AVALANCHE FORECASTING IN JUNEAU ALASKA

R. Hutcheon and L. Lie

Introduction

Juneau lies in the rugged mountainous regions of southeast Alaska. This region, with its many islands and deep fjords, is within the maritime influences of the north-eastern Pacific. Juneau's climate is characterized by little sunshine, moderate temperatures, and abundant precipitation (U.S. Dept. of Commerce, 1976). At times, however, the climate reverts to continental conditions. In winter, this is characterized by temperatures below -20°C and gusty northeasterly winds.

Average annual temperatures throughout southeast Alaska are between 5°C and 10°C, but in the winter months temperature extremes may range from -29°C to +16°C (Searby 1971).

Precipitation also varies greatly, with Little Port Walter (192 km south of Juneau) averaging 4780 mm annually and Skagway to the north averaging 660 mm annually. Comparing downtown Juneau's average annual precipitation, 2340 mm, with that of Juneau's Airport 14 km away, 1400 mm, demonstrates the wide variation within relatively short distances (U.S. Dept. of Commerce, 1973).

The steep, rugged terrain combined with abundant precipitation and widely varying temperatures during the winter months, result in a high threat of avalanche activity throughout Southeast Alaska (Fig. 1).

In the Juneau area, avalanche hazard zones exist along the Thane Road, which extends between the community of Thane and the city of Juneau, the residential Behrends Avenue area, east of Juneau along the south slopes of Mt. Juneau, and recreational back-country areas (Frutiger, 1972; LaChapelle, 1968; State of Alaska, 1963).

Avalanches occur annually along Thane Road, closing the road temporarily at least once each winter. In the Behrends Avenue area, there is a record of slides in 1890, 1917, 1926, 1929, 1935, 1946, and 1962 (Hart 1967). Each winter, avalanches occur in the back-country areas, with increasing hazard as these areas become more and more utilized for recreation.

This paper describes the avalanche forecasting techniques utilized at the Weather Service Forecast Office in Juneau. It describes the types of avalanches that are of most concern to the forecasters in Juneau, and the procedures used to forecast them, with particular emphasis on the synoptic weather patterns that trigger avalanches. In addition, a case study will be presented of one of the major avalanche episodes that occurred in the Juneau area during 1976.

On September 23, 1975, Dr. George P. Cressman, Director of the National Weather Service, assigned the responsibility of routine avalanche forecasting to the Weather Service Forecast Office at Juneau. It is our hope that the experiences of the forecasters at Juneau, and the techniques used, will be of some value to others engaged in avalanche forecasting.

Forecasting Methods

A. Terrain. Three major avalanche paths exist along the Thane Road south of Juneau. The first of these, Snowslide Creek, located three miles south of Juneau, has an average slope of 33°, but is steeper at the top than in the middle and lower sections. The second path, located directly below Gastineau Peak, has an average slope of about 30°. Cross Bay Creek, the third major avalanche path, has an average slope of slightly less than 30° but it is considerably steeper at the top than in the middle sections. The gullies associated with the creeks and the large unbroken slopes above timberline favour avalanche formation. Vegetation is sparse along the creek beds and in the area below Gastineau Peak.

The "Behrends Avenue" slide path on Mt. Juneau (Fig. 2) has an average slope of 45° with a steeper slope in the upper sections. Vegetation is sparse above the 150 m level. Gullies in the slope favour avalanche formation.

B. Prelude to Avalanche Activity. The forecasting programme at WSFO Juneau begins with the first snowfall, which usually occurs in the latter part of October and typically covers the higher elevations. Normally, there is little accumulation in the lower elevations until the last of November. Beginning with the first snowfall, precipitation amounts, snow depths, wind, and temperature are measured daily at an observation site located near sea level within 1.6 km of the major avalanche paths. This, along with visual observations of the avalanche paths, allows the forecaster to determine when enough snow has accumulated to provide a good sliding surface.

Once enough snow is accumulated to cover the undergrowth, the forecasters estimate the hazard from continuous records of local observations: snow depth, new snow amounts, water equivalent of snow, freezing level, temperatures, and wind. In addition, the forecasters study the synoptic weather patterns at the surface, and at upper levels (850 mb, 700 mb, and 500 mb). In producing a forecast, a distinction is made between conditions that cause wet and dry avalanches.

C. Wet Avalanches. Wet avalanches are the most frequent kind to occur in the Juneau area, and the easiest to forecast. The synoptic pattern associated with wet slab avalanches begins to take shape 24 to 36 hours before the avalanche occurs. Typically, a ridge of high pressure at the 500 mb level extends along the west coast of British Columbia and over southeast Alaska. A deep low pressure area exists south of the Alaska Peninsula (Fig. 3, Top). The isotherm pattern shows warm air advection into the Gulf of Alaska. The surface analysis (Fig. 3, Bottom) associated with this upper air pattern shows a deep low south of the Alaska Peninsula with a front in the central Gulf of Alaska. Snow begins shortly after this map time in northern southeast Alaska as the upper level ridge moves eastward. As the front moves over southeast Alaska, about 12 hours later, snow changes to rain as temperatures rise above freezing. As rain and warm air advection continues, the snowpack becomes more unstable. Wet slab avalanches will occur if rain continues 12 to 24 hours with an accumulation of 20 mm or more.

The freezing level should rise at least to 760 m. In order for this to occur, the synoptic pattern at the surface must result in a persistent southerly flow, extending southward from northern British Columbia to south of 50°N. The flow aloft should be from the south or southwest.

D. Dry Snow Avalanches. This type of avalanche occurs less frequently than the wet avalanche and is more difficult to forecast. In the Juneau area, critical loads of dry, new snow usually result from strong northeast wind transport. Slab conditions on Mt. Juneau occur during prolonged periods of low temperature (10°C to 20°C below normal[1]), deep snowfall at all elevations (0.3 m), and strong northeast winds causing drifting snow for three or four days (LaChapelle 1968).

The synoptic pattern that produces sufficient winds to transport snow onto the slope is shown in Fig. 4. This pattern has a very strong and persistent high pressure area

---

[1] Mean December temperature is -3°C; January mean, -4°C; and February mean, -2°C.

over northwestern Canada with low pressure in the Gulf of Alaska. A very tight pressure gradient exists over northern southeast Alaska.

Case Study

A major avalanche cycle occurred in the Juneau area on March 16, 1976. Several periods of snow occurred during the first half of the month, both of which were followed by cold temperatures and gusty northeast winds. By March 12th, adequate snow for an avalanche was available on the slopes around Juneau. The cold temperatures between snowfalls had kept the snowpack from completely stabilizing. A triggering mechanism was all that was needed to start an avalanche. The triggering mechanism began to develop on March 13th, with the movement of a low pressure area into the northern Gulf of Alaska and the eastward movement of another low south of the Aleutians.(Fig. 5, Top).

By the evening of the 13th, snow had spread over northern southeast Alaska as the low in the northern Gulf moved northeastward. Warm advection aloft had begun by the morning of the 14th (Fig. 5, Bottom).

Snow continued in the Juneau area throughout the day of the 14th with an accumulation at the Juneau Airport of 100 mm.

By the morning of the 15th, the low in the northern Gulf had moved into the southern Yukon territory and weakened (Fig. 6). The low south of the Aleutians had moved into the central Gulf and split into two separate centres. A southerly flow of 28-37 km/hr at low levels had developed over southeast Alaska and had moved the Arctic Front north of Juneau by 12 Z. This caused a rise in the surface temperatures and the snow changed to mixed rain and snow. The 500 mb flow at this time (Fig. 6) showed 65-74 km/hr southwesterlies over southeast Alaska. The 700 mb chart (Fig. 6) showed continued warm advection over southeast Alaska.

By the morning of the 16th (Fig. 7, Top), the first low pressure area had moved into the northern Gulf of Alaska and the second low had continued eastward into the southern Gulf. A southerly low level flow of 37-46 km/hr continued over southeast Alaska.

In the Juneau area, the mixed rain and snow changed completely to rain in the lower elevations as surface temperatures during the morning climbed to +5°C. Low level winds in the area were southeasterly 37-56 km/hr. As the low and front in the southern Gulf moved northward during the day

(Fig. 7, Bottom), moderate rain spread over southeast Alaska. Rainfall for the 16th totalled 25.4 mm in downtown Juneau. By late afternoon (00Z) on the 16th, the freezing level over the Panhandle had risen to the 850 mb level, nearly 1,500 meters (Fig. 8, Top).

Major avalanche activity occurred in the Juneau area during the afternoon of the 16th. The Thane Road south of Juneau was closed in two places, with numerous other avalanches occurring in the mountains around Juneau.

After the frontal passage on the 17th (Fig. 8, Bottom), precipitation became showery over the northern sections of southeast Alaska, reducing the amount of free water available in the snowpack. This, combined with the stabilizing of the slopes that had already avalanched, resulted in a diminished threat of avalanches by the evening of the 17th.

ACKNOWLEDGEMENT

We wish to express our appreciation to the following for their suggestions during the preparation of this manuscript: Mr. Keith Hart, avalanche consultant; Thomas Laurent, Robert Gustafson and Ramon Clark, all of the U.S. Forest Service. We also thank Elizabeth Mooney for her assistance in the preparation of this manuscript.

References

Frutiger, Hans. 1972. Avalanche hazard inventory and land use control for the City and Borough of Juneau, Swiss Federal Institute for Snow and Avalanche Research, Davos, Switzerland. (Unpublished report to the City of Juneau.) 92 p.

Hart, Keith. 1967. Report of the preliminary evaluation of the Behrends Avenue avalanche path. (Unpublished report to the City of Juneau.) 37 p.

LaChapelle, E.R. 1968. The Behrends Avenue avalanche and other avalanche hazards in the Greater Juneau Borough: A report based on an inspection trip to the Juneau area on August 29-31, 1968. (Unpublished report to the City of Juneau.) 20 p.

Searby, Harold W. 1971. Southeast Alaska, Climatic Summaries of Resort Areas. U.S. Dept. Comm., NOAA, Nat. Weather Serv., Anchorage, Alaska. Climatography of the United States No. 21-49-5. 6 p.

State of Alaska. 1963. Avalanche Study. prepared by State of Alaska Dept. of Highways Planning and Research Section. In cooperation with U.S. Dept. Comm. Bureau of Public Roads, Juneau, Alaska, 41 p.

U.S. Dept. Comm. 1976. Local climatological data, Annual Summary with comparative data. NOAA, Environmental Data Service, National Climatic Centre, Ashville, N.C. Summary for Juneau, Alaska. 4 p.

U.S. Dept. Comm. 1973. Monthly normals of temperature, precipitation, and heating and cooling days 1941-70, NOAA, Environmental Data Service, Ashville, N.C. Climatography of the U.S. No. 81, Alaska. 5 p.

Discussion

MARRIOTT: How do you verify the accuracy of your hazard warnings?

HUTCHEON: Verification of avalanche forecasts is a difficult problem. For example, suppose you issue a forecast for avalanche activity, but only a small avalanche runs. Do you score this as a hit or a miss? Similarly, do you penalize yourself when the avalanche runs larger than you expected?

MOORE: Do you have any remote instrumentation to assist your forecasts?

HUTCHEON: Not yet, but we expect to get some data on conditions aloft from a new ski development.

CARDINAL: After you issue the warning, do you take any preventive actions?

HUTCHEON: The Weather Service only issues the warnings. It is up to groups and individuals to take necessary measures. Maybe, Tom Laurent of Juneau would also like to comment on this question.

LAURENT: The City of Juneau has a controversial warning system. We used to broadcast warnings on the radio, but we were accused of causing avalanches by broadcasting about them. Now we get together with the Police Department, discuss the problem, and usually knock on individual doors to advise people to take precautions.

MOORE: You mentioned that houses were destroyed by avalanches, and then reconstructed on the same site. Why?

LAURENT: Some people want to forget about the problem. Keith Hart sponsored a study of avalanches and other geophysical hazards threatening the City of Juneau. The Chamber of Commerce and other special interest groups managed to keep the study under cover. People try to forget, but they get reminded periodically, like the time a school bus turned around because the road was blocked by an avalanche, only to be almost hit by a second avalanche which trapped the school bus and the children aboard between the slides.

LACHAPELLE: Allow me to add a story about a consulting trip I made to Juneau after the city was hit by an avalanche in 1962. I visited the office of the city manager and explained the seriousness of the avalanche problem. I explained why I felt this was one of the most avalanche-threatened communities in the U.S. After I was finished, another geotechnical engineer stepped forward and said: "If you think you have avalanche problems, wait until I tell you what happens when an earthquake hits Juneau".

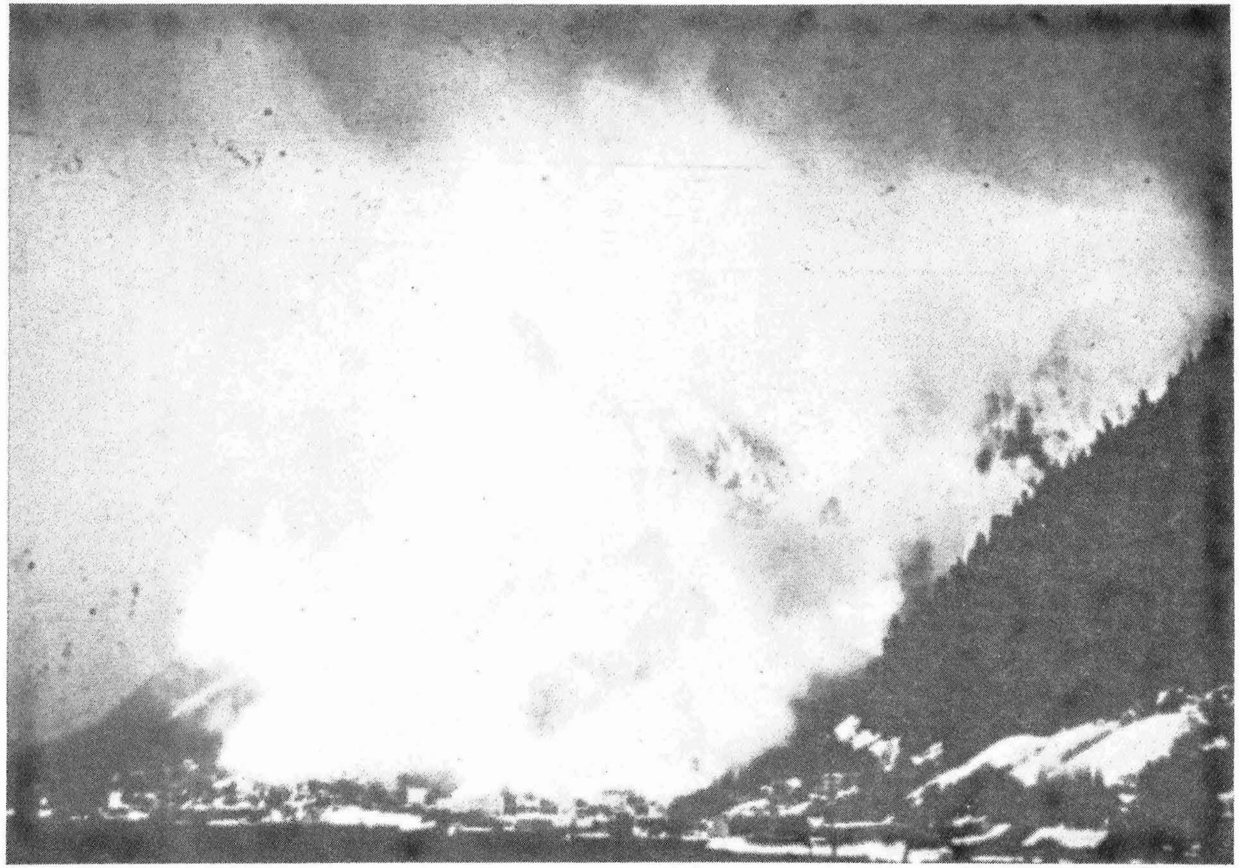

FIGURE 1 AVALANCHE DUST CLOUD HITS JUNEAU, ALASKA (PHOTO BY S. GRAY)

FIGURE 2 VIEW DOWN THE "BEHRENDS AVENUE" AVALANCHE PATH (PHOTO BY K. HART)

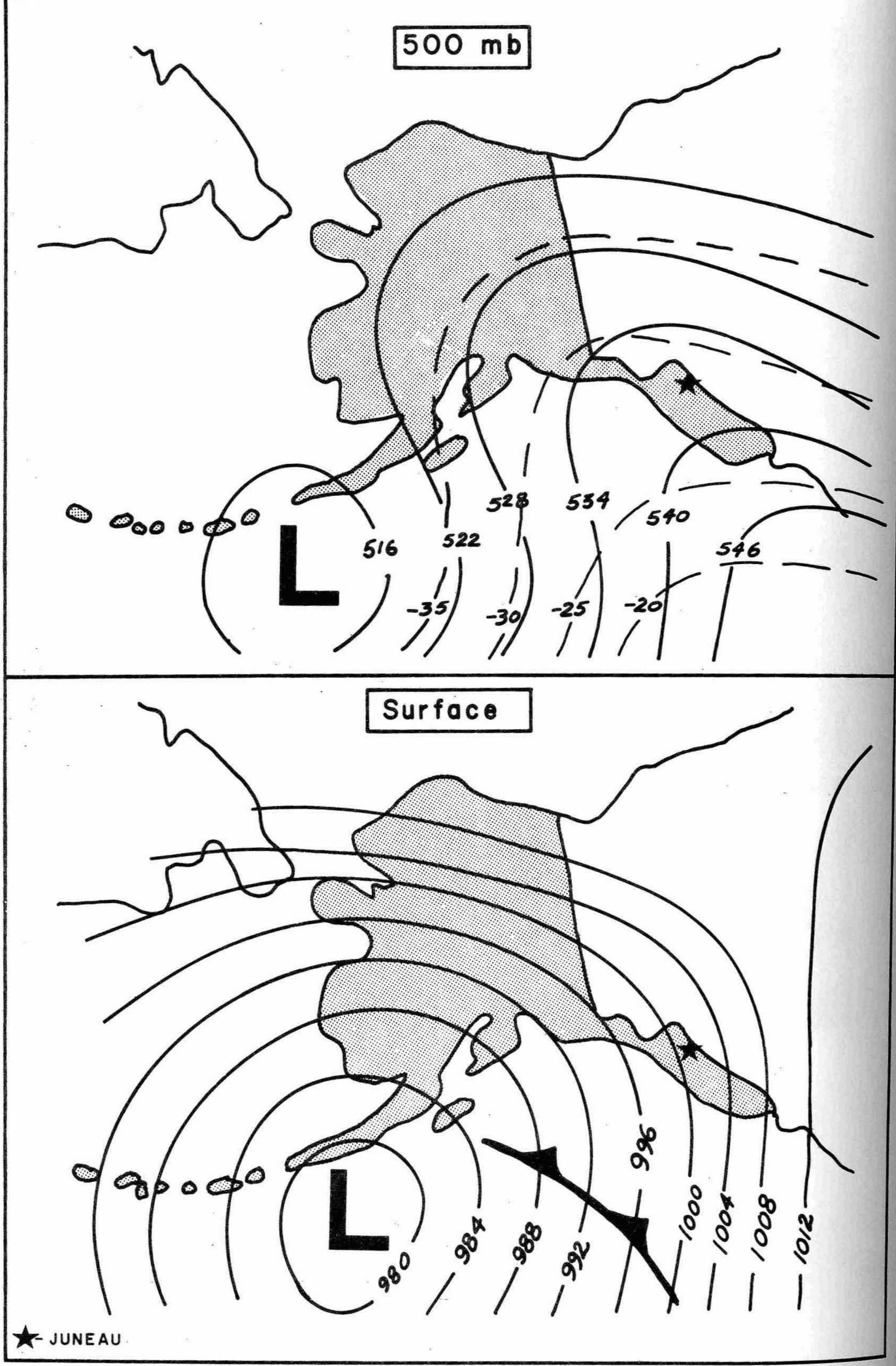

FIGURE 3 TYPICAL SYNOPTIC CONDITIONS 24 TO 36 HOURS PRIOR TO WET SLAB AVALANCHES. TOP: 500 mb PRESSURE PATTERN. BOTTOM: SURFACE ANALYSIS

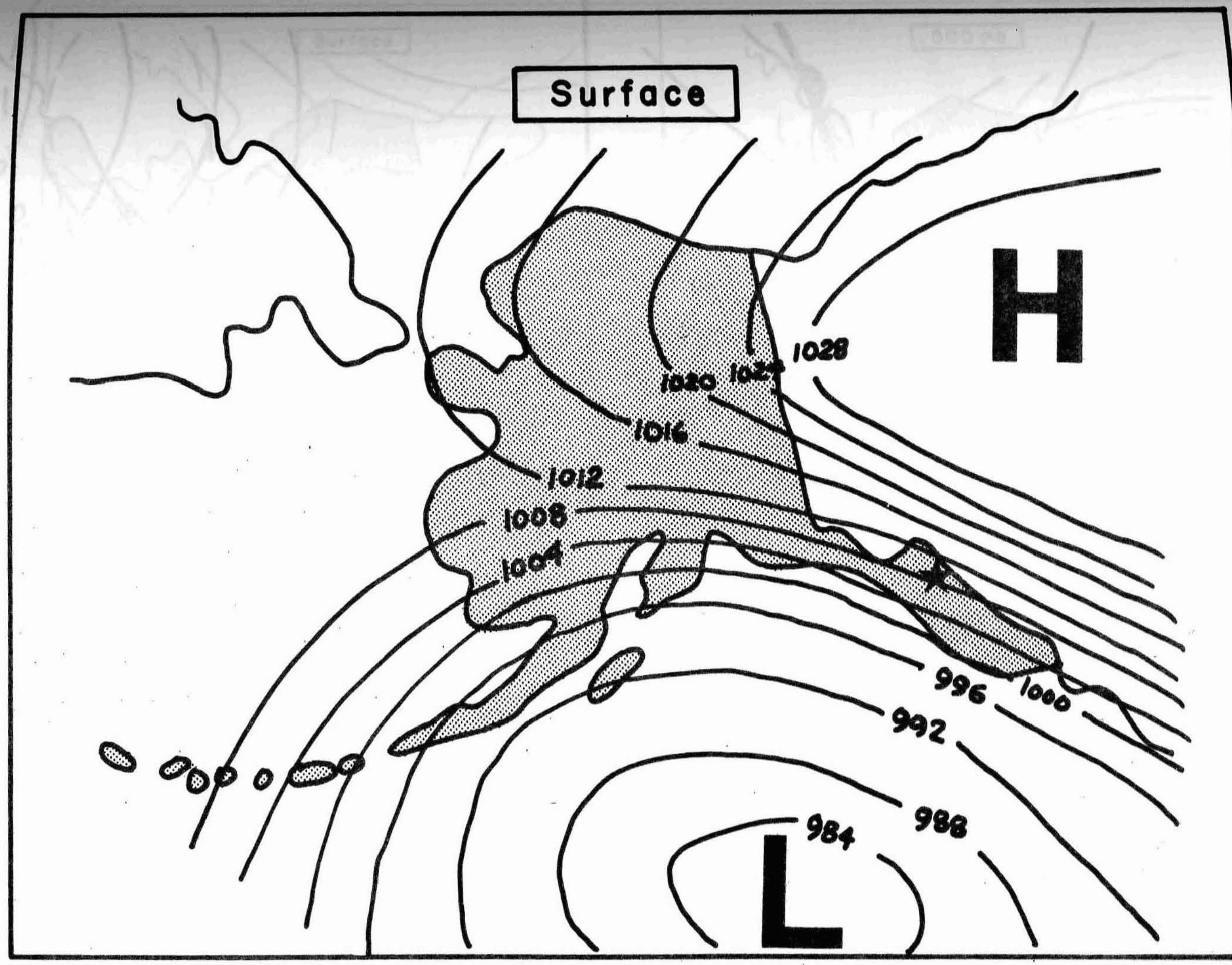

FIGURE 4 SURFACE ANALYSIS SHOWING STRONG PRESSURE GRADIENT OVER SOUTHEAST ALASKA

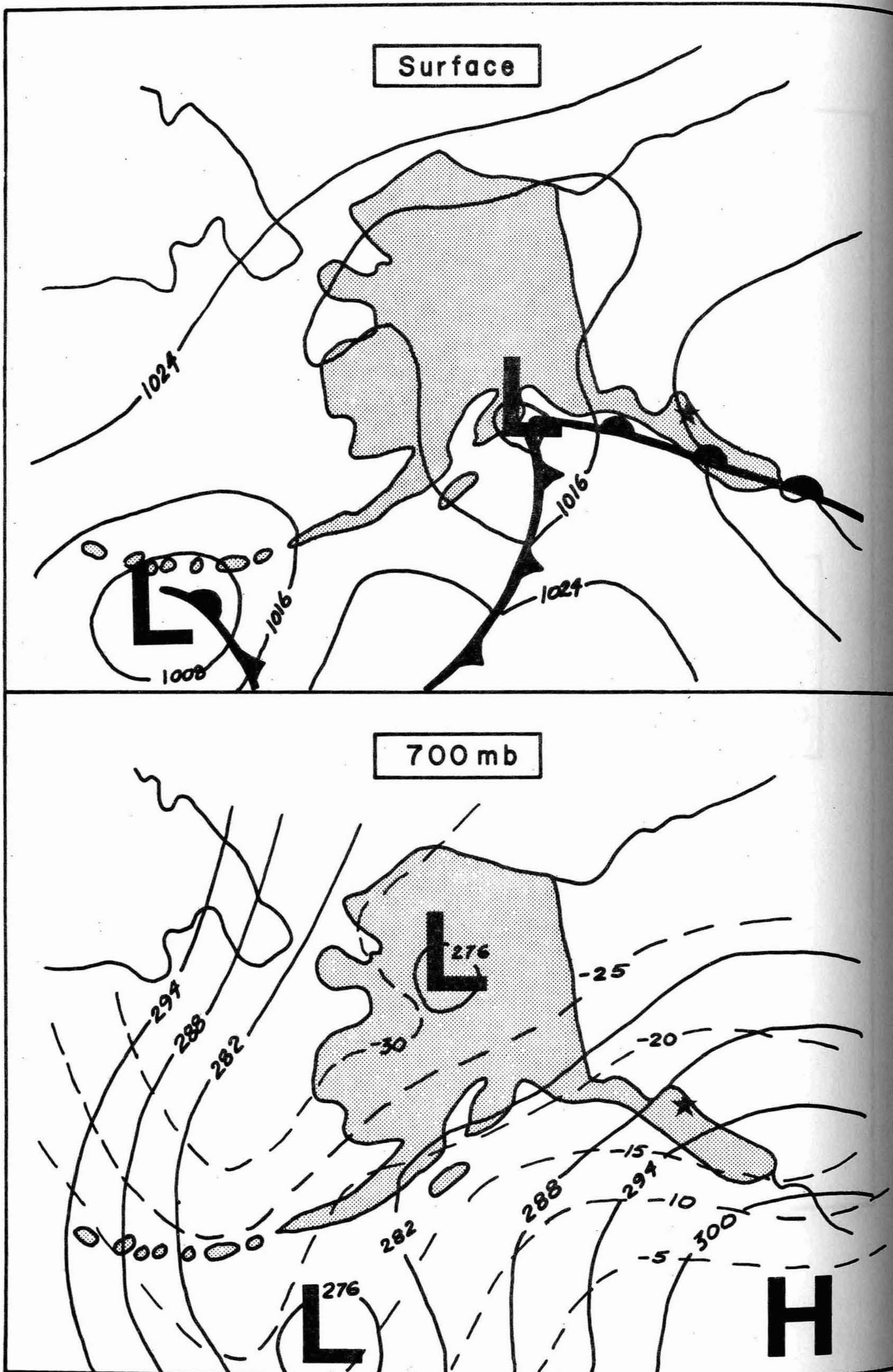

FIGURE 5 TOP: SURFACE ANALYSIS AT 18 Z ON 13 MARCH 1976. BOTTOM: 700 mb ANALYSIS AT 12 Z ON 13 MARCH 1976

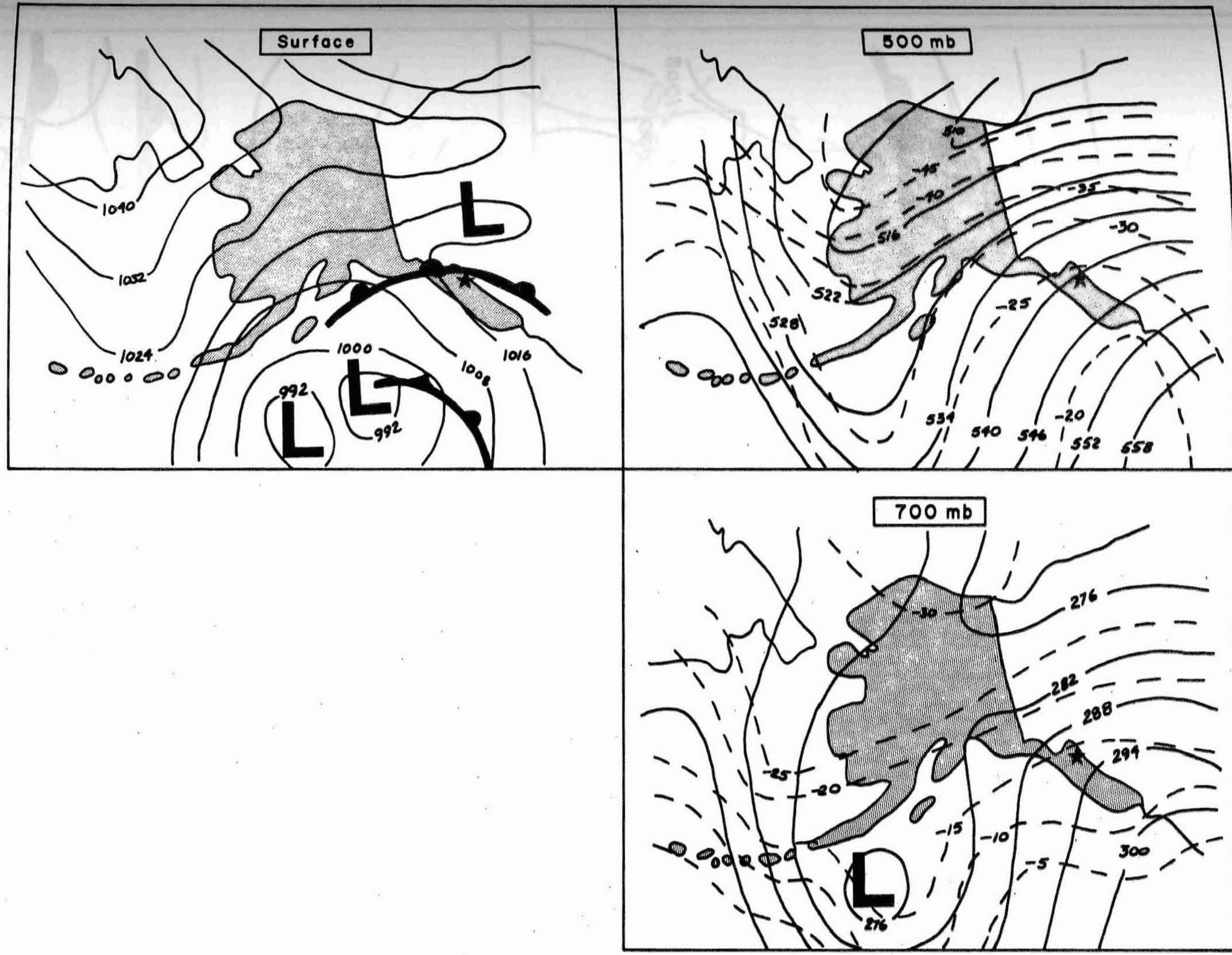

FIGURE 6 ANALYSIS AT 12 Z ON 15 MARCH 1976

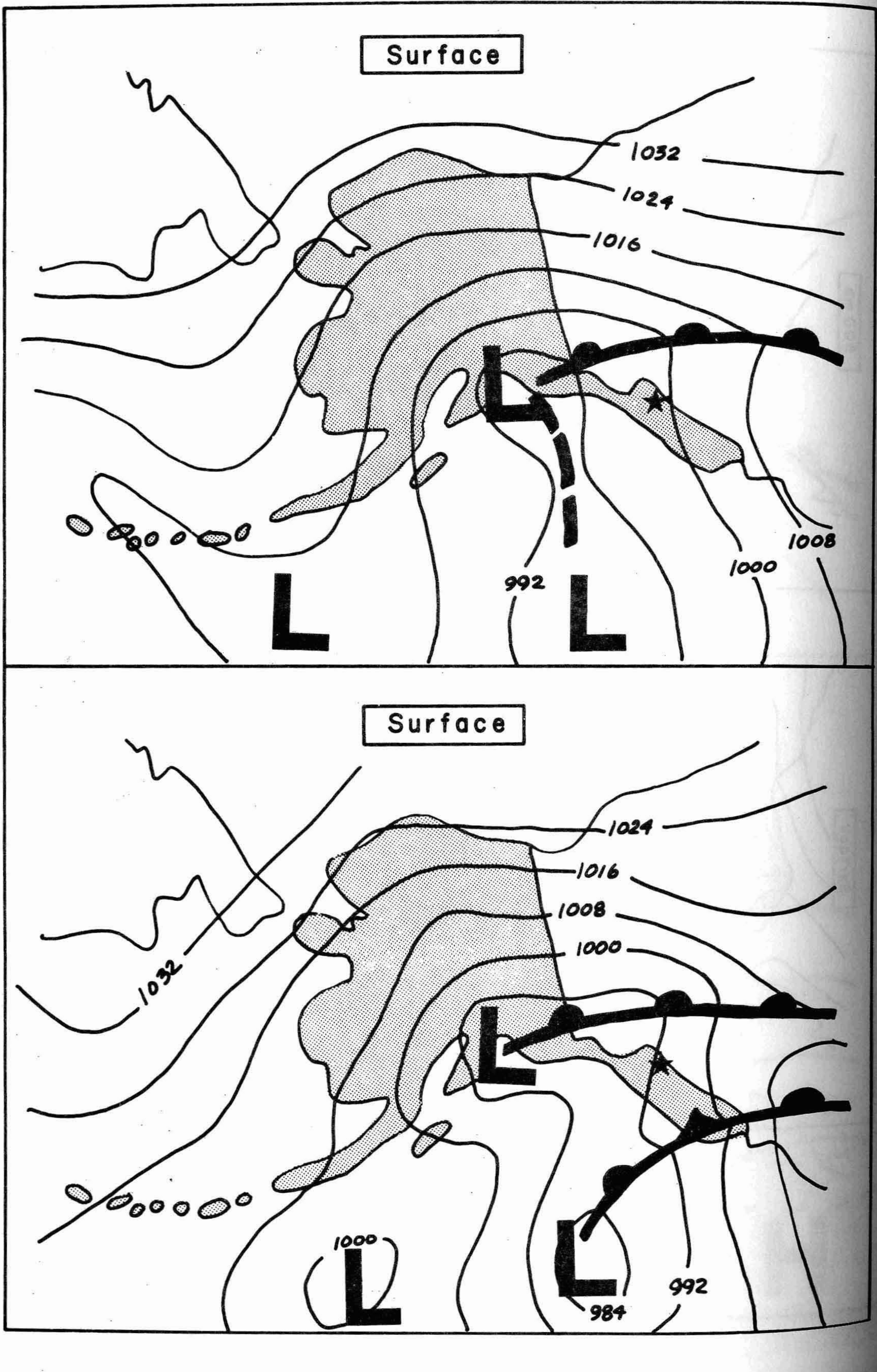

FIGURE 7 TOP: SURFACE ANALYSIS AT 12 Z ON 16 MARCH 1976. BOTTOM: SURFACE ANALYSIS AT 18 Z ON 16 MARCH 1976

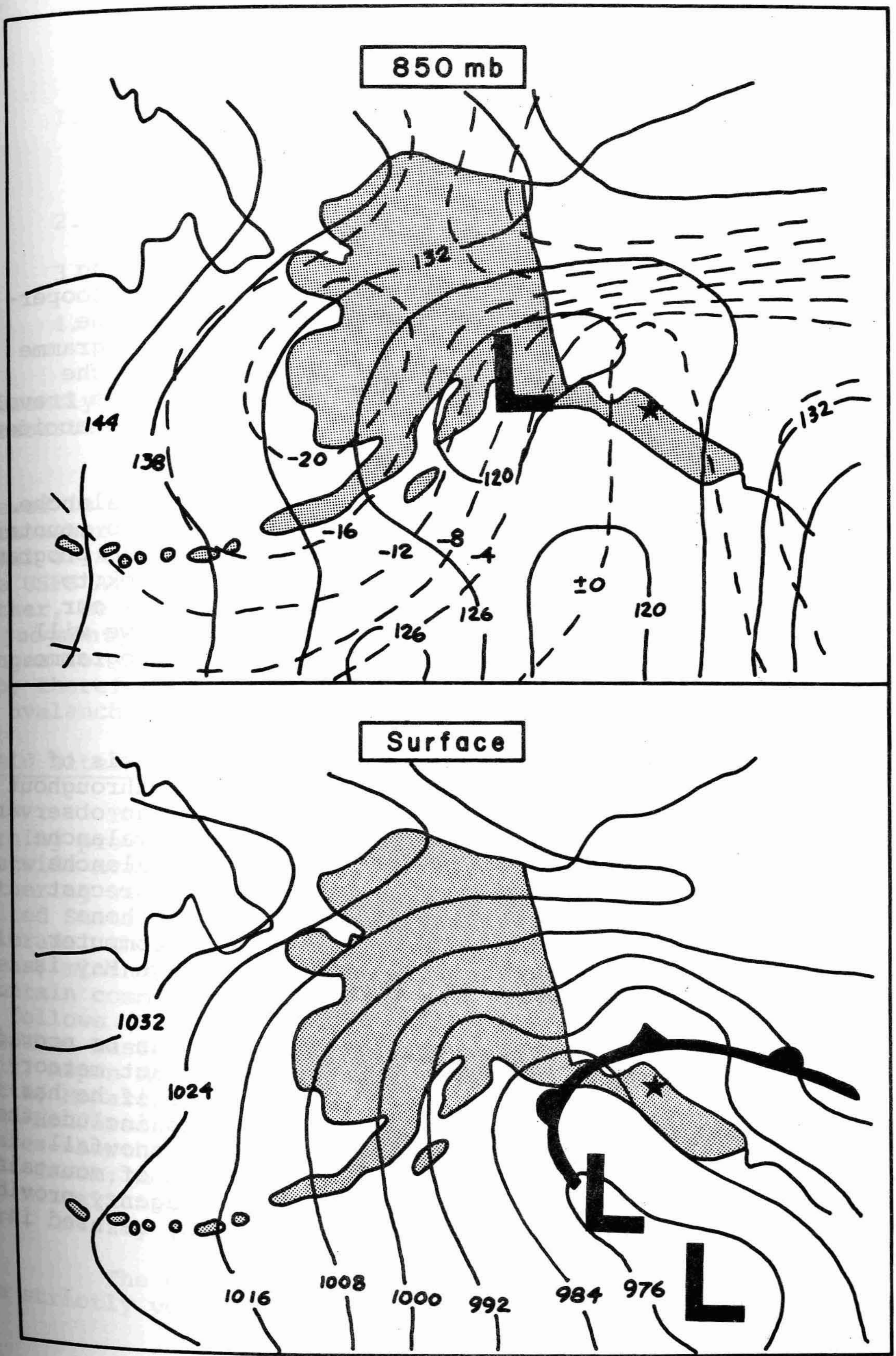

FIGURE 8 TOP: 850 mb ANALYSIS AT 00 Z ON 17 MARCH 1976. BOTTOM: SURFACE ANALYSIS AT 12 Z ON 17 MARCH 1976