



**VARIATIONS AND STABILITY OF COLUMBIA GLACIER**

Nearly all glaciers in Alaska and other parts of the world which end in the oceans (here called tidal glaciers) have experienced very large scale synchronous advances and retreats which are not directly related to climate. Changes in snowline altitude and glacier width as a glacier advances or retreats can create instabilities which may continue long after the triggering mechanism has dissipated (Mercer, 1961).

Independent studies of tidal glaciers by the author and by Hoppe (1969) and Grosswald (1974, p. 73) have disclosed that another very critical factor in the stability of these glaciers is the water depth at the glacier's terminus. Instability results when a tidal glacier retreats even a short distance into a deep basin from a stable position on a terminal shoal. The glacier may then retreat many kilometres per year as innumerable icebergs, some of immense size, break away from the glacier.

Since first mapped in 1794 by Vancouver (1798), nine Alaskan tidal glaciers have made large-scale drastic retreats, including the 100-km retreat of ice in Glacier Bay, which is probably the greatest retreat in historic time in the world. Columbia Glacier, 1,100 km<sup>2</sup> in area and the largest glacier in Prince William Sound, is now the only tidal glacier remaining on the North American Continent which is still in an extended Neoglacial position.

The terminus of Columbia Glacier has been in a state of near equilibrium since first mapped. Even under these conditions icebergs occasionally drift into the shipping lanes in northern Prince William Sound and the approaches to Port Valdez, southern terminal of the new trans-Alaskan pipeline (U.S. Coast and Geodetic Survey, 1964, p. 32, 41). Drastic retreat of the glacier would vastly increase icebergs hazards to shipping, especially to large, unwieldy vessels such as oil tankers. Thus it is important to know if Columbia Glacier is in a situation where drastic retreat is possible. Also the dynamic condition of the glacier needs to be determined so that its future stability may be predicted. This atlas pertains to the first of these questions.

The data reported here resulted from a first-of-its-kind hydrographic survey made of a tidal glacier by use of a specially equipped mother ship and an unmanned, instrumented launch which could be run by radio control directly to the glacier's hazardous tidal cliff. Positions of both vessels were determined by theodolite intersection from shore and by sextant angles and radar ranging from shipboard.

These surveys show that Columbia Glacier, as was anticipated, ends on a shoal judged to be a terminal moraine, which extends completely across Columbia Bay. Water depths on this bar, where measured in this preliminary examination, ranged from less than 2 to about 30 m. Soundings by skiff (1973) in a large terminal embayment on the west side of the glacier and radar soundings (1974) of the ice thickness obtained at various points on the glacier's surface disclose that the shoals at the terminus do not continue far under the ice. For at least 30 km up the glacier from the terminus much of the bottom is far below the sea, and ice depths as great as 700 m below sea level were recorded.

The data on the following sheets show that for more than 70 years Columbia Glacier's terminus has been virtually stable, with frequent temporary advances being balanced by retreats of the same magnitude. This stability is in marked contrast to other glaciers in the area, most of which have thinned and retreated during this interval, the only other notable exceptions being tidal glaciers which have previously made large-scale drastic retreats and which are currently advancing. Columbia Glacier's extended position and advances in recent decades over areas not glaciated for more than 9,000 years (J. H. Mercer, written commun., 1975) are anomalous. Very large embayments which form some years in the glacier's terminus cliff may present a serious hazard to the glacier's continued stability. Drastic retreat with associated increased icebergs discharge could occur within a few years should the glacier retreat from the shoals. These fluctuations at the terminus and changes in thickness in other parts of the glacier are being carefully monitored in order to predict the glacier's future stability.

<sup>1</sup>Not necessarily having a floating terminus.

Photographic station and name or number, those without center dot indicate approximate locations.  
△ 1974 triangulation station and name.  
□ Grab sample site, position approximate.

Shorelines are approximate mean high tide from NASA 19,800 metres altitude and aerial photographs, May 1974.  
Dotted line furthest from shore indicate approximate shoreline at extreme low tide. Shorelines, shoals, and off-shore rocks not field checked.

Lines with dates show glacier terminus on that date; July 1974 line is dashed where terminus lies on land.

☼ C-14 wood sample dated 9,200 ± 160 years before present, collected at base of 2 metres of peat (Mercer, written communication, 1975).

Interior-Geological Survey, Reston, Va.—1973—W-7654

ALASKA  
LOCATION MAP

Triangulation by U. S. Geological Survey 1974.  
Topography modified U. S. Geological Survey 1:63,360 quadrangles Cordova D-8, Seward D-1, Valdez A-8, and Anchorage A-1.  
Hydrography from 1973 and 1974 surveys by U. S. Geological Survey with charted University of Alaska Research Ship Arona and radio-controlled launch Firefish.  
Surveyed in cooperation with the National Oceanic and Atmospheric Administration.

188 Soundings positioned by theodolite and sextant surveys, corrected for tide.  
184 Soundings positioned by radar or dead reckoning, not corrected for tide.  
PA POSITION APPROXIMATE  
PD POSITION DOUBTFUL  
ED EXISTENCE DOUBTFUL

19 When less than 10 metres, soundings are in metres and tenths.

MAP SHOWING REGIONAL SETTING OF COLUMBIA GLACIER

SCALE 1:10,000  
0 10 20 30 KILOMETRES

GLACIER OUTLINES

SCALE 1:10,000  
0 5 10 KILOMETRES  
CONTOUR INTERVAL ON LAND 30 METRES  
HEIGHTS AND DEPTHS IN METRES  
DATUM IS MEAN SEA LEVEL

MAP OF PRELIMINARY HYDROGRAPHIC SURVEY OF COLUMBIA GLACIER TERMINUS