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Geologic Studies Related to Earthquake Potential and Recurrence in the "Yakataga Seismic Gap"

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Geologic data relevant to earthquake recurrence times in the "Yakataga seismic gap" are primarily the ages of coseismic marine terraces at Middleton Island in the Gulf of Alaska and along the mainland coast between Yakataga and Icy Bay (Plafker and Rubin, 1967, 1978; Plafker, 1969; Plafker and others, 1981). These terraces are believed to record one or more abrupt coseismic uplifts of the shoreline relative to sea level following long periods of interseismic strain accumulation and relative stability with respect to sea level.

Middleton Island, near the margin of the continental shelf in the northern Gulf of Alaska, has emerged from the sea during six major episodes of coseismic uplift from oldest to youngest of about 7 m, 8 m, 6 m, 9 m, 7.5 m, and 3.5 m which are recorded by exceptionally well-exposed and preserved marine terraces (fig. 1). All but the youngest uplift have been dated by radiocarbon methods at roughly 5,090, 3,890, 3,500, 2,420, and 1,290 (all $\pm$ 250) calendar years before present, respectively, and the most recent uplift occurred during the great March 27, 1964 Alaska earthquake. The radiocarbon-dated material is either driftwood or the oldest peat on the terrace surface. Recurrence time for these movements is on the order of 400 to 1,300 years. During this period, the eustatic level of the sea was either slowly rising or stable; thus the episodic nature of the emerging terraces requires that the pre-1964 terraces are also primarily tectonic in origin. Average uplift rate is approximately 10 mm/yr since the island first emerged from the sea 5,090 years ago and there appears to be an abrupt decrease in the rate of uplift to 6 mm/yr in the interval preceding uplift of the 1964 terrace. Independent evidence for the long strain accumulation period that preceded the 1964 event comes from radiocarbon dating of shorelines that were tectonically submerged in the eastern part of the earthquake focal region (throughout Prince William Sound, the Copper River Delta, and Cape Suckling). These data indicate that submergence occurred throughout this region and that at Montague Island it was continuous for at least 1,180±70 calendar years prior to the earthquake at an average rate of 6 mm/yr. (fig. 2). These data preclude the possibility that a 1964-type event involving significant uplift affected the Montague Island area for at least 1,180 years prior to 1964.

The accumulated Middleton Island terrace data suggest recurrence intervals of 400 to 1,300 years for large arc-related events of the 1964 type. The data from terrace uplift steps and rates at Middleton Island, together with the results of triangulation resurveys in the earthquake-affected region, suggest that at least half of the strain accumulated during the 1,300 years that preceded the 1964 earthquake has yet to be released, assuming no significant aseismic prequake creep. The accumulated strain could be released either by aseismic creep or in one or more large earthquakes over a time interval that is short, relative to the interval between successive terrace uplifts. Because the tide gage data indicate recovery rather than continued gradual strain release since the 1964 earthquake, it appears more likely that any residual accumulated strain at Middleton Island will be released during future earthquakes.

Along a heavily forested segment of the mainland between Cape Yakataga in the west and Icy Cape, four marine terraces have been dated by their included peat, wood and organic sediment layers. Radiocarbon dates obtained on organic material from these raised shorelines provide approximate terrace ages of 6,520, 4,990, 2,820 and 1,400 (all ± 250) calendar years for corresponding average uplift of about 63 m, 37 m, 21 m and 13 m (fig. 3). The terraces have similar depositional sequences, with thin deposits of beach and lagoon facies overlying surfaces cut into both unconsolidated sediments and bedrock. The terrace sequences are commonly overlain and concealed by thick fluvial and fluvioglacial deposits; dated material comes from the lagoonal facies on each terrace.

The average uplift rate (corrected for eustatic sea level rise but not isostatic uplift) for the past 6,500 years is about 10 mm/yr near Icy Cape and approximately half this amount at Cape Yakataga. The upward slope in elevation of the terraces eastward towards Icy Cape may be due to an isostatic component related to deglaciation at Icy Bay. Assuming the entire terrace uplift occurred as discrete major coseismic steps, the recurrence intervals from oldest to youngest would be 1,530, 2,170, 1,420, and 1,400 calendar years, with steps of about 15.5, 17, 7.5, and 13.5 meters. However, because of the dense vegetation cover and poor exposure on the terraces, it is probable that not all terrace steps above the stage III terrace have been identified. The plate-convergence rates along this part of the Pacific margin are 50-60 mm/yr so that the terraces record only part of the tectonic deformation in this structurally complex and tectonically active region.

The last uplift step of about 13 m that formed the stage IV terrace occurred about 1,420 years ago. Thus, if the average recurrence interval for major terrace-forming earthquakes in this area is about 1,400 years, as suggested by the interval between the stage III and IV terraces, the data suggest that the next uplift event in the Cape Yakataga-Icy Cape area may be imminent.

In summary, terrace data suggest that tectonic uplift rates in both the

Cape Yakataga-Icy Cape and Middleton areas near both ends of the "Yakataga seismic gap" lag behind the long-term average rates. Future uplift of these areas most probably would occur during one or more major earthquakes along the convergent boundary between the Yakutat and Wrangell blocks which extends northeastward from the eastern end of the Aleutian Trench along the Pamplona zone to the Fairweather transform fault. Because major earthquakes along this boundary are also likely to be accompanied by large vertical displacements on the continental shelf, they could generate seismic sea waves capable of causing coastal damage far from the earthquake focal region.

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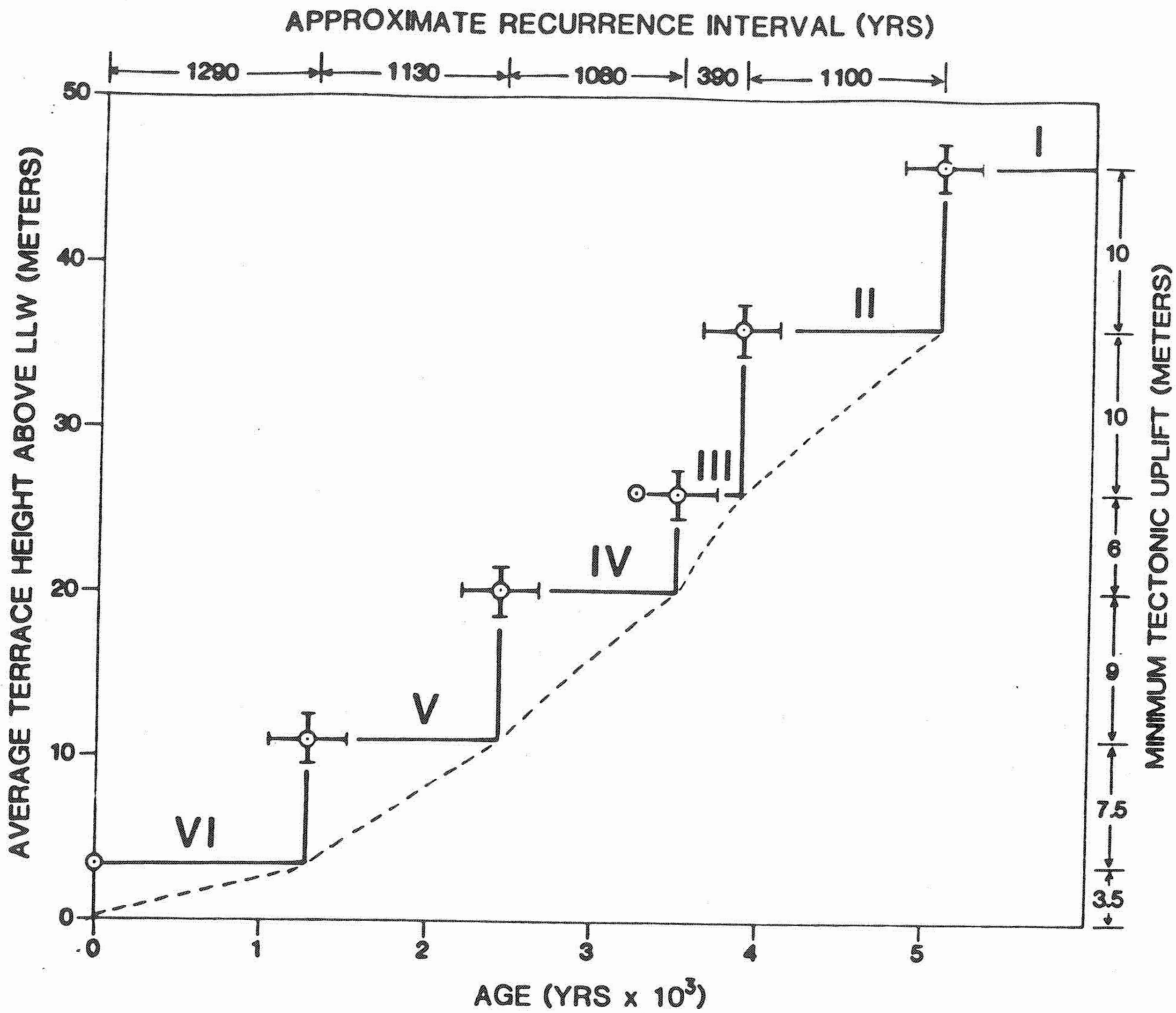

Figure 1. Generalized diagram showing average terrace height at Middleton Island (Roman numerals) and minimum tectonic uplift per event(s), versus terrace age and indicated recurrence interval. Terrace heights corrected forHolocene sea level rise; radiocarbon ages corrected to calendar years. The solid curve shows an inferred uplift sequence assuming no interseismic vertical movement. The dotted line indicates the average uplift rate between terraces. After Plafker and Rubin (1978).

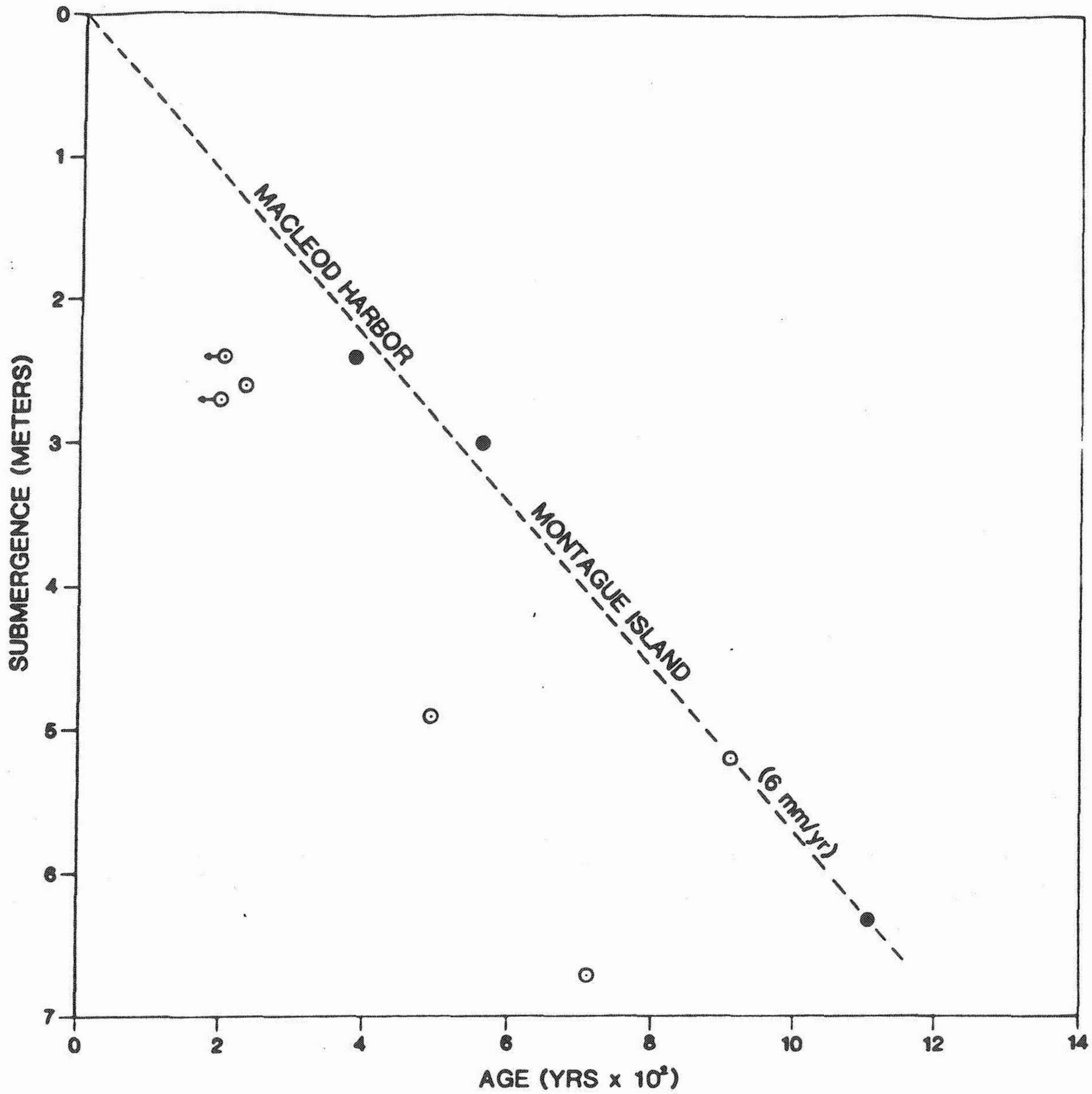

Figure 2. Pre-1964 positions of submerged radiocarbon-dated shoreline samples (dots) from the eastern end of the 27 March 1964 earthquake focal region. All sample localities are in the region of coseismic uplift during the 1964 earthquake; the Montague Island localities (solid dots) were uplifted about 9 m. Widespread interseismic submergence of shorelines at average rates ranging from 5 to 11 mm/yr for 1,180 calendar years indicates an absence of 1964-type tectonic uplift for at least this period. After Plafker and Rubin (1967), Plafker (1969), and unpublished data.

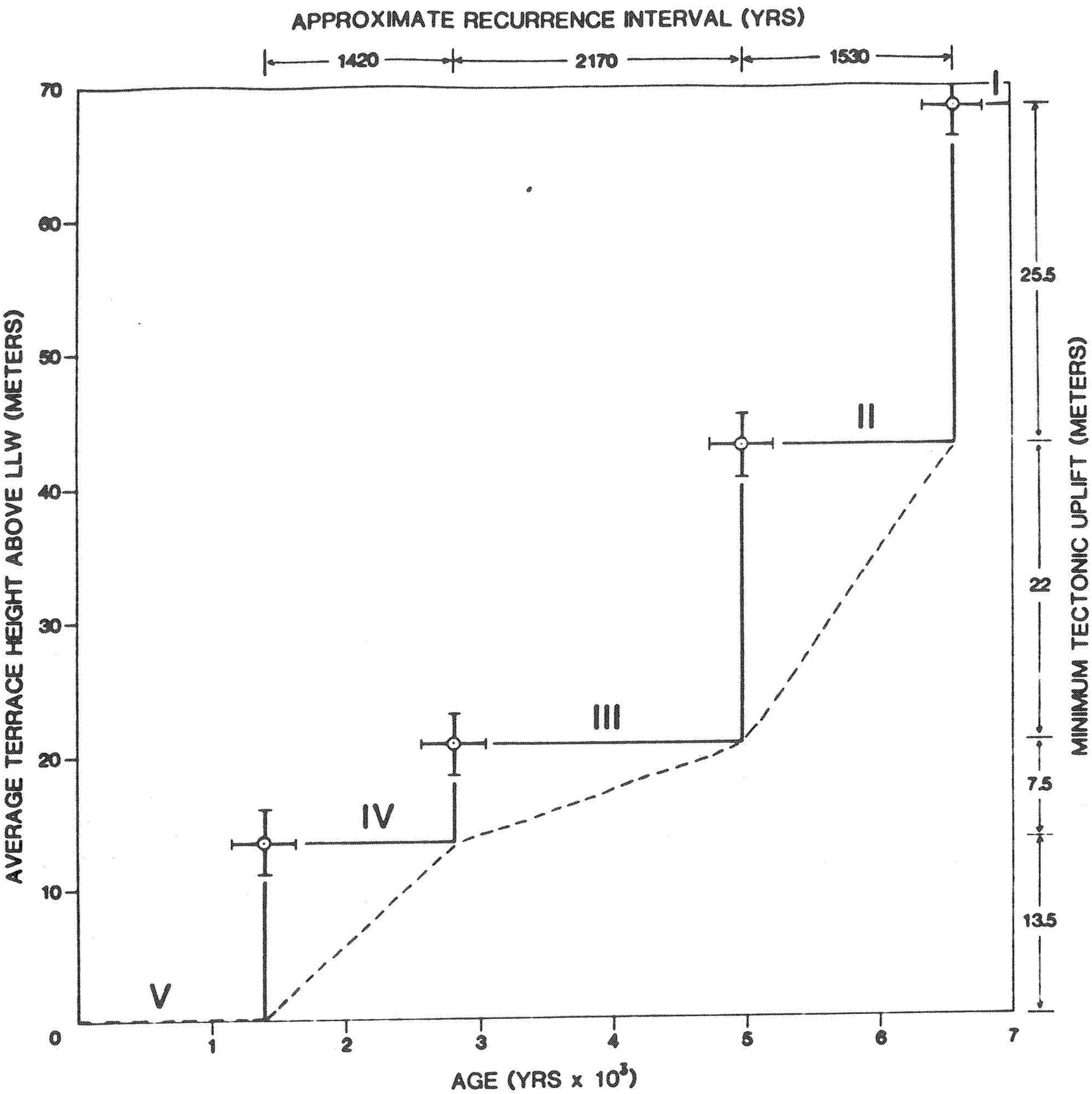

Figure 3. Generalized diagram showing average terrace height in the Icy Cape area (Roman numerals) and minimum tectonic uplift per event(s), versus terrace age and indicated recurrence interval. Terrace heights corrected for holocene sea level rise; radiocarbon ages corrected to calendar years. The dashed line shows an inferred uplift sequence assuming no interseismic vertical movement. After Plafker and others (1982) and Rubin and others (1982).