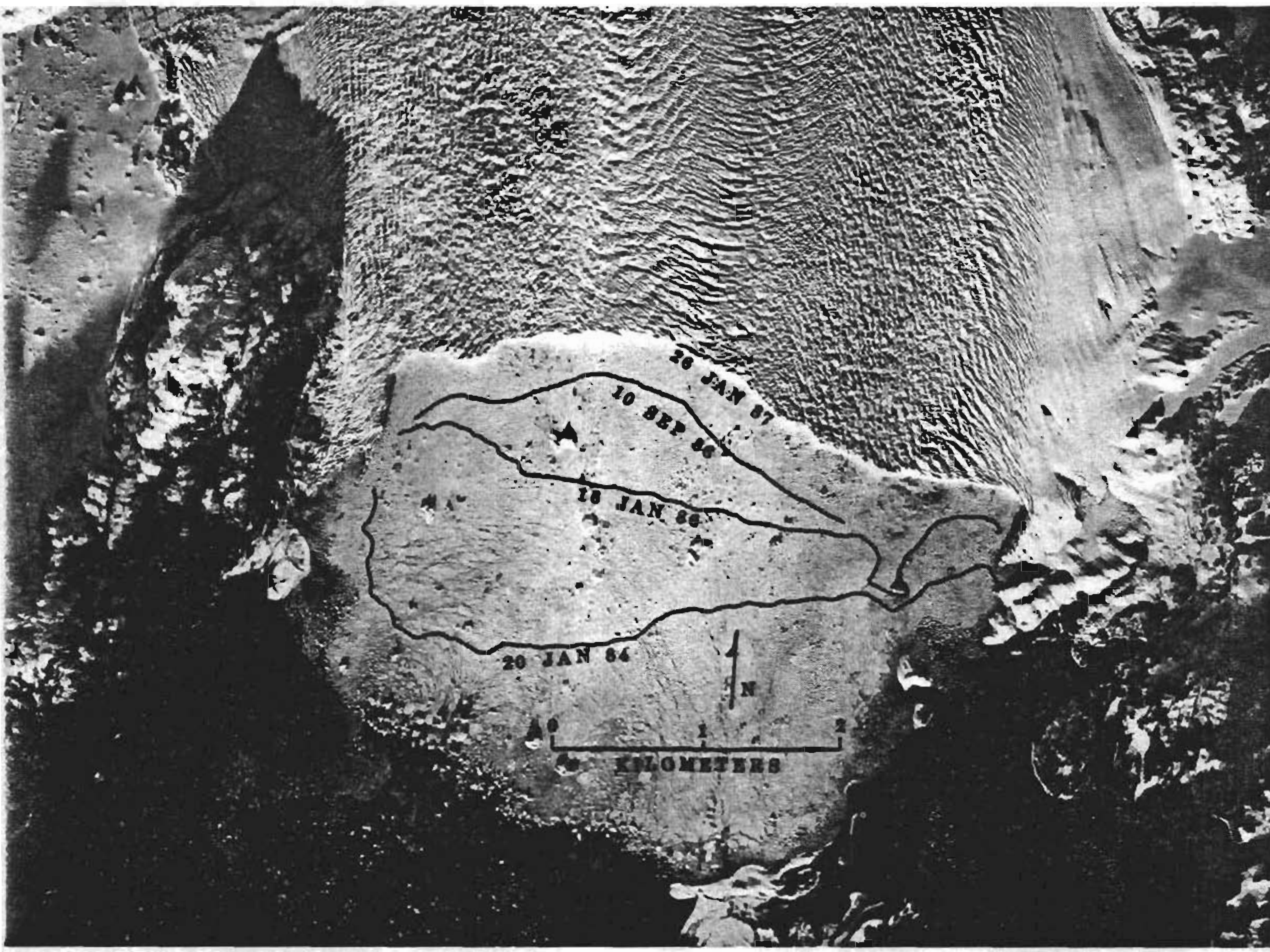
Columbia Glacier in 1986: 800 Meter Retreat



U.S. GEOLOGICAL SURVEY

Open-file Report 87-207

Cover — Vertical aerial photograph of the terminus of Columbia Glacier, 26 January 1987. The positions of the terminus, taken directly from similar aerial photography on 20 January 1984, 16 January 1986, and 10 September 1986, are also shown for reference.

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By Robert M. Krimmel

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Open-file Report 87-207

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DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS

For the use of readers who prefer to use inch-pound units, conversion factors for metric (International System) units used in this report are given below:

Multiply metric unit	By	To Obtain inch-pound unit
kilometer	0.6214	mile
meter	3.281	foot

COLUMBIA GLACIER IN 1986:

800 METER RETREAT

Robert M. Krimmel

ABSTRACT

Columbia Glacier, in Prince William Sound, Alaska, continued its rapid retreat in 1986, with a retreat of 800 meters. Average velocity of the lower portion of the glacier, 10 September 1986 to 26 January 1987, was three kilometers per year, or about one-half of the velocity during similar periods for the previous three years. This reduced velocity is a new development in the progression of the retreat, and if the calving rate follows the pattern of previous years, will result in continued retreat.

TEXT

Columbia Glacier is a rapidly retreating tidewater glacier in Prince William Sound, Alaska. Annual recession has been continuous since mid-1981, and in 1984 was 1,100 meters (Meier and others, 1985a). In 1985, retreat was 250 meters (Krimmel and Vaughn, 1987). The purpose of this brief report is to disseminate information on the position of the Columbia Glacier terminus in 1986 and early 1987.

The most precise and economical way to obtain data on the position of the Columbia terminus is by vertical aerial photography. Beginning in 1976 vertical photography of the lower glacier has been obtained several times each year to document changes in the terminus position, velocity, and thickness. The flight dates, data from the photography, and results of photogrammetry have been published for flights from 1976 through 1985 (Fountain, 1982; Meier and others, 1985b; Krimmel, 1987).

The flights in 1986 occurred on 16 January, 24 March, 13 June, and 10 September. Due to unusually persistent poor weather in southern Alaska during November and December of 1986, and January 1987, vertical photography was not obtained between 10 September 1986 and 26 January 1987. The flight on 26 January 1987 gave a glacier length of 64.0 kilometers, or nearly 800 meters less than the length just over a year ago on 16 January 1986. The average date (1977-1985) for the minimum glacier length is 21 November (Krimmel and Vaughn, 1987), after which the glacier begins a seasonal advance. The seasonal advance between late November 1983 and late January 1984 amounted to 100 meters, and for a similar 1984 to 1985 period was 250 meters. Based on the assumption that in the fall of 1986 the glacier behaved similarly as in the previous fall periods, it is likely that the minimum length for Columbia Glacier in 1986 was about 63.9 kilometers (fig. 1).

While the seasonal variations in glacier length behaved in similar fashion from as early as 1977 through 1985 (Meier and others, 1985a; Krimmel and Vaughn, 1987), the velocity near the terminus has not been so seasonally predictable for the last three years. Generally, the highest ice velocity within one kilometer of the terminus occurred simultaneously with the minimum length of the glacier, however the highest ice velocities that occurred associated with the 1983, 1984, and 1985 minimum lengths did not occur until one to three months later. Also, the highest velocities in the 1984-1986 period were about two times higher, as much as 6,000 meters per year, than previous to 1982 (Krimmel, 1987). The average velocity one kilometer above the terminus for the 10 September 1986 to 26 January 1987 period, measured by the desktop photogrammetry overlay methods described by Meier and others (1985b), was 3,000 meters per year, about one-half that seen in the same season in 1983-1985 (fig. 2).

The change in length of an active tidal glacier is the sum of the forward movement (positive) and the calving (negative). If the calving rate remains constant while velocity decreases, then retreat must occur. The factors that control calving rate have been analyzed to some extent. Brown and others (1983) showed annual calving to be directly proportional to the water depth at the terminus. Sikonia and Post (1980) showed strong correlation between river discharge and embayment formation, suggesting that calving rate is controlled by subglacial water discharge. In a later paper Sikonia (1982) also included a term for the height of ice unsupported by buoyancy. While all these theories make intuitive sense and fit the data well, it is difficult to use them to explain the changing position of the Columbia Glacier terminus for several reasons. The water depth at the terminus is increasing as the terminus retreats (Brown and others, 1986), the height of ice unsupported by buoyancy is changing as the glacier thins (Krimmel, 1987), and the ice velocity is changing. The velocity change is critical, but not explained. Work on surging glaciers (Kamb and others ,1985) suggests that the sliding velocity, by which Columbia Glacier dominantly moves, is controlled by basal water pressure in a system of linked cavities, with higher pressure and velocity in winter when water flux is low. Meier and Post (1987) suggest that in tidal glaciers velocity will increase when the glacier thins because the ice overburden pressure, and hence basal friction, is reduced. The 1983 to 1985 velocity increase at Columbia could be explained by its thinning and the position of the terminus relative to the moraine shoal (Krimmel and Vaughn, 1987), but there has not been a corresponding increase in thickness or position change relative to the moraine shoal to explain the 1986 velocity reduction.

The reduced average velocity in late 1986 and early 1987 is a major development in the progression of the drastic retreat, and can not be explained by the available theories and observations. It is conceivable that the year to year variations in weather result in year to year variations in basal water pressure of significant magnitude to affect velocity dramatically, but no suitable models have been applied to the hydro-meteorological system to prove such a relation.

The velocity decrease, considered by itself, and assuming a constant calving rate, would result in continued retreat. The direct measurement of calving rate at Columbia indicates higher calving rates in the late summer through late fall, and reduced winter calving rate. In past years the increased winter velocity, combined with reduced winter calving has resulted in winter and spring glacier advance. Because of the anomalously low velocity in the late fall and early winter of 1986/7, the usual seasonal advance may not occur, or at least be anomalously small. Considering the reduced ice velocity, the retreat will likely accelerate more.

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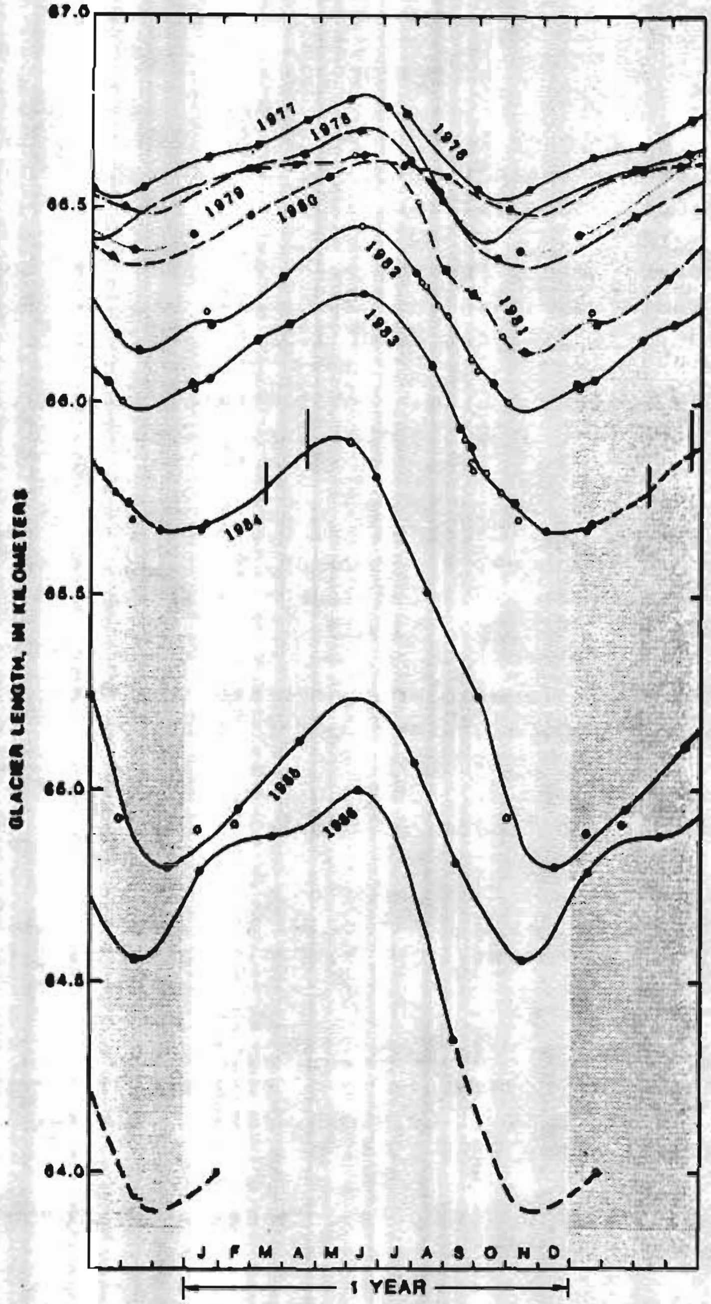

Figure 1. -- Seasonal advance and retreat of Columbia Glacier for the years 1976-1986, superimposed onto one year for comparison. The curves are repeated in the gray areas to either side to help visualize trends. Solid dots are data points obtained by photogrammetry (error is about 10 meters), open circles are observations by less-accurate methods (ship-borne radar, ground surveys), and smooth curves are drawn through data points. Data from aerial photographs taken on 12 March and 24 April 1984 are plotted as vertical lines because of the difficulty in differentiating the low, irregular ice cliff from floating ice. Values are averaged over the width of the active terminus. This figure adapted from Meier and others, 1985a.

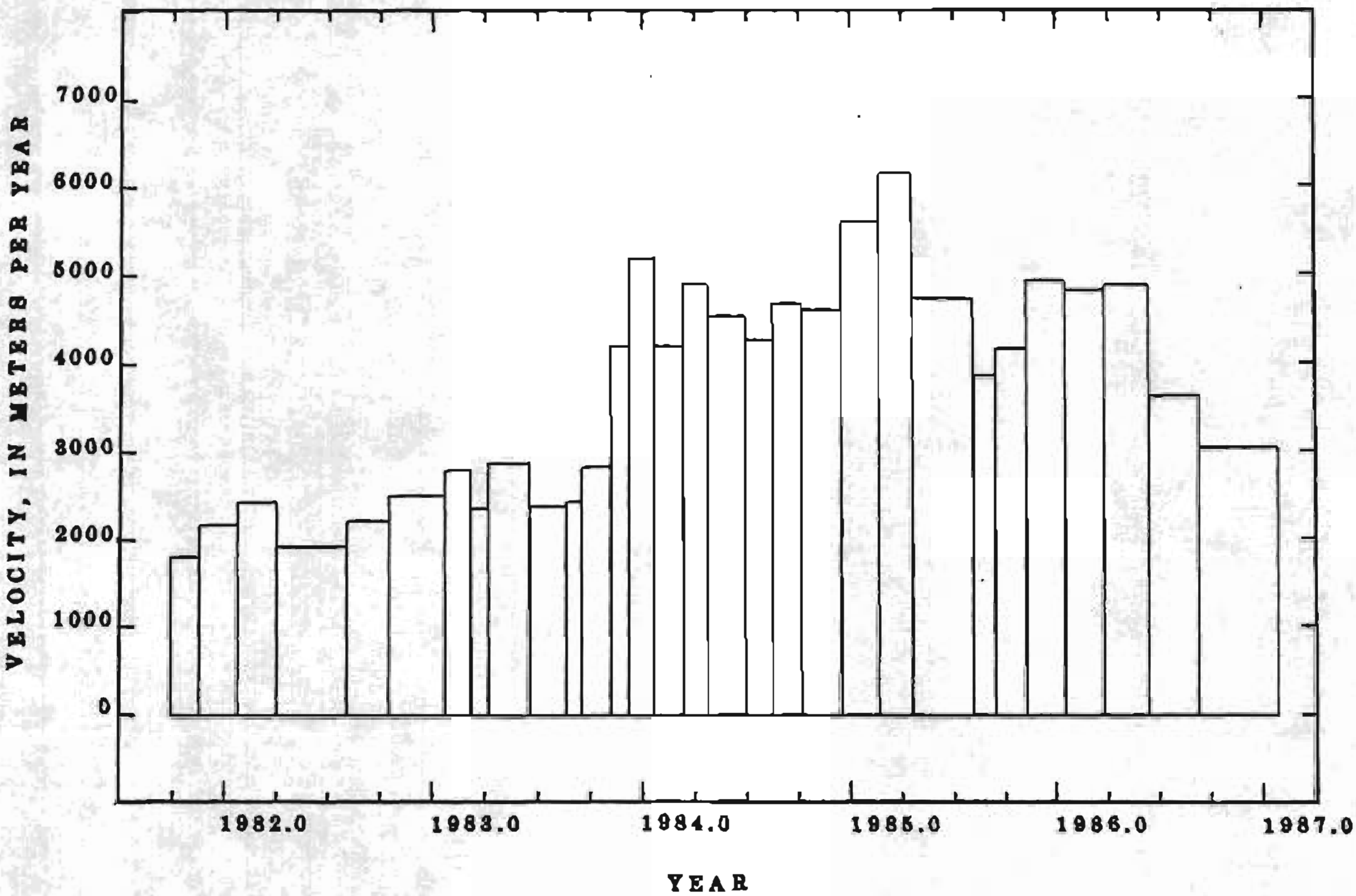

Figure 2. -- Velocity of Columbia Glacier within about one kilometer of the terminus as measured from vertical photography by desktop photogrammetry. Error in this method is in the order of 300 meters per year. Vertical bars represent time intervals between flights with the average velocity shown by the bar heights. Velocity prior to 1982 was 1,000-3,000 meters per year (Meier and others, 1985b).