DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF – 782
TYSDAL, OTHERS--SURFACE FEATURES AND RECENT
MOVEMENT ALONG RAGGED MOUNTAIN FAULT, ALASKA

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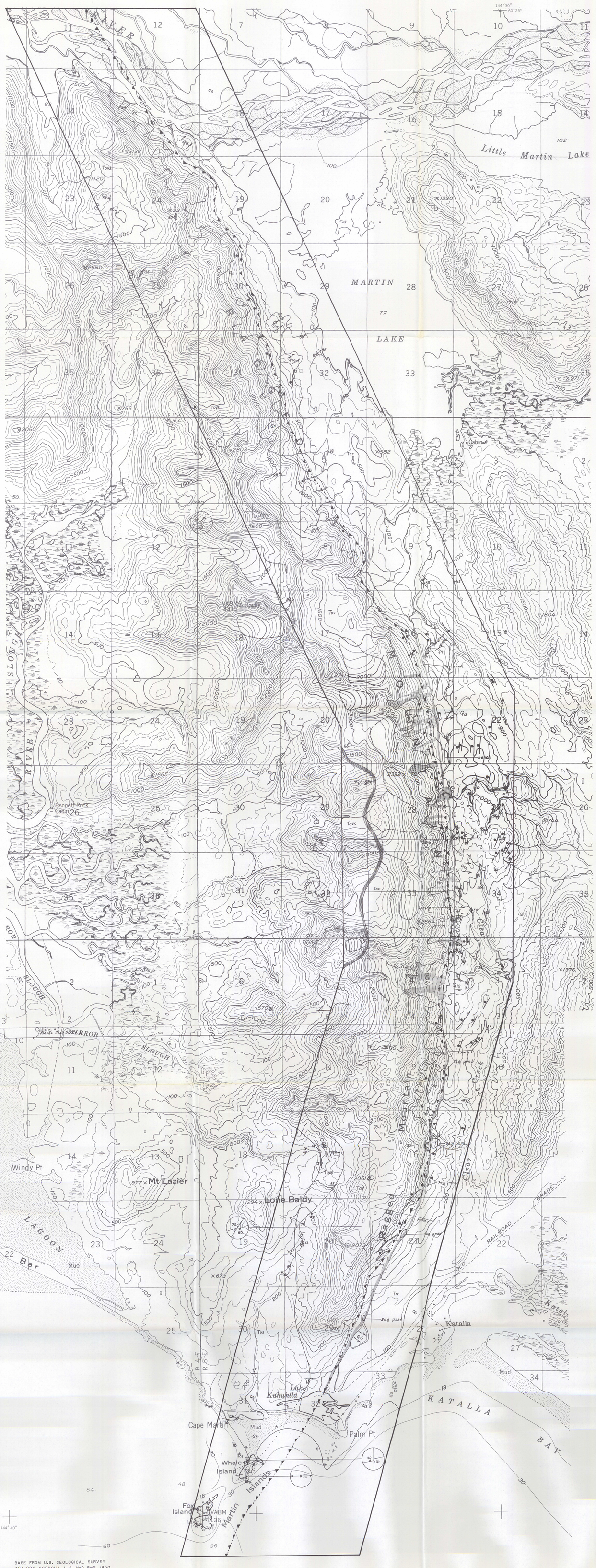

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INTRODUCTION

The Ragged Mountain fault, in the Katalla district, is a 30-km-long westward-dipping fault that bounds the eastern margin of the topographically rugged Ragged Mountains. The fault has long been considered as active because of the prominent scarp and fissures that are developed along it (Kachadoorian, 1960), although the trace had been examined in only a few localities. The authors spent about 15 man-days in 1973 and 1974 carrying out helicopter-supported detailed strip mapping along the fault. This study details the surficial features possibly associated with recent movement on the Ragged Mountain fault, interprets their origin, and evaluates the potential of the fault for future seismotectonic activity.

THE RAGGED MOUNTAIN FAULT

The trace of the Ragged Mountain fault describes a gentle arc convex to the east that extends from the Gulf of Alaska coast at its southern end 30 km northward to where it is covered by alluvial deposits of the Martin River. The fault is located in a structurally complex area of the Gulf of Alaska Tertiary province where dominantly east-west-trending Tertiary structures bend abruptly to become more nearly north-south (fig. 1).

The fault trace delineated on the map is located on the basis of the abrupt topographic and lithologic change that marks the surface junction of the upper and lower plates. The eastern face of Ragged Mountain is an imposing fault-line scarp that rises abruptly 300 to 600 m above the more gentle slopes east of the mountain. The face is composed largely of massive greenstone of the Orca Group. The greenstone is highly resistant to erosion, forming steep slopes, cliffs, protruding ridges, and jagged peaks. In contrast, the weakly resistant Eocene siltstone and shale sequence to the east forms gentle slopes inclosed locally by narrow stream-cut valleys. It is this strong contrast in resistance to erosion that accentuates the trace of the Ragged Mountain fault.

The fault dips about 8° to the west, as determined by the three-point method, using points near sea level at the northern and southern ends of the fault trace and a point at 1,500 feet elevation on the easternmost part of the trace near the head of Clear Creek. The fault is inferred to extend westward at an unknown, but probably shallow, depth for at least 8 km. This interpretation is based on the presence of several oil and gas seeps in the area of Mirror Slough west of Ragged Mountain, where the surface outcrops of the Orca Group are too highly altered and indurated to be the source of oil. This suggests that the oil originated in younger petroliferous Tertiary rocks that have been overridden by the Orca Group along the Ragged Mountain fault (Miller, 1951). The Alaska Coal Oil Co. #1 well in the Mirror Slough area penetrated to a depth of 317 m, with a small quantity of oil and a show of gas at a depth of 213 m (Martin, 1921, p. 25), but in what unit the hole bottomed is unknown.

SURFICIAL DEPOSITS AND SURFACE FEATURES ALONG THE FAULT

In addition to the marked topographic variations produced by fault juxtaposition of lithologic units of very different erosional resistance, other features are preferentially developed near or along the fault trace. These include landslides, talus slopes, a large trench, and linear fissures. The fissures are developed in the landslide and talus deposits; the trench, though developed in bedrock, is partly filled with talus. Both the trench and the fissures are believed to be topographic expressions of Holocene movement along the Ragged Mountain fault.

Landslide deposits

A number of landslide deposits occur along the east face of Ragged Mountain, the largest and greatest number near the eastern and highest part of the Ragged Mountain fault. They are composed largely of angular blocks of massive greenstone boulders as much as 15 m across. The largest landslide, in secs. 21 and 22, T. 18 S., R. 5 E., extends about 1,000 m eastward from the mountain front and originally covered more than 1.5 km^2 to an average depth of about 3 m. The headward parts of most of the landslides are overlain by talus deposits and are cut by a trench or, locally, by one or more fissures. A soil profile several centimetres thick has developed over the finer material of some of them, and the presence of evergreen trees that are several tens of centimetres in diameter suggest that the landslides have been stable for hundreds of years. Stream dissection of some of the landslides has produced an irregular or modified form.

Talus deposits

Talus deposits, made up largely of angular cobbles and boulders of greenstone and aquagene tuff, mantle the Ragged Mountain fault trace for its entire extent. Most of the talus slopes are inactive and stable. These are generally covered with vegetation and overlie much of the inner (western) sides of the trench developed along the fault trace and they partially mantle the older landslide deposits. The stable talus deposits are cut by fissures and grade laterally into zones where the talus slopes are active. The active talus slopes, indicated on the map by a stippled pattern within the areas of talus deposits, are present mostly along the central part of the Ragged Mountain fault trace. Because they are bare of vegetation and lighter in color they are distinct from the inactive talus slopes. The movement of talus on the active slopes has evidently destroyed the surface expression of the fissures developed along the inactive talus slopes and has contributed material that has partly filled the trench and mantled the upper parts of some landslide deposits.

Trench

A prominent trench marks much of the central and southern section of the Ragged Mountain fault trace in the zone of junction between the upper and lower plates. The trench is as much as 200 m wide as measured from the highest elevation of the eastern flank to an equivalent elevation on the western side, and is about 5 to 30 m deep. It is generally shallowest where widest, in areas of unconsolidated deposits that are not immediately flanked by bedrock on the east, as along the northernmost part of the trench. The deepest and narrowest parts of the trench are present where bedrock of the upper plate crops out near resistant bedrock of the lower plate, as in the uppermost reaches of Clear Creek (southeastermost corner of sec. 28, T. 18 S., R. 5 E.). In many places the bottom of the trench is fairly broad and gently sloping to flat because it is partly filled with talus and minor amounts of other surficial debris (fig. 2).

The trench is a conduit for runoff from the east face of Ragged Mountain and in places is eroded by streams, especially in the area 0.5 to 2 km south of profile b (fig. 2). It is also a locus of snow accumulation and is marked by the presence of several ponds, mainly in low areas between avalanche, talus, and landslide deposits.

The trench is below tree line along the southern part of the fault where it contains straight, vertical sitka spruce and western hemlock with trunks 0.3 to 0.6 m in diameter; the trees are probably several hundred years old, indicating stability for at least this period of time. On the sloping flanks of the trench, the lower part of the trunks commonly lean slightly toward the trench because of downslope surface creep.

Fissures

The term fissure is used here for linear notches, commonly V-shaped, that exhibit uphill-facing scarplets. Fissures in the talus deposits along the front of Ragged Mountain are as much as 1,000 m or more long, a fraction of a metre to about 5 m deep, and several metres wide. A series of generalized profiles across a fissure is shown in figure 3. Along the length of the fissure, the profile changes gradually from a V-shaped trough where the fissure is well developed (fig. 3a); to a profile where the uphill slope remains steeply inclined but the opposing slope is less steep (fig. 3b); to a profile where the uphill slope remains steep but the opposing slope forms a bench (fig. 3c); to one continuous slope that is inclined away from the mountain, merging with the talus slope and showing no indication of a fissure. The figure illustrates the general range of fresh fissure forms found in the unconsolidated deposits along the fault trace, although fissures may occur at differing stages of development and subsequent erosion or infilling with talus.

The fissures are mainly on inactive talus slopes and are most common along the central part of the fault trace. The longest continuous fissure, more than 1,000 m long, is in this area; its total length is probably more than 2,000 m, but active talus deposits conceal it at places to the north and south. Other fissures are much shorter, only a few tens of metres long, and die out within the inactive talus deposits or are partly covered by active talus deposits. Multiple fissures are not common but are found where the talus deposits are most extensive, as along the fault trace about 1 km north of the largest landslide deposit.

ORIGIN OF THE FISSURES AND TRENCH

The fissures and trench are surface features closely related to the history of the youngest movements on the Ragged Mountain fault. The morphology of these features indicates that the west or uphill side of each is relatively downthrown. Figure 4, an enlargement of profile b of figure 2, shows the subsurface relationships presumed to exist along those parts on the east face of Ragged Mountain where the fissures and trench occur. The fault, formed originally by eastward thrusting, is interpreted as now being a gravity slide surface and all of Ragged Mountain as a slide block. Following this interpretation, the eastern side of the trench is apparently part of the lower plate, exposed by the westward sliding, and the fissures are subsidiary ruptures formed by lateral extension in the talus deposits.

In figure 4, theoretical conjugate sets of slip planes represent the most likely directions of tensional failure in the talus (Kanizay, 1962). The set represented by solid lines is believed to be manifest by the uphill-facing scarps or fissures; the uphill talus west of these shear planes has moved down and to the west. No evidence was found to indicate that movement has taken place along the set of shear planes represented by the eastward-facing dashed lines, although any such movement would be difficult to detect, as it would result in oversteepened slopes that would be quickly modified by gravitational slumping.

Nowhere along the fault trace is the amount of westward displacement evidenced by the fissures close to that indicated by the trench and the exposed lower plate on its eastern side. The westward sliding has apparently taken place repeatedly, and fissures so formed have been eroded or infilled by surface talus movements in much the same manner as fissures present today are being modified.

DISPLACEMENT ON THE FAULT

The Ragged Mountain fault has had a long and complex history. Relative eastward tectonic movement in late Tertiary time juxtaposed the Ragged Mountain block over sedimentary rocks that range in age from Eocene to possible early Miocene; horizontal displacement involved undoubtedly exceeds the 6 km indicated on the cross section. Displacement since the fault scarp was glaciated during the Wisconsinan has been by gravity sliding in the direction opposite to the original thrusting; the amount of this westward movement may be as much as 180 m.

The net amount of westward gravity sliding is inferred from the three profiles of figure 2. If the east wall of the trench is interpreted as the exposed lower plate beneath the fault plane, the maximum displacement due to sliding is estimated to be the distance from the eastern lip of the trench westward to the projected location of bedrock beneath talus on the upper plate (indicated by the double arrow on the profile, fig. 2). The eastern lip of the trench in profile a is believed to have been eroded as suggested by the broad flat part of the profile; the dashed line is an interpretation of its former profile. In figure 2, displacement is about 130 m in profile a, about 140 m in profile b, and about 180 m in profile c. Northward a few kilometres from profile a, the trench ceases to exist, indicating that the displacement dies out or that the lip on the lower plate has been removed by erosion. If the displacement dies out to the north, the relative movement of the upper plate may be rotation about a point along the northern part of the fault. If it is, the Ragged Mountain fault may originally have been continuous with the east-west-trending Chugach-St. Elias fault, which juxtaposes the Orca Group on the north against younger Tertiary rocks along much of its extent (fig. 1).

GEOLOGIC HAZARDS

The cause of the inferred sliding is not known. There is no indication of significant recent westward tectonic tilting of the mountain block that would cause the postulated sliding. One possibility is that the Pleistocene Martin River Glacier cut a deep valley west of Ragged Mountain (west of map area) during periods of low eustatic sea level and that this valley intersects the fault, thereby providing a free surface toward which the Ragged Mountain block could gradually slide. Gravity sliding on the fault surface may have been facilitated by periodic major seismic events, although no such movement appears to have occurred during the 1964 earthquake.

A number of earthquakes were felt at Katalla, near the south end of Ragged Mountain, before the village was abandoned during the 1940's. In 1899, a series of major earthquakes occurred near Yakutat, about 275 km east of the map area, causing avalanches, dust clouds, and wavering of trees in the mountains adjacent to Katalla (Martin, 1910; Tarr and Martin, 1912). Oil was reported to have been seen in large amounts on the surfaces of streams and ponds near Katalla (Martin, 1908) following this earthquake. Tarr and Martin (1912) reported that an earthquake occurred in the Controller Bay region near Katalla on May 14, 1908, but the resulting damage was minor. The Alaska earthquake of March 27, 1964, centered about 190 km northwest of the map area, magnitude estimated at about 8.4 (Plafker, 1969), caused "unusually severe" snow avalanching in the Ragged Mountains but very little rock avalanching (Tuthill and Laird, 1966, p. 19 and 26). Tuthill and Laird described nine conical mounds of alluvium deposited by avalanches onto the outwash plain of Martin Lake. Ragged Mountain was uplifted 2.5 to 3 m as part of a broad regional upward following the 1964 earthquake (Plafker, 1969), but no evidence was found to indicate that any of the known faults in the Ragged Mountain area were reactivated (Tuthill and Laird, 1966, p. 26).

The apparent absence of movement on faults in the Ragged Mountain area during the 1964 event and our mapping along the fault trace suggest that the fault is not active at this time and does not constitute a serious earthquake hazard. Earthquakes that might be generated by renewed sliding of the Ragged Mountain block would probably be small. Sliding, if it recurs, might be accompanied by the formation of fissures in talus deposits, talus slides, landslides, rock falls, and snow avalanches in the Ragged Mountains. As there is no construction on or near the steep mountain front and this area within the Chugach National Forest will probably remain undeveloped for the foreseeable future, falls, slides, and avalanches here are not likely to constitute serious geologic hazards.

SUMMARY

The Ragged Mountain fault is a major westward-dipping low-angle fault that juxtaposes indurated rocks of the Paleocene and(or) early Eocene Orca Group over less-indurated siltstone and sandstone of the Eocene Stillwater Formation. Surface features along the 30-km-long fault that suggest Holocene movement include a prominent trench that may represent the exposed lower plate of the fault and a series of uphill-facing scarplets that cut inactive talus deposits at and near the fault trace.

The most recent movement is interpreted as westward-directed gravity sliding of the Ragged Mountain block, which constitutes the upper plate. This is opposite in sense to that of the relatively eastward-directed tectonic thrusting that juxtaposed the Ragged Mountain block over younger strata in post-early Eocene time. Gravitational sliding of the Ragged Mountain block is believed to occur in increments of unknown amount when some critical shear stress on the fault is exceeded, perhaps as a result of strong seismic shaking. The maximum measurable net westward displacement of the Ragged Mountain block during the Holocene is estimated to be about 180 m, although displacement is not uniform along the fault trace.

Any earthquakes that may be generated by slippage of the Ragged Mountain block are likely to be small. Landslides, rock falls, and snow avalanches may occur along the steep eastward-facing fault scarp, particularly during slippage of the Ragged Mountain block, but also by strong shaking associated with earthquakes generated on other faults in southern Alaska. As this is an uninhabited and rather inaccessible area, these rapid movements of materials are not serious geologic hazards.

REFERENCES CITED

Kachadoorian, Reuben, 1960, Engineering geology of the Katalla area, Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map I-308.

Kanizay, S. P., 1962, Mohr's theory of strength and Prandtl's compressed cell in relation to vertical tectonics: U.S. Geol. Survey Prof. Paper 414-B, p. B1-B16.

Martin, G. C., 1908, Geology and mineral resources of the Controller Bay region, Alaska: U.S. Geol. Survey Bull. 335, 141 p.

_____1921, Preliminary report on the petroleum in Alaska: U.S. Geol. Survey Bull. 719, p. 11-34.

Martin, Lawrence, 1910, Alaskan earthquakes of 1899: Geol. Soc. America Bull., v. 21, p. 339-406.

Miller, D. J., 1951, Preliminary report on the geology and oil possibilities of the Katalla district, Alaska: U.S. Geol. Survey open-file report, 66 p.

Plafker, George, 1967, Geologic map of the Gulf of Alaska Tertiary province: U.S. Geol. Survey Misc. Geol. Inv. Map I-484.

_____1969, Tectonics of the March 27, 1964, Alaska earthquake: U.S. Geol. Survey Prof. Paper 543-I, 74 p.

Tarr, R. S., and Martin, Lawrence, 1912, The earthquakes of Yakutat Bay, Alaska, in September 1899: U.S. Geol. Survey Prof. Paper 69, 135 p.

Tuthill, S. J., and Laird, W. M., 1966, Geomorphic effects of the earthquake of March 27, 1964, in the Martin-Bering River areas, Alaska: U.S. Geol. Survey Prof. Paper 543-B, p. B1-B29.

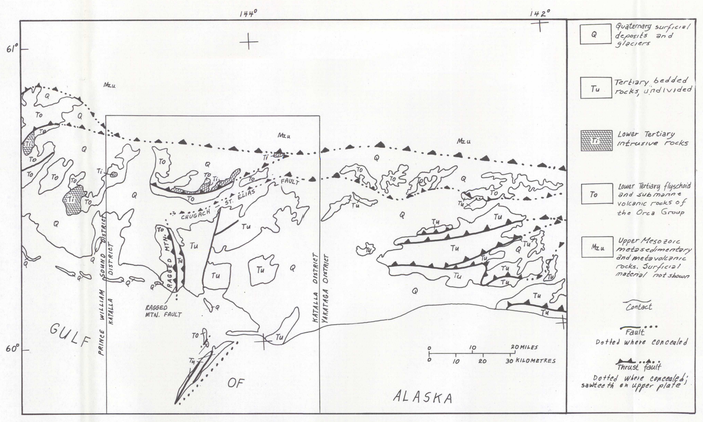


Figure 1.--Index map showing location of the Ragged Mountain fault and major faults and rock units in the Katalla District, Gulf of Alaska Tertiary province (after Plafker, 1967, and unpub. data).

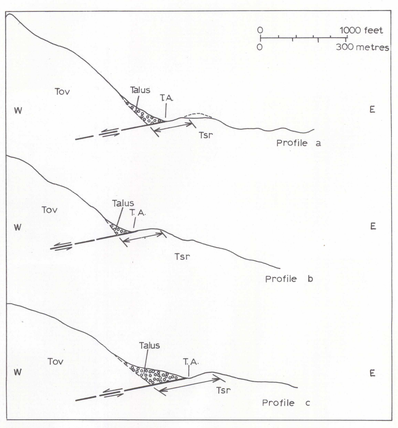


Figure 2.--Profiles across the trace of the Ragged Mountain fault. T.A. - trench axis, Tov - massive resistant greenstone of Orca Group, Tsr - thin-bedded shaly, incompetent Stillwater Formation; double-headed arrow indicates inferred net westward displacement of upper plate. Profile a - SE-1/4 sec. 28 and SW-1/4 sec. 27, T. 18 S., R. 5 E.; profile b - NE-1/4 sec. 9 and NW-1/4 sec. 10, T. 19 S., R. 5 E.; profile c - N-1/2 sec. 21, T. 19 S., R. 5 E.

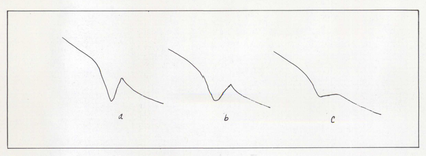


Figure 3.--Sketch (not to scale) of talus profiles showing some of the different expressions of a fissure along its length. See text for explanation.

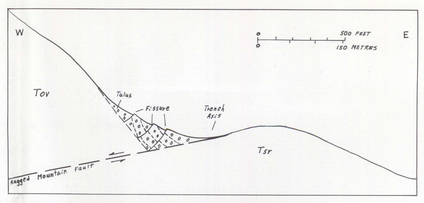
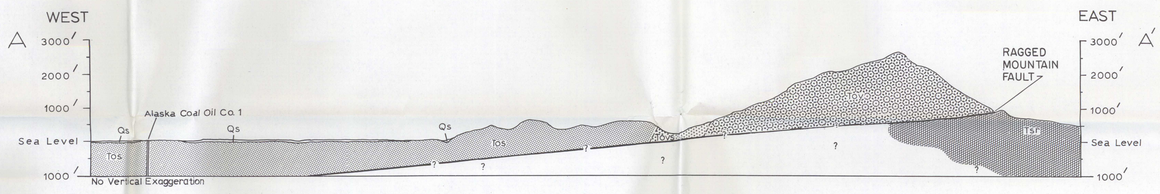


Figure 4.--Enlargement of part of profile b in figure 2 with hypothetical fissures added to illustrate their formation. Fissures form when upper plate slides to west. Solid and dashed lines in talus represent conjugate planes that are surfaces of potential slippage within talus as a result of westward displacement of Ragged Mountain; evidence of movement is confined to westward-sloping slip planes.



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CONTOUR INTERVAL 100 FEET
DATUM IS MEAN SEA LEVEL

SURFACE FEATURES AND RECENT MOVEMENT ALONG THE RAGGED MOUNTAIN FAULT, SOUTH-CENTRAL ALASKA

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1976

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