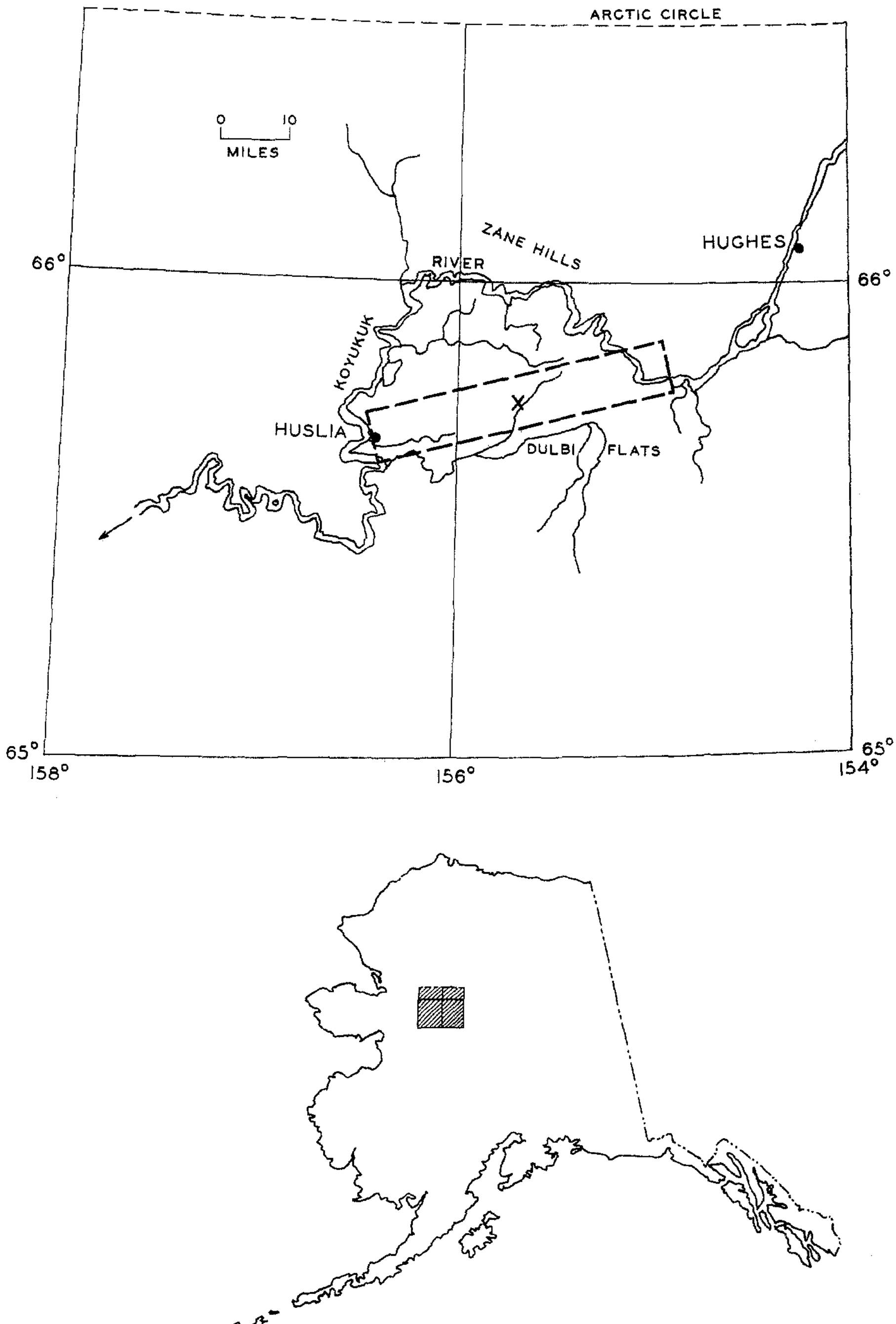

Fig. 1. Location of the field epicenter of the April 7, 1958 earthquakes. × marks the approximate center of the damage zone.

from Huslia. The sand deposits are a conspicuous feature because of their light vegetation cover and surface dryness as compared to the surrounding swampy areas. Except for occasional windswept patches the entire epicentral region was snow-covered when the earthquake occurred. Lakes and rivers were frozen to depths of 3 or 4 feet, and the ground surface was frozen to a depth up to 4 feet. Below this top layer of seasonally frozen ground permafrost is found wherever the drainage is limited or the surface cover of moss and trees is heavy. At other locations, where the soil has been recently deposited or where other conditions have prevented the formation of permafrost, this lower layer is not frozen.

This earthquake series, and others previously described by Bramhall (1938) and St. Amand (1948) occurred in that part of Alaska north of the seismically more active areas, the Alaska Range and the Aleutian Arc. It has never been possible to instrumentally locate with any degree of accuracy the earthquakes occurring in the mainland of Alaska due to the absence of any seismic network. Thus, it is difficult to discuss the seismic history of Interior Alaska. Relatively few sizeable earthquakes are known to have occurred here and their positions are usually not well-known, nor is it known where many of the active faults in the area are located.

The investigation of the April 7, 1958 earthquakes consisted of collection of intensity questionnaires and aerial and ground examinations during April 1958. A brief account of this work has been published (Davis, 1958). The U. S. Air force obtained vertical aerial photographs of the epicentral area on May 13, 1958, and following this, further ground studies lasting into July 1958 were made.

Ground and Ice Breakage Caused by the Earthquake

Earthquake effects readily noticed during the aerial searches in April were the formation of pressure ridges of ice and extensive fissuring on the surface of lakes and streams. Sand, silt, and vegetation from the stream or lake bottoms appeared on some of the pressure ridges and near the larger cracks in the ice surfaces. Pressure ridges and fissures occurred along the length of the Koyukuk River from a point 8 miles southwest of Hughes to more than 15 miles south of Huslia (see figure 1). The alignment of the pressure ridges and fissures was controlled primarily by the shape of the river and by the direction to the epicenter. Most fissures and pressure ridges were parallel to the length of the river, and the pressure ridges usually formed near the shore of the river farthest from the epicenter. Transverse fissures in the ice occurred at a few locations, mostly at bends in the river. In these instances, a number of the fissures extended into the loose deposits on the gently-sloping slip-off shores. The largest of those observed were at Huslia where residents said some cracks were 20 feet deep immediately after the earthquake. However, subsequent ground motion partially filled them, and on April 10 they were not more than 8 feet deep, and the widest measured was 43 inches. The larger of these were parallel to the river (as in figure 2) and were caused by slumpage of the soft soil towards the river channel.

The breakage of ice in the numerous small lakes served as a good indicator of the shape of the area where the most severe ground motion occurred. Most breakage of lake ice was in a zone 15 miles wide and extending northeasterly from Huslia for approximately 70 miles to the mouth of the Indian River. Practically all the lakes in this area showed fracturing of the ice around the perimeter where the floating ice broke free from the ice frozen to the shores. In addition to the perimeter cracking, there were long fractures across the lake ice. These fractures generally had a single alignment on any lake and this alignment was usually the same for all akes within a small area. Figure 3 shows fractures on the surface of one lake. Mud and vegetation lying on the ice surface indicates the positions of the larger fractures. On the left side of the photograph is a pressure ridge where the ice was pushed against the lake shore.

Fig. 2. Fissures caused by slumping of the gently sloping Koyukuk River bank near Huslia.

The surface of several lakes appeared to be covered by clear or muddy water and some lakes appeared to be filled or covered by a layer of silt or sand. In figure 4 blocks of ice which have been broken free from the main ice mass covering the small lake are shown. Much of the ice is submerged, and that portion shown in the lower right of the photograph is covered by silt or sand either from beneath the lake or from a source on the shore.

In the area where most damage occurred, approximately 30 miles northeast of Huslia, the water level in several lakes rose as much as 10 feet and completely shattered the ice surface. The undisturbed snow around these lakes indicated that the increase of water level could only have been due to an underground flow of water into the lake. The water in a few lakes remained relatively clear after the earthquake, but in most the water contained enough solid material to be murky,

Fig. 3. Fracturing of the ice on a small lake near Huslia. Dark areas near fissures are mud cast up from the lake bottom.

Fig. 4. Remains of ice and snow on a small lake. Sand partially fills the lake at the lower right.

and in some a great proportion of the material in the lake was solid. The injection of considerable water and silty sand into the lakes caused overflowing into several drainage channels. Some of the overflows contained only enough suspended matter to lightly coat the moss and trees over which they passed while others carried

Fig. 5. Field map of the central portion of the field epicentral region.

Map of a portion of the field epicenter. Alaska earthquake of 7 April 1958. (Compiled from vertical air photos and USGS Alaska Topographic Series 1:63,360, Melozitna and Kateel River Quadrangles, 1954.

-250- Contour lines (contour interval, 50 feet).

Lake

Swampy area (mapped area is arrested sand dunes excepting where this symbol occurs).

Fissure alignments. Where shown on lake surfaces indicates fractures in ice.

On lakes only, indicates shattering of ice surface.

Sand flows.

Area flooded by water carrying light to heavy sand load during the earthquakes

Section A–A′

enough sand to more than fill a few lakes and to leave heavy deposits along stream channels.

Conspicuously absent at the field epicenter was any evidence of a single fault trace or narrow-fractured zone. Instead, much of the area was covered by small fissures ranging in width from 20 inches to those barely visible, except where collapses had enlarged the openings. It has been possible to map a few of the fissures from vertical aerial photographs of scale 1:17,000 taken on May 13, 1958. Most fissures were aligned parallel to the length of the epicentral zone. In some small areas other alignments predominated, or several preferred alignments existed (see the map, figure 5). Figure 6 shows an example of the fissures.

The largest displacement measured along any fracture was on a short fault trending northwesterly and parallel to a small drainage cutting diagonally across a northerly slope. Figure 7 is a photograph looking northwest along the fault. It

Fig. 6. Fissure up to 3 feet wide cutting across a slope on the arrested sand dune surface.

shows the relative upwards movement of the down-slope or northeast side and the tipping of trees away from the fault-line on either side. The maximum vertical movement was 4 feet 6 inches. This fault is perpendicular to most fissures in the immediate area; and has, in fact, a rather singular alignment if compared to all fissures in the epicentral zone. The tipping of the trees on either side away from the fault indicates fracture as a result of an upward stress rather than due to slumping.

Measurements of vertical displacements on 35 fissures lying parallel to the damaged zone indicated a net movement of the northwest side 45 inches downward over the $\frac{1}{2}$ mile length of the traverse. A traverse made parallel to and $\frac{1}{2}$ mile northeast of this indicated relative movement 18 inches upwards of the northwest side.

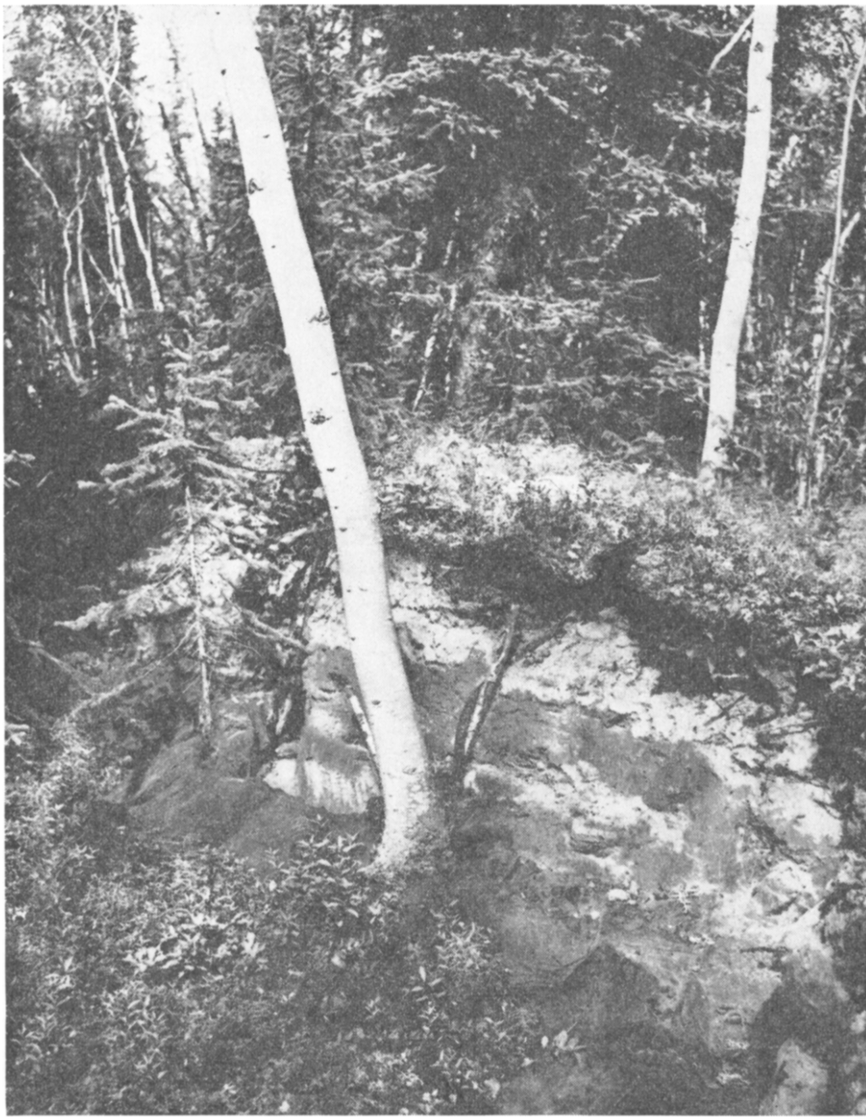

Fig. 7. A 4-foot short vertical fault showing the tipping away of trees on either side of the fault.

A third traverse $\frac{3}{4}$ mile to the northeast gave identical results to the latter. Thus, one traverse indicated downward motion of the northwest side and the others indicated downward motion of the southeast side, so no evidence was found of any consistent vertical movement along the length of the zone.

Careful measurements were made on the lateral displacements along the fissures using split trees, broken and exposed roots, and other displaced objects as indicators of relative movement. Although relative movement as great as 4 inches occurred on some fissures, the total movement, irrespective of direction, was less than 36 inches when measured on one traverse 5 miles in length. The greatest net movement measured on a traverse was less than 18 inches in the right-hand sense, and two other traverses yielded measurements of net motion near zero.

It is concluded that the apparent lateral and vertical displacements along the fissures are probably related more to local topography than to the orientation and direction of primary fault movement. Quite probably the orientation of many fissures is dependent upon local topography, although the majority of fissures parallel the length of the damage zone. Such an interpretation implies that the fissures are a secondary surface effect of fault motion in competent rocks buried by and unknown depth of unconsolidated alluvial deposits. A possible exception is the short vertical fault mentioned above; yet its alignment parallel to a nearby minor drainage gully and its position on one of the steeper slopes of the area cast doubt upon its being a surface expression of a primary fault.

The damage zone's considerable length as compared to its width is indicative of a fault or fault complex along the zone. This alignment is parallel to many drainages and other topographic features in this part of Alaska. In particular, the damage zone is nearly parallel to the Gisasa River fault (Bickel and Patton, 1957) exposed approximately 50 miles to the southwest and may represent movement on a fault which is an extension of it.

Lateral Movements of the Surface Layer

Along the northeastern border of the arrested sand dunes are a number of shallow lakes which are now mostly covered by floating moss layers up to 2 feet thick. At the time of the earthquake these moss layers were frozen solid. The ground motion, and perhaps to a greater extent the motion of the underlying water, caused severe fracturing of the moss layers. On several of the larger lakes, the entire moss surface moved as much as 30 feet, generally towards the north, until it piled up on the lake shores. Figure 8 shows some of these angular moss blocks piled against a shoreline.

Similar movement of the top layer occurred in swampy areas adjoining the longitudinal ridge in the central portion of the epicentral area. Here there is strong likelihood that the near surface layer is permanently frozen. However, the fact that there was extensive motion of the frozen top few feet relative to the lower layers indicates the presence of unfrozen and probably water-saturated material 2 or 3 feet below the surface. The swamp surface in one area moved east and northeast against the base of a low ridge where it formed a pile of moss and trees as much as 15 feet high.

Sand Flows and Surface Collapses

The filling of lakes and stream channels by water-borne sand deposits has been previously mentioned in connection with the breakage of lake ice during the earthquakes. Similar deposits occurred on the surface of the arrested sand dunes at places distant from lakes or stream channels. In figure 9 is an example of such a deposit which is typical of the small to moderate-sized occurrence. The dark mass in the center of the photograph is the sand deposit; the material appears to have originated primarily at one source near the center of the deposit. This deposit occurs on level ground and is more than 300 feet across; the trees shown are up to 30 feet in height. The typical sand deposit of this type is quite uniform in depth ranging from 3 to 4 feet near the center to 2 feet near the edge where the thickness decreases to zero within a distance of 20 or 30 feet. Fine horizontal layering shows in the deposit which consists of a grey silty sand. The grey coloring contrasts sharply with the brown surface sand which is also slightly coarser. The surface of the sand deposit of figure 9 is cut by a channel running from the center of the picture towards the observer. This is typical of many other deposits, also. At the

Fig. 8. Moss blocks pushed against the shore of a former lake, now moss-covered.

far end of the channel is a pit formed by collapse of the surface. The existence of such channels indicates that after most or all of the sand was deposited, water continued to flow from the opening with sufficient velocity to cut away a part of the previously deposited sand.

On the surface of several of the flows were shells of small fresh-water snails and pieces of water-worn wood. These materials furnish further evidence that the flows originated in the alluvial deposits beneath the sand dunes. Also contained in one of the flows were a number of sand concretions several inches in length and a well-preserved leg bone, possibly from a young caribou.

Frequently, wood debris was deposited along a level line near the edge of the sand flows in much the same fashion as is done by a receding tide along an ocean beach. Such wood deposits show clearly that surges of water flowed out of the ground after most of the sand was deposited and in some instances receded back into the ground opening leaving floating material at the high-water mark.

An aerial photograph of the dune surface taken shortly after the earthquake, figure 10, indicates the areal density of the sand flows in a part of the area. Another photograph, figure 11, is included to show the surface appearance of the flows. Associated with each flow, except some of the very smallest, were collapses on the

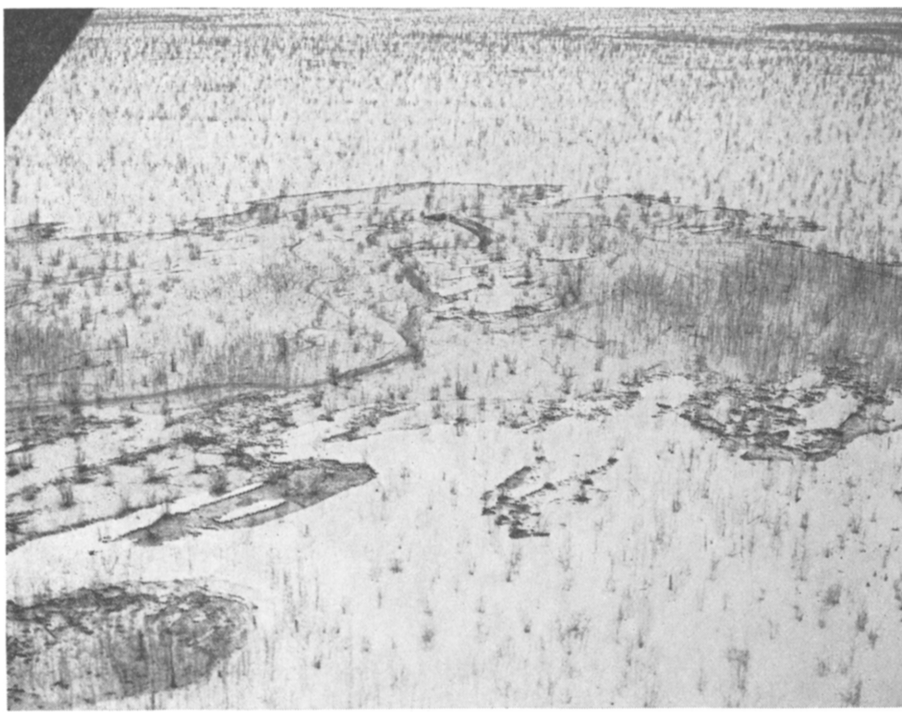

Fig. 9. Aerial view of sand flow deposit up to 3 feet in thickness. Radiating from the collapse in the center are channels cut in the flow by water ejected during the latter stages of the occurrence. All area not snow-covered is overlain by sand deposits. The collapse in the center of the flow is approximately 30 feet across.

surface, either within the area covered by the flow or within a few hundred feet of it. These collapses ranged in size from a few feet to more than 120 feet across. The depth of the collapses was generally 6 to 15 feet, but the greatest measured was in excess of 30 feet. Many of the collapses were along fissures whereas others appeared apart from other earthquake features. Figure 12 is an example of a fissure resulting in an irregular elongated collapse. A small graben exposed on the side of this collapse is shown in figure 13. Figure 14 shows a large circular collapse 106 feet in diameter and 13 feet deep. To the right of the photograph is a smaller circular collapse connected to the larger by a shallow depression. This depression evidently shows the path along which material moved underground before coming to the surface near the larger collapse. Figure 15 shows another collapse in an area covered by a sand flow, and in figure 16 is a collapse 200 yards from the nearest sand flow.

It is certain from the general appearance of the collapses that they occurred at the end or in the last stages of the sand flows. The fact that collapses are evident within some of the flows requires that most of the sand be deposited before the collapses occurred, otherwise the flow would have filled the resulting depression. Also, as can be seen in figure 15, the walls of several of the collapses extend to the surface of the sand flow deposit. This indicates that collapses occurred after the sand deposits became too viscous to flow.

Fig. 10. Aerial view of a portion of the arrested sand dune surface. All dark areas in the center and foreground are sand flows or minor sand deposits from fissures. Beyond the spruce forests in the background are the Kokrine Hills.

Several of the surface collapses are in excess of 100 feet in diameter. All such collapses are characterized by not exceeding 20 feet in depth and by having flat bottoms, whereas the smaller collapses, up to 50 feet in diameter, are usually conical. The depths of very few of the smaller collapses exceed 20 feet. There is a tendency for the larger collapses to accompany the larger sand flows, but the volume of the sand flows far exceeded the volume of associated collapse features. A typical moderate-sized flow had a sand volume of approximately 3,000 cubic yards and an associated collapse volume of less than 100 cubic yards. One of the larger flows has a sand volume near 100,000 cubic yards with an associated surface collapse of 3,000 cubic yards. These calculations of volumes of sand contained in the flows do not include the volume of the expelled water which was frequently greater than that of the sand. It appears likely that some overall settling of the surface may have followed the expulsion of the sand and water. Even though thousands of flows occurred and covered an area of several square miles with sand to a depth of several feet, the affected area is greater than 200 square miles and so settling, if uniformly distributed, would be quite small.

Local Geology

A part of the field investigation was directed towards obtaining a better understanding of the conditions which caused the sand flows and the associated surface col-

Fig. 11. Surface of one of the major sand flows covering an area greater than $\frac{1}{4}$ square mile. The silty sand has a relatively uniform thickness of approximately $2\frac{1}{2}$ feet.

lapses. As has been stated earlier, these phenomena occurred only on the sand dune surface and not in the surrounding swampy areas. Figure 17 is a cross-sectional drawing of the arrested sand dunes. (Refer also to the map, figure 5). The horizontal contact between the alluvial deposits and the sand dunes is inferred from the observation that the edges of the sand dunes occur at a ground elevation of approximately 200 feet and it is assumed that the entire area was at this elevation prior to the deposition of the dunes. Most of the sand flows and surface collapses occurred on the northwest side of the dune surface where the inferred thickness of the dune layer is 50 feet or less. Frequent borings to a depth of 6 feet were made in this part of the dune surface during the field investigation of May 1958. At this time of year it would be expected that considerable seasonal frost would exist near the surface and yet very little was encountered.

The results of the shallow borings, of resistivity profiles, and other observations indicate that most of the sand dune deposits are quite dry and contain little or no frozen ground. Exceptions occur where heavy vegetation and poor drainage conditions exist. At these places there is likely to be a permanently frozen layer extending from near the surface to a depth of several tens of feet. The material under the shallow lakes is not frozen and contains considerable water. The depth of the water table undoubtedly is variable and depends in part upon the topography. At Huslia, located on the dune surface, a well was drilled to a depth of 60 feet before striking water, but then the water rose to within 30 feet of the surface, about the level of the nearby Koyukuk River. It seems likely that, before the deposition of the sand dunes, the water table was within a few feet of the pre-dune surface. Subsequent to the sand deposition, the water table may have risen somewhat to conform to the

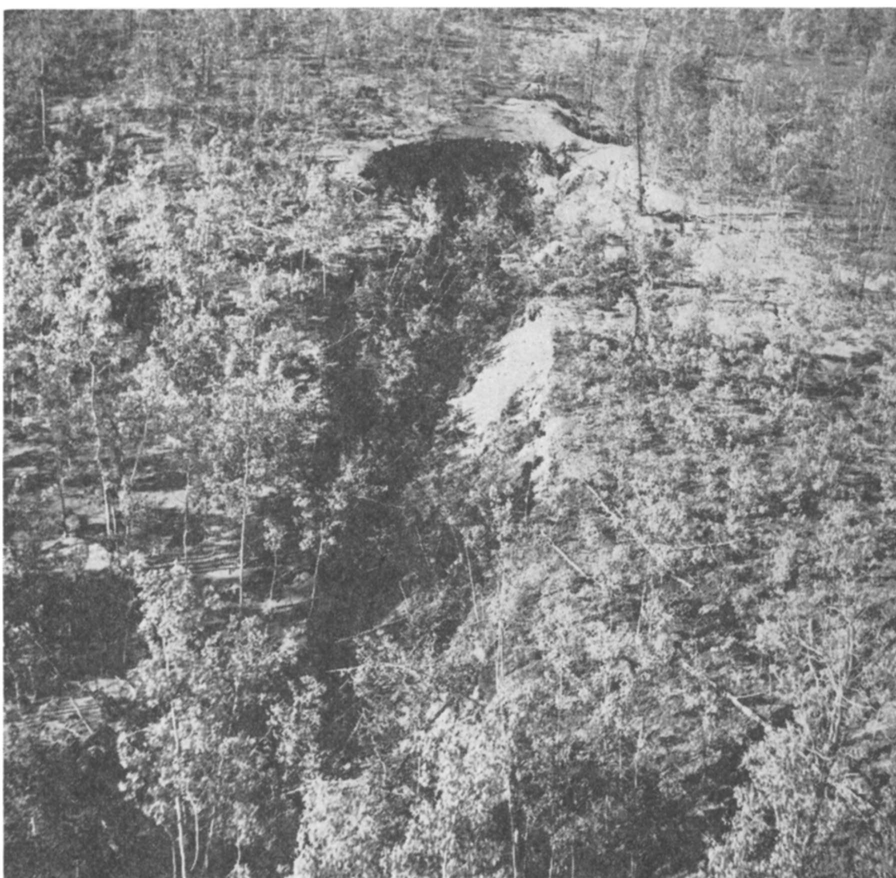

Fig. 12. Aerial view of a collapse along a fissure. The collapse is 40 feet wide and over 200 feet long. It was caused by the removal of sand and water in a direction toward the observer where it came to the surface and formed one of the larger sand flows.

new topography. For the purpose of explaining the occurrence of the sand flows it seems reasonable to assume that the water table is presently at or above the base of the dune sand.

At the present time the Koyukuk River in this area is a typically mature stream, rapidly filling old and cutting new channels. Except where the ground surface is covered by eolian deposits, there is evidence of considerable meandering of the

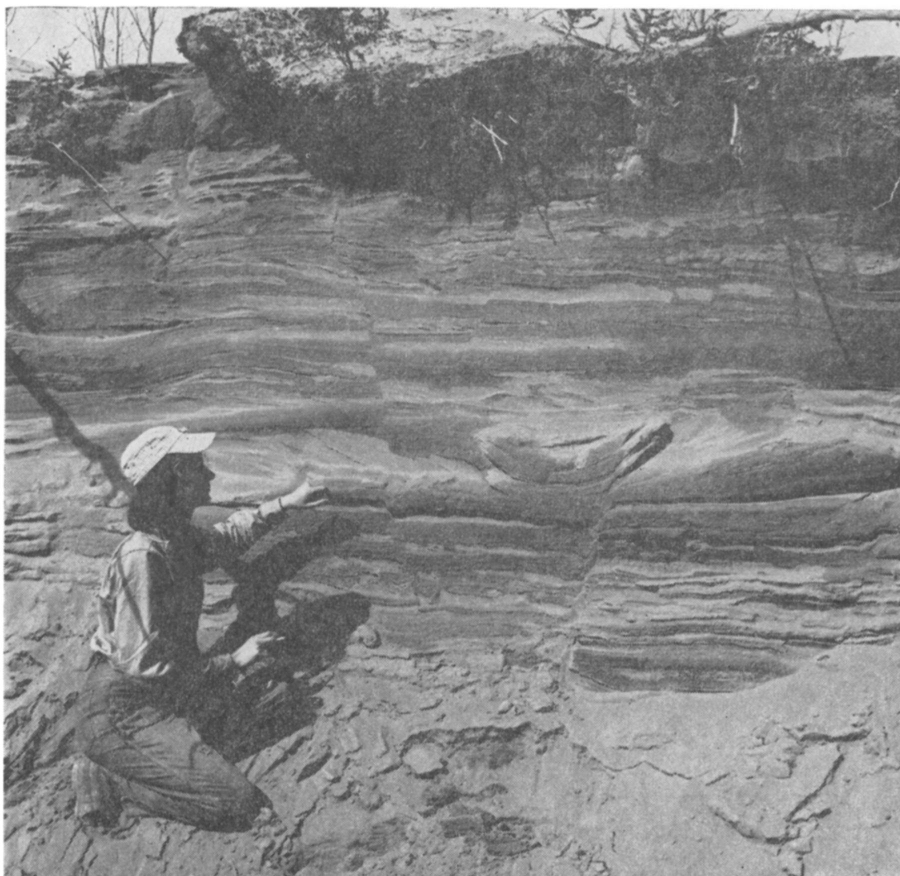

Fig. 13. Small graben exposed in the side of the collapse shown in the previous figure.

river during the past few thousand years. In fact, the present northwestern boundary of the sand dune surface marks the southeasterly limit of the river meanders subsequent to the sand deposition, and the river is now rapidly cutting into the southwest edge of the dune surface. Almost certainly the sand dunes are underlain by deposits from the meandering Koyukuk River. Thus, the pre-dune surface was probably a near-level swampy area containing many ox-bow lakes and cut-off stream channels. Whether or not this previous alluvial surface layer was mostly frozen would depend on the age of the alluvial deposits at the time of formation of the sand dunes. It is evident that the water and grey sand of the sand flows originated in this lower layer, and hence at least a part of the pre-dune alluvial deposits are now unfrozen.

Possible Mechanism of Sand Flows

The characteristics of the sand flows are as follows:

1) The sand flows consist of water-deposited grey silty-sand which originated below the near-level ground surface.

2) The size of the sand flows ranges from a few feet to more than $\frac{1}{4}$ mile across.

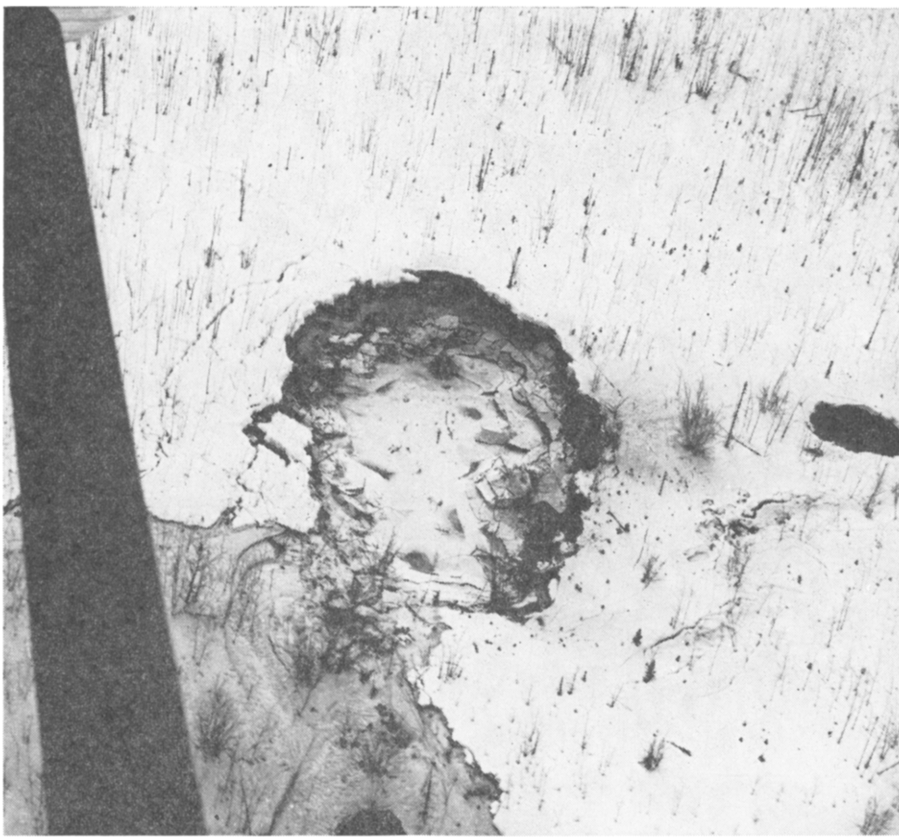

Fig. 14. Aerial view of a major collapse with a smaller one to the right. The underground path of sand from beneath the smaller collapse to where it apparently emerged at the edge of the larger collapse is easily seen. The dark mass in the left foreground is a portion of one of the largest sand flows.

3) Except where flowing into a closed depression created a thicker deposit, the flows are approximately 2 to 5 feet thick. The flows are usually thickest near the center and decrease in thickness very slowly outwards, except near the edge of the flows, where the thickness may decrease from 2 feet to nothing within a distance of 20 feet.

4) Very fine varve-like horizontal layering occurs in the flow deposits.

5) The sand flow deposits contain sandy concretions, water-worn wood debris, shells of fresh water organisms, and occasional vertebrate bones.

6) There is evidence that the sand flows were deposited from volumes of water at least twice as great as that of the sand.

7) During the deposition the sand and water mixture was usually fluid enough

to flow around even the smallest trees and bushes without bending them over.

8) The sand and water emerged from the ground through fissures formed during the earthquake.

9) Associated with the sand flows were surface collapses. Some were near the fissures from whence the sand issued, but it is evident that some material moved nearly horizontally for distances greater than $\frac{1}{4}$ mile before coming to the surface.

Fig. 15. A portion of a circular collapse within a sand flow. The former ground level is marked by the moss layer beneath the sand flow. Horizontal layering can be seen within the sand flow.

10) Towards the end of the sand flow deposition, water flowed from the ground openings and cut away some of the deposits, leaving channels in the sand flows.

Examination of these characteristics shows that the sand flows are a different phenomenon than mud flows or sand blows, which often occur as secondary earthquake phenomena. Mud flows are a downward motion of lubricated soil and are frequently started by ground motion due to earthquakes. The viscosity is usually great enough to shift or topple over stable objects. Sand blows, on the other hand, are a result of ground motion occurring in an area of unconsolidated surface deposits

Fig. 16. A conical collapse nearly 20 feet deep. It occurred approximately 200 yards from the nearest sand flow.

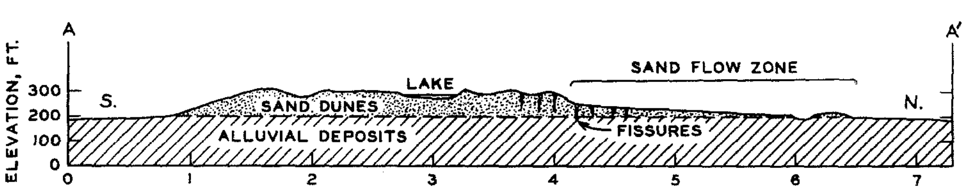

Fig. 17. Cross-section *A-A'* showing the arrested sand dune deposits resting on the alluvium below. Location of the cross-section is shown on the map (figure 5).

where the water table is near the surface. Sand blows build cones around their openings whereas the sand flows described here produce a widespread sand deposit of near-uniform thickness. Descriptions and a mechanism to explain sand blows has recently been published by Housner (1958), and Davis & Sanders (1960) have described the extensive sand blows occurring during the Alaska earthquakes of July 10, 1958.

An explanation of the sand flows must, among other things, account for the occasional horizontal movement of sand and water before coming to the surface. The nature of the sand-water mixture must be such that a considerable sand load can be carried to the surface and once there, be fluid enough to spread uniformily over the ground. Also, the uniform thickness of the sand flows and the horizontal layering within them implies that the deposition occurred, not within a few seconds, as in the case in sand blow formation, but over a period of several minutes or even hours. The occurrence of the sand flows only on the arrested sand dune surface, and mainly where the dune thickness is implied as being less than 50 feet, suggests that the existence of this relatively dry layer overlying wetter alluvial sand is a prerequisite for the sand flow occurrence.

The hypothesis suggested here to account for the sand flow occurrence depends upon the earthquake motion and upon static gravitational forces to provide the energy necessary to move the sand and water both horizontally and vertically. The suggested sequence of events is as follows:

Violent ground motion accompanying the first strong shock at 1530, April 7, 1958 (UT) caused fissures to open in the sand dune surface. These fissures extended to or into the alluvial deposits in that part of the sand dune area where the dune thickness was approximately 50 feet or less. The residents of Huslia reported almost continuous ground motion during the next hour and at least two violent aftershocks within 12 hours, so there was continued ground motion for some time. The motion of the dune surface was no doubt quite complex, with both vertical and horizontal accelerations occurring. In addition to wave motion within the sand deposits, it is supposed here that portions of the deposit moved relative to the alluvium below and possibly to each other. Relative motion between portions of the sand dune deposit might occur across fissures extending through the deposits, but it is not thought that such motions were necessary to produce the sand flows. A more important relative motion is that between the sand dune deposits and the underlying alluvial deposits. It is suggested that such motion may originate at the discontinuity between the dry dune deposit and the wet alluvial material. Should such relative motion begin, especially if there is a vertical component, it appears likely that a pumping action would result analogous to that created by a vibrator placed on un-set concrete. The result is to cause the near-surface layer to become less viscous. Hence, if a relative motion between the dry and wet layers began during the strong initial ground motion, subsequent less intense motion may have produced a pumping action. This would give at the interface a highly fluid sand water mixture which, due to continued pumping and/or the downward pressure of the more rigid dune sand layer, could be forced upward through fissures to flow over the surface. If the alluvial deposits at the base of the sand dunes are laterally homogenous, then mass moving upwards through the fissures could be replaced by horizontal flow of the fluid alluvial material and by overall settling of the dune layer without the occurrence of collapses in the dune layer. The alluvial pre-dune surface is, however, probably composed of old lake beds and stream channels separated by previously vegetated and swampy soil which may have been all or partially frozen. In this case, the pumping action would have its greatest effect in the lake beds and stream channels. The fluid material would then be constrained to move horizontally within the old channels and lake beds and vertically through fissures. This would explain why there was occasionally considerable horizontal movement of the fluid before it came to the surface. The irregular support provided to the sand dune layer after the outflow of the fluid mixture, could then be the cause of local collapse of the dunes. The relatively clear water which eroded the surface of the sand flows was perhaps forced upwards by the weight of the dunes after lessening ground motion had reduced the pumping effect to the point where there was no longer sufficient agitation to maintain a heavy sand load in the water at the interface.

No conical sand blow deposits were found in the epicentral area. However, sand blows may have occurred and later been covered over by the more extensive deposition of the sand flows.

Evidence of Former Earthquakes

A number of small closed depressions having the appearance of older collapse features were noticed on the sand dune surface during the field observations. Shallow excavations in and near several of these showed the presence of a grey sand layer several inches to several feet thick just below the surface mass. As has been previously mentioned, the normal coloring of the dune sand is brown and contrasts sharply with the grey of the sand flow deposits associated with the 1958 earthquakes.

Also at Huslia, stripping away of the moss during construction of the airfield revealed a deposit of grey sand, in places over 7 feet thick, which rests on the brown dune sand. Counting the rings in trees growing on these deposits shows that if these deposits do represent former sand flows they occurred prior to 1932. The older residents of Huslia remember a large earthquake, of size comparable to the one in 1958, which they thought occurred before 1930 and quite possibly a number of years prior to that date. It seems likely that the grey sand deposits are sand flows associated with former earthquakes and perhaps with the one mentioned above as occurring before 1930.

Ground Motion Intensity Distribution

The only village proximate to the epicenter is Huslia. All of the approximately 150 people at Huslia were awakened violently by the main shock at 0530 April 7 and immediately left their homes. Most remained outdoors during the next hour because of continuing ground motion. None were injured, and there was little damage to structures within the village. A number of the sod-roofed log residences suffered minor damage to roof structure, and logs shook loose from the walls of two dwellings. The only buildings of modern construction are a frame church, a steel and plywood school, and a steel and plywood teachers' residence. These buildings were hardly affected by the earthquake except for broken paint seals and slight damage to concrete foundation blocks beneath the school building. Minor slumping cracks near houses in that part of the village closest to the Koyukuk River caused the community to move a number of these houses to safer ground in the weeks following the earthquakes. However, even if the earthquakes had not occurred, it would have been necessary to move these houses within a year or two because the river is rapidly encroaching upon the village.

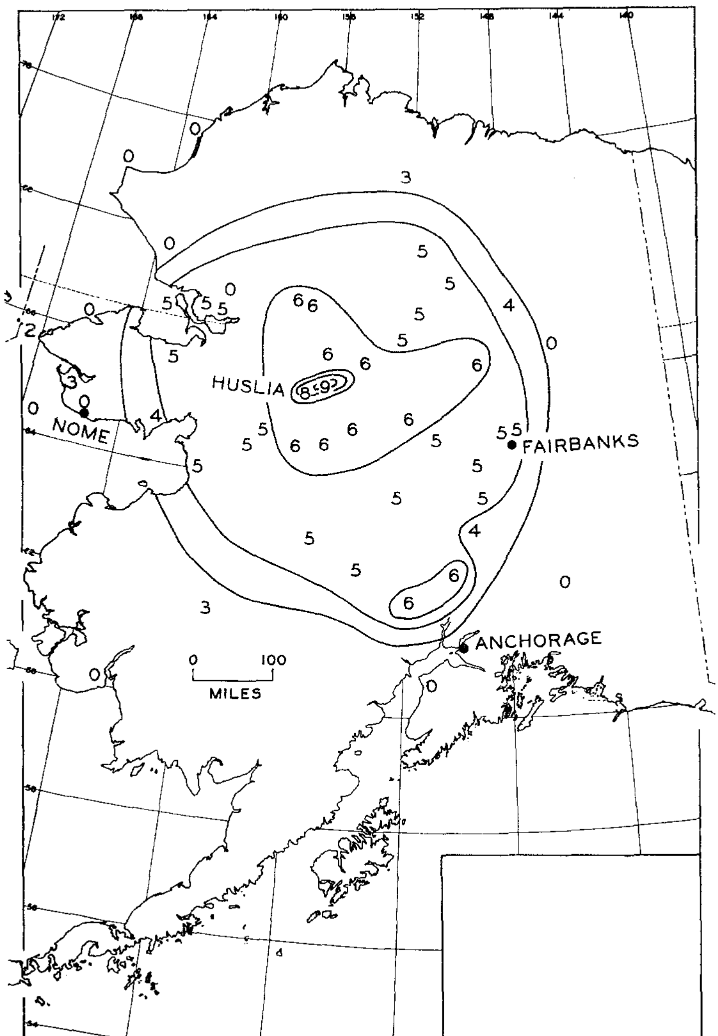

Fig. 18. Isoseismal map of the intensities of the April 7, 1958 earthquake, (Modified Mercalli scale).

Since the main source of income at Huslia is beaver and muskrat trapping, the residents were concerned about the effect of the earthquakes on these animals. The residents observed a number of dead beaver and muskrats floating on the surface of lakes subsequent to the earthquakes, and many beaver houses were severely damaged. Evidently, the earthquakes killed many of these animals, but it is not known whether there was an appreciable reduction in the overall population within the area.

Figure 18 is an isoseismal map showing the intensity distribution as determined from the return of questionnaires sent to Alaska residents. The map is based on the modified Mercalli scale and shows that the earthquake was felt with an intensity of V or greater over an area in excess of 100,000 square miles. The earthquake occurred when most people were asleep, so the proportion awakened at each location was a strong factor in assigning intensity values. V was assigned if most or all were awakened and VI was assigned if, in addition, heavy objects were moved. Damage was slight or non-existent at locations other than Huslia, although Bureau of Indian Affairs schools at Tanana and Stevens Village, 120 and 190 miles distant from the epicenter, respectively, were closed following the earthquakes. These schools were located in very old buildings unable to withstand moderate ground motion. Details of the ground motion observed at these and other locations in Alaska, as well as additional photographs taken near the epicenter, are included in another report (Davis, 1960).

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