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MARINE TERRACES OF THE WESTERN ALEUTIAN ISLANDS, ALASKA

(Amchitka-30)

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ABSTRACT

The islands of the Rat Islands group, which includes Amchitka Island, have active sea cliffs, well-developed intertidal platforms, and a prominent submarine platform at -100 m. These features have not been disturbed by tectonic activity for the past 17,000 years. The islands of the Delarof Islands group, located east of Amchitka Pass, have inactive sea cliffs and emergent low terraces that indicate relatively recent uplift, possibly as much as 4 m. Higher and older marine terraces on the islands of both groups cannot be correlated, and some tectonic adjustment between the island groups is suggested.

INTRODUCTION

During the past several years, while the AEC (Atomic Energy Commission) has been developing Amchitka Island, Alaska, as an underground nuclear test site, the USGS (U.S. Geological Survey) has been conducting related geologic investigations on their behalf. One of the purposes of these studies is to determine the regional geologic environment of the site. Investigations of the regional structural geology and historical geology are parts of these studies. One of the means by which a better understanding of the structural history can be attained is through a study of the marine terraces that have been formed at various levels as a consequence of prolonged stillstands of the sea during glacial and interglacial episodes of the Quaternary Period.

The Aleutian Ridge, a narrow elongate arcuate plateaulike ridge flanked by slopes that descend on the north to the Aleutian and Bowers Basins and on the south to the Aleutian Trench, is segmented into physiographic blocks; the peaks of these blocks constitute the island groups. The Rat Islands group, the Delarof Islands group, and Tanaga Island of the Andreanof Islands group define the principal area of this study (fig. 1).

The islands are composed of Tertiary submarine and subaerial volcaniclastic rocks, intrusive dioritic masses, basaltic and andesitic dikes and sills, composite Tertiary and Quaternary volcanic cones, and Quaternary sediments. The present varied topographic forms have resulted from constructional processes and glacial and marine erosion. Topographic forms include snowcapped symmetrical volcanic cones, rugged glacially dissected mountains, undulating elevated marine terraces, and steep sea cliffs.

The study of relict shoreline features, marine terraces, and submarine platforms was made using aerial photographs of various scales, topographic maps at a scale of 1:25,000, U.S. Coast and Geodetic Survey bathymetric maps (Adak No. 1810N-2, Attu No. 1910N-2, and Kiska No. 1910N-1) at a scale of 1:400,000, and miscellaneous bathymetric charts at various scales. Field investigations were made on Tanaga and all islands of the Rat and Delarof Islands groups except Buldir, Semisopochnoi, and Gareloi. Reports on these and other islands, published by the U.S. Geological Survey (Coats, 1953, 1959; Fraser and Barnett, 1959; Lewis and others, 1960; Nelson, 1959;

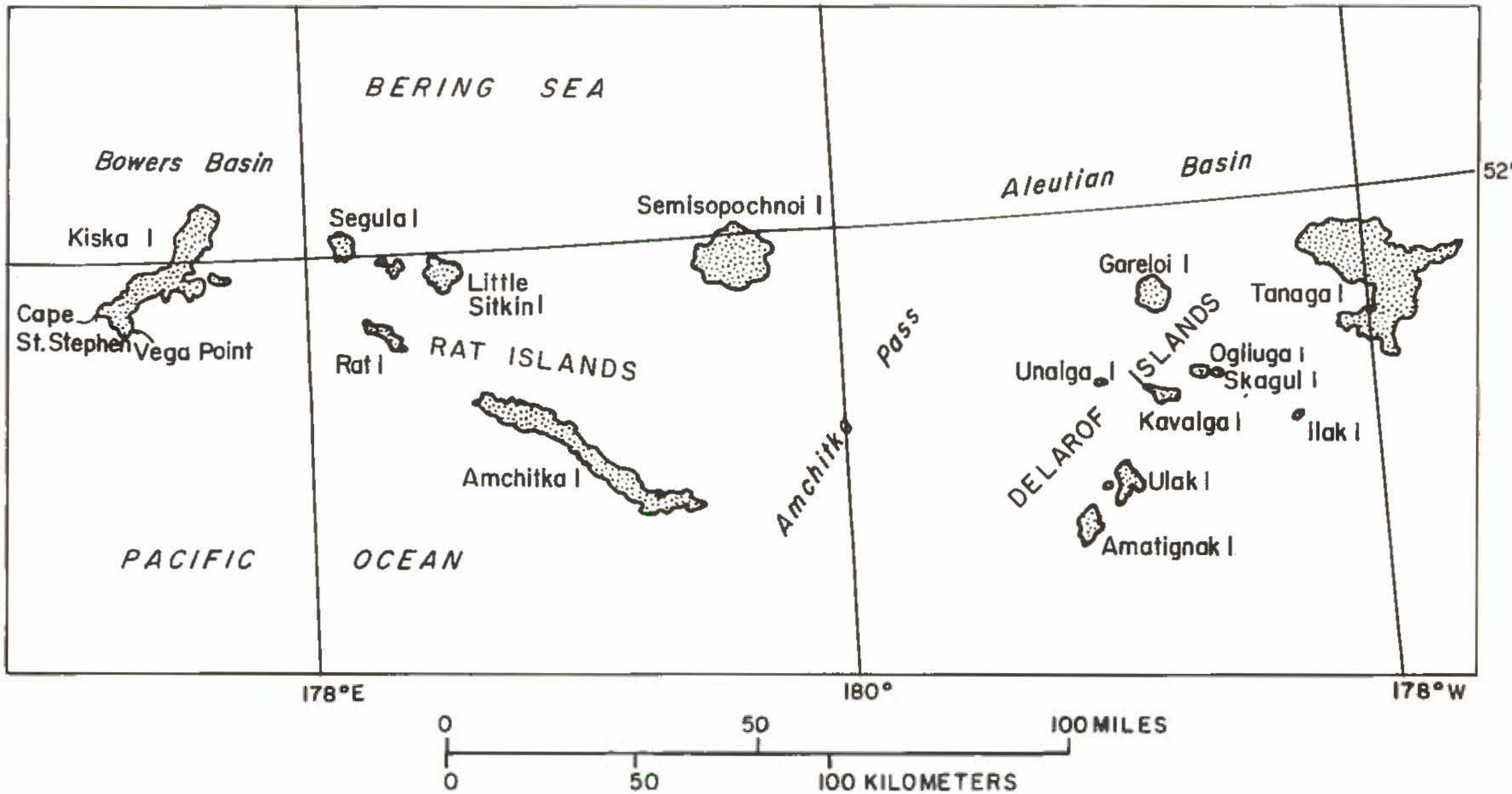

Figure 1.--Index map of the western Aleutian Islands showing the Rat Islands group, Delarof Islands group, and Tanaga Island of the Andreanof Islands group.

Powers and others, 1960; Snyder, 1957, 1959), describe marine terraces and platforms, but, unfortunately, the treatment of the subject by the several authors is not consistent, thus making the data difficult to synthesize.

Field examination of the marine terraces of Tanaga Island, seven islands in the Delarof Islands group, and seven islands in the Rat Islands group west of Amchitka Pass was made during August and September 1970. These islands were selected because they provide representative physiographic examples on either side of the seismically active Amchitka Pass. Comparison of marine terraces across Amchitka Pass provides a basis for interpreting the geologic structural history, particularly isostatic movement, of this part of the Aleutian Ridge since the terraces were formed.

MARINE TERRACES

The intertidal platform

An intertidal platform is currently being sculptured at about mean sea level. The platform varies in form from an almost planar horizontal surface as much as 100 m in width and cut on fine-grained sedimentary rock to an irregular slightly undulating surface cut on coarser grained breccia and intrusive rocks. Landward the platform merges with an active sea cliff or a bedrock ramp, often beach-cobble covered.

Figure 2 shows the well-developed intertidal platform truncating fine-grained bedrock of the Banjo Point Formation south of Rifle Range Point, Amchitka Island. An active sea cliff about 16 m (50 feet) high borders the platform. Similar platforms are found throughout the Rat Islands except in areas of more resistant rock types near centers of volcanism.

Sea level has been at about its present position for at least the past 4,000 years (Milliman and Emery, 1968), during which time this platform is believed to have been formed. The distinct horizontal planar surface of the intertidal platform is an ideal reference datum, and isostatic adjustment of any of these islands within the past 4,000 years would be evidenced by displacement of the intertidal bench and disruption of the marine ecosystems. In the Rat Islands the intertidal platform is not tilted nor is it displaced along faults; therefore, these islands are believed to have remained structurally stable during the past 4,000 years.

The 3-5 m terrace

A marine terrace 3-5 m above present mean sea level is found throughout the Rat Islands (Powers, 1961); however, there are only scattered meager remnants present on any one island. Apparently the sea remained at this level only long enough to carve a narrow bench. Other evidence of the former level of the sea is restricted to occurrences of beach gravel and associated deposits above the present

Figure 2.--The well-developed intertidal platform and active sea cliff south of Rifle Range Point, Amchitka Island, Rat Islands group.

storm berm and to terrace remnants exposed in active cutbanks along the lower reaches of streams that drain into larger bays and coves. In some places a distinct terrace may be seen extending several hundred meters along the coast and upstream along valleys of major tributary streams. A bedrock knickpoint at about 5 m is present along the channels of some streams.

The 3-5 m terrace is presumed to be greater than 5,000 but less than 10,000 years old (Powers, 1961). C^{14} samples (tree logs) were recovered from 4 m above sea level on Amchitka and Kiska Islands. The sample W-2543 from Amchitka is 900±200 years old and one from Kiska, W-2578, is 3,100 years old (Meyer Rubin, U.S. Geol. Survey, oral commun., 1971). In each case the age of the tree logs is a minimum age for the respective terraces; the terraces obviously are older than the C^{14} dates.

Figure 3, a view of Ilak Island, one of the Delarof Islands, shows the inactive sea cliff typical of these islands, which is separated from the present beach by a broad bench. The break in slope at the base of the cliff is about 7 m (21 feet) above sea level. The broad bench is characterized in places by a series of gravel beach ridges that are believed to mark the successive stages of a receding sea, which is indicative of slow island emergence. At the seaward margin of the bench the modern intertidal platform is being developed. At some places, as on Amatignak Island, the two surfaces--the broad bench and the intertidal platform--are separate and distinct. Unfortunately, no related

Figure 3.--The inactive sea cliff and the slightly emerged marine terrace on Ilak Island are also typical of other islands in the Delarof Islands group. The planar upper surface of the island is an older marine terrace that slopes southwestward (away from observer).

beach deposits containing marine fossils were found from which radiometric age-dating samples could be obtained. Peat and soil samples (W-2579 and W-2588) 7-8 m above sea level in the Delarof Islands, are 7,450 and 7,070 years old, respectively (Meyer Rubin, U.S. Geol. Survey, oral commun., 1971). The 7-m terrace is more than 7,500 years old. It is reasonable to postulate that the 7-m terrace is the former 3-m terrace that has subsequently been uplifted. The evidence from the regressive beach ridges on many of the Delarof Islands indicates gradual emergence rather than one abrupt steplike uplift. It can be concluded, therefore, that tectonic uplift beginning more than 7,500 years ago has affected the Delarof Islands (all of which lie east of Amchitka Pass) but has not affected the Rat Islands (which lie to the west).

The -100-m platform

Sea level was lowered considerably during the times of maximum glaciation; however, the exact levels to which it was lowered are still debated. There is general agreement that during the latest glaciation, 17,000 to 12,000 years B.P., sea level was about 100 m lower than it is today (Milliman and Emery, 1968).

In the western Aleutian Islands a platform can be identified on detailed bathymetric charts. This platform ranges in depth from approximately -90 to -110 m, and is most extensively developed southwest of Amchitka Island (fig. 4). The inner boundary of the platform is along the -90-m (50 fathoms) contour, the outer boundary is at -100 m (55 fathoms). In places the platform is as much as 3 miles wide. Like the present-day sea-level terrace the -100-m platform is well developed along the Pacific Ocean side of Amchitka Island but imperfectly developed on the Bering Sea side. The -100-m platform is the lowest one recognizable and from its outer margin the sea floor slopes uniformly downward without interruption. The -100-m platform is traceable around all islands of the Rat Islands group, though nowhere else is it as well developed as southwest of Amchitka. If it is assumed that this -100-m platform was carved by the sea during the last glaciation then it must be at least 12,000 to 17,000 years old. This platform can be traced around Amchitka Island without apparent vertical displacement or tilting (the limit of accuracy of the bathymetry is, however, about 5 fathoms) and is thus indicative of structural stability during and since its development, or for at least during the past 17,000 years.

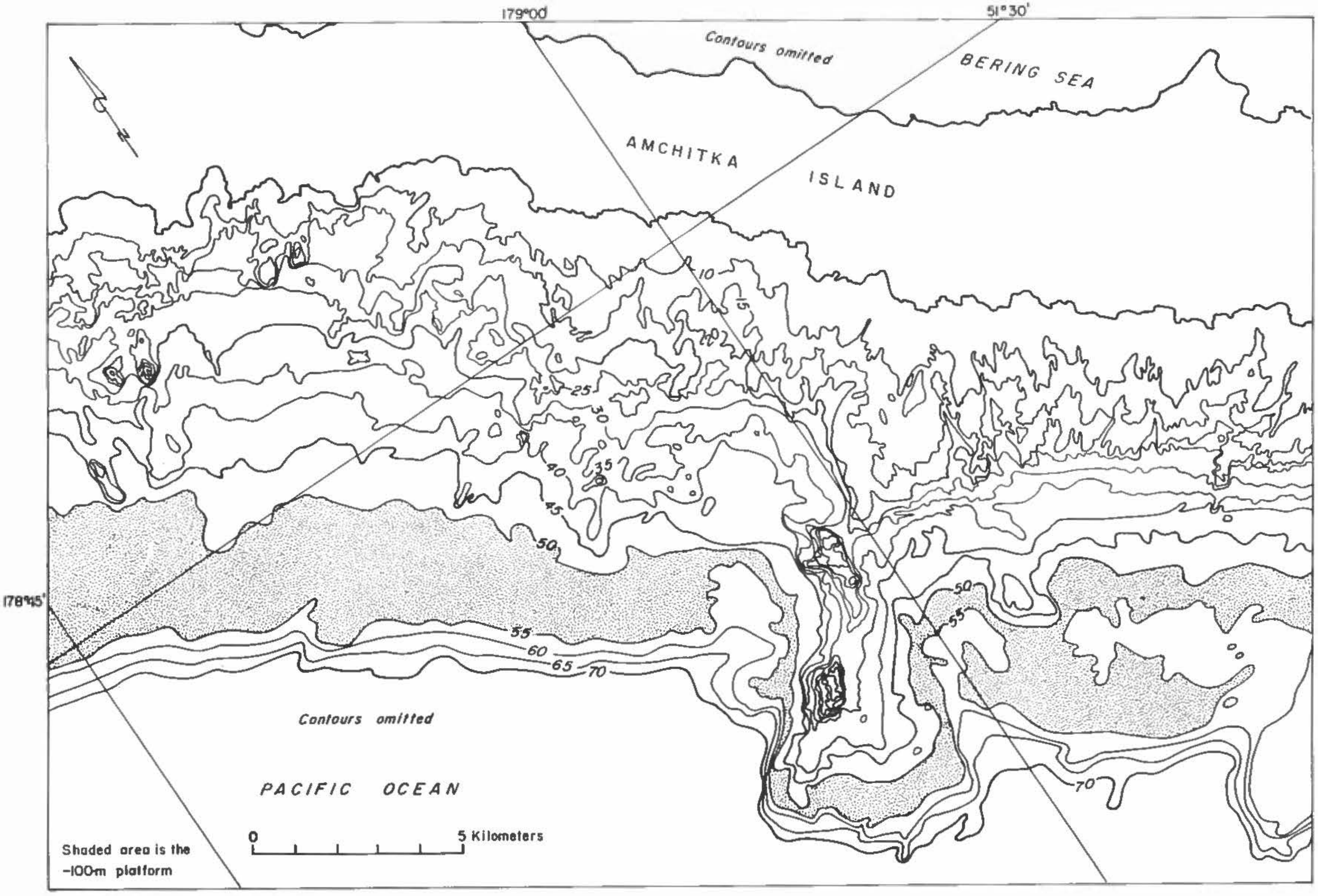

Figure 4.--Bathymetric map of the ocean floor southwest of central Amchitka Island, Alaska. Contour interval 5 fathoms.

Older terraces

Remnants of older marine terraces on most islands are found at altitudes as high as 165 m (Morris, 1970). Precise correlation of these terraces could be made if radiometric age determinations of associated deposits were feasible. However, the only location where radiometric age determinations could be employed is at South Bight, Amchitka Island. No datable terrace deposits were found on any of the 14 other islands examined. At South Bight tilted and faulted upper Pliocene(?) or lower Pleistocene(?) (E. B. Leopold, written commun., 1971) strata in a graben are unconformably overlain by poorly consolidated lenticular beds of gravel, sand, and silt. The unconformity appears to be a sloping surface that is at an altitude of 36 m above sea level on the north side of South Bight and at 17 m near the south side (L. M. Gard, oral commun., 1971). Within these sand and gravel deposits in the central part of the cliff and at an elevation of 35 m above sea level are fossils of assorted mollusks and the bones of a Steller's Sea Cow for which a radiometric age date has been determined. The age of the sea cow is about 135,000±12,000 years B.P. (Gard and Szabo, 1971). The strata enclosing the sea cow bones are interpreted as being beach deposits related to the 52-m marine terrace that is well developed around the southern part of Amchitka Island. These strata, from which the age-date samples were obtained, buried faults in the upper Pliocene(?) or lower Pleistocene(?) rocks. The photograph, figure 5, shows the structural and stratigraphic relationships at South Bight.

Figure 5.--Sea cliff at South Bight, Amchitka Island, showing unfaulted Pleistocene strata overlying tilted and faulted Pliocene(?) or lower Pleistocene(?) strata.

The fact that the overlying strata truncate the faults and are not themselves faulted indicates that these faults apparently have not been reactivated for at least 135,000 years. However, there may have been some penecontemporaneous movement along the south-bounding fault of the graben during deposition of these deposits, which may account for the slight tilting of the unconformity.

At two other locations on Amchitka--Rifle Range gravel pit and the Fox Runway pits--are strata believed to be equivalent to those at South Bight, but positive correlation has not been made. The structural relationships, however, are similar; that is, a lower (older) fine-grained sandstone is faulted and overlain unconformably by a younger conglomeratic sandy gravel that is not faulted. In each case the unconformity is at about the 30-m altitude and thus, logically, the deposits seem to be correlative.

If strata at each of these locations are correlative it follows that the faults (Constantine graben, Rifle Range fault) that predate the upper strata are also older than 135,000 years and since then have not been reactivated. It also suggests that the 52-m terrace around the southern part of Amchitka has not been structurally dislocated during the past 135,000 years.

On Kiska Island a terrace traceable on both aerial photographs and topographic maps extends from an altitude of about 80 m (250 feet) at Cape St. Stephen to an altitude of about 50 m (150 feet) at Vega Point. The apparent dip of the terrace is less than 1/2°, toward the southeast. No field data were obtained upon which a relative age of the terrace could be determined. The apparent tilting predates the development of the modern intertidal bench.

Elsewhere in the Rat Islands no field evidence was obtained upon which conclusions could be based regarding equivalent late Pleistocene and Holocene structural events.

In the Delarof Islands group a very prominent marine terrace on Ulak Island slopes southward about 1/2°. The terrace ranges in altitude from 80 to 30 m (250 to 100 feet), and direct correlation to terraces on other islands in the Delarof group or in the Rat Islands group cannot be made. The uppermost surface of Ilak Island is a marine terrace with a southwesterly component of tilt, whereas the emergent low terrace and the present intertidal platform are horizontal. The significant conclusion is that minor tilting is recognized as having occurred in the Delarof Islands sometime during the Pleistocene Epoch, probably the late Pleistocene, and that the tilting was followed by slow emergence of the Delarof Islands.

SUMMARY

The major conclusions from the foregoing discussion are:

(a) The present intertidal platform that has developed around most islands of the Rat and Delarof Islands groups is interpreted to be about 4,000 years old and has not been displaced by recent faulting.

(b) The 3-5-m terrace has remained static in the Rat Islands but appears to have been uplifted about 4 m in the Delarof Islands.

(c) The -100-m platform around Amchitka Island is believed to be about 17,000 years old and does not appear to have been disrupted by faulting.

(d) The radiometric age date of fossil bones on Amchitka Island indicates faulting at South Bight occurred over 135,000 years ago and has not been reactivated. The associated marine terrace at 52-m altitude has not been displaced vertically in the southern part of Amchitka Island.

(e) Correlation of older terraces in the Delarof Islands with those in the Rat Islands is not possible.

(f) Older high marine terraces on Kiska Island, Ilak Island, and Ulak Island are tilted.

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