A LOOK AT SOME UNUSUAL CONVECTIVE ACTIVITY ASSOCIATED WITH VOLCANIC ERUPTION

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St. Augustine Island located in lower Cook Inlet was the scene of some rather unusual convective activity on January 23, 1976. On that day the tiny volcanic Island 150 n. mi. southwest of Anchorage, Alaska, erupted, spewing moisture, ash, and debris into the cold arctic atmosphere. The first of a series of eruptions occurred during the early morning hours of January 23, with the most intense eruption occurring about 7:30 a.m., AST. Each eruption was accompanied by a release of water vapor and ash heated to hear 800°C. According to Mr. Tom Miller, a volcanologist with U.S. Geological Survey, about 95 percent of the cloud and debris released by volcanic eruptions is composed of heated water vapor. Considering an environmental temperature of -10°C surrounding the volcano at the time of eruption, one could expect rather intense convection to accompany each steam release. Mr. Jim Reardon, outdoor editor of *Alaska Magazine,* captured a series of pictures (fig. 1) illustrating the explosive nature of this convection during the late afternoon hours of January 23. The total elapsed time from the initial steam release to the fully developed cumulonimbus cloud in figure 1 was less than 30 minutes. Eyewitness accounts indicated that clouds produced by the morning eruption rose to more than 40,000 ft. in a few minutes. Considerable lightning activity was also observed within the cloud mass during the morning and evening releases.

The NOAA-4 Satellite captured a picture of the volcano area and cloud remnants at 10:05 a.m., AST, January 23, 1976, some 2 to 3 hours after the most intense eruption. The photograph of figure 2 is a ½-mi. resolution infrared pictured with temperature range from black at 7°C to white at -51°C. Since warm objects appear black and cold appear white, the volcano center located at point (A) is easily recognizable. The trajectory of the clouds and debris released by the volcano can also be easily traced along the A-B-C line. The debris and cloud drift would suggest a westerly flow at cloud level with a slight northerly drift at low levels in the immediate vicinity of the volcano. A closer look will reveal a small area of white (cold) clouds just to the east of the volcano; this suggests that the clouds had reached to considerable heights as a result of convective currents generated by the steam released from the volcano.

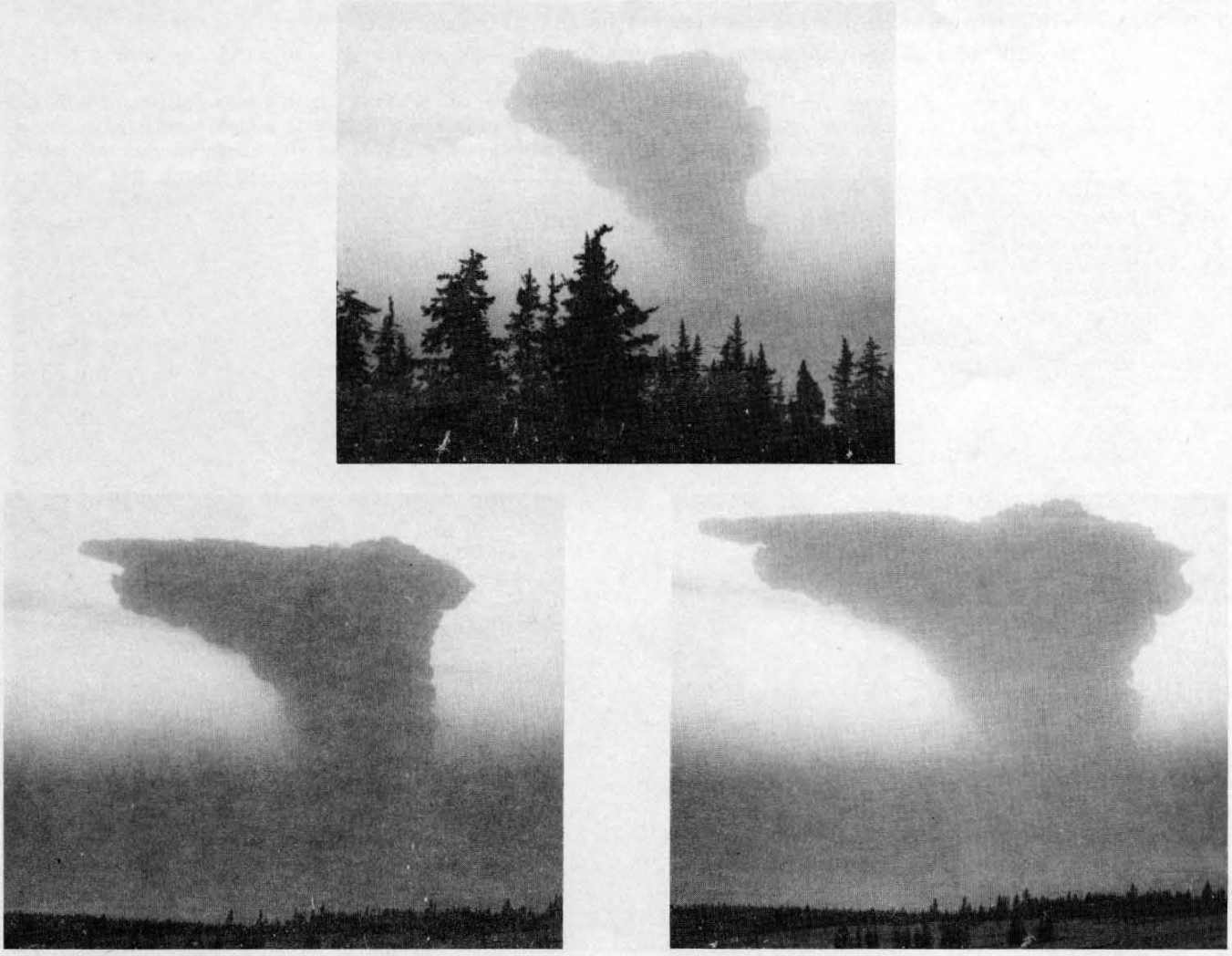

FIG. 1. Developing convective activity produced by St. Augustine during the late afternoon of 23 January 1976. Courtesy of Mr. Jim Rearden, *Alaska Magazine.*

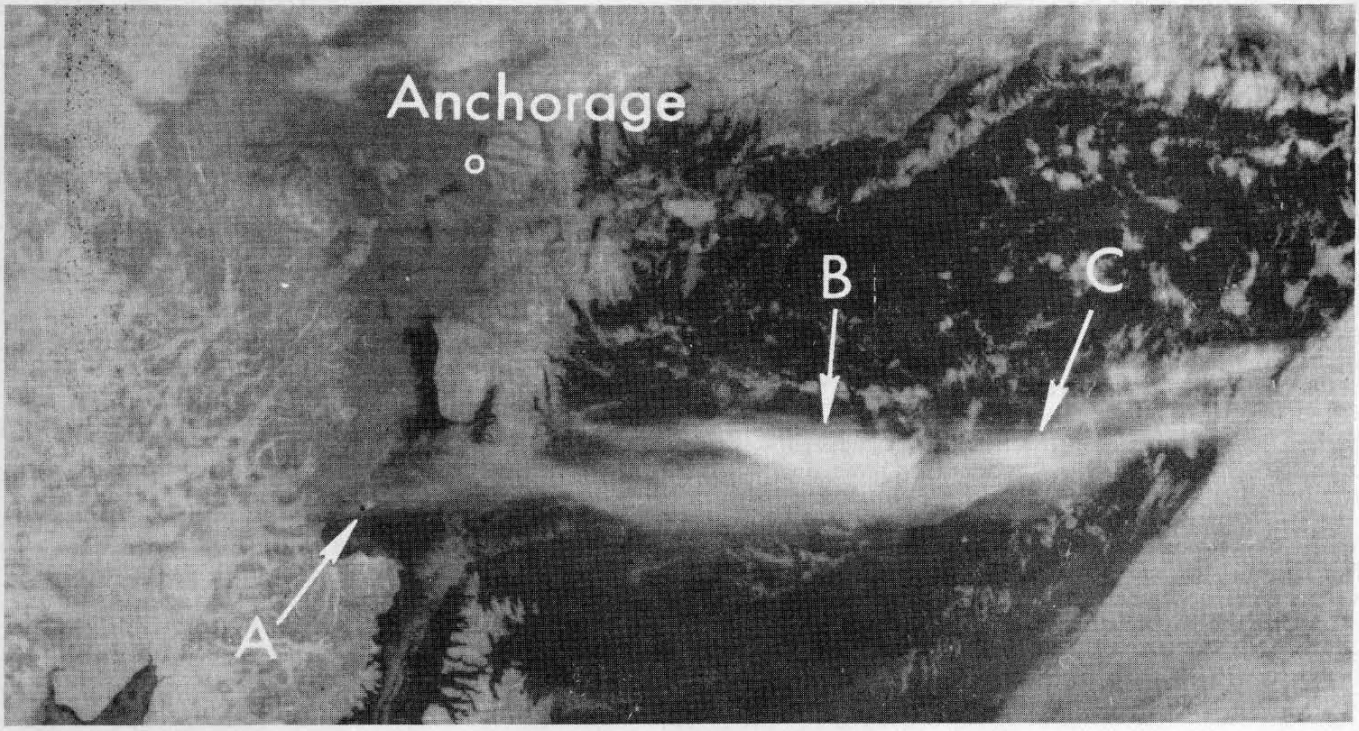

FIG. 2. NOAA-4 VHRR-infrared imagery taken at 2009 GMT (1005 AST) 23 January 1976.

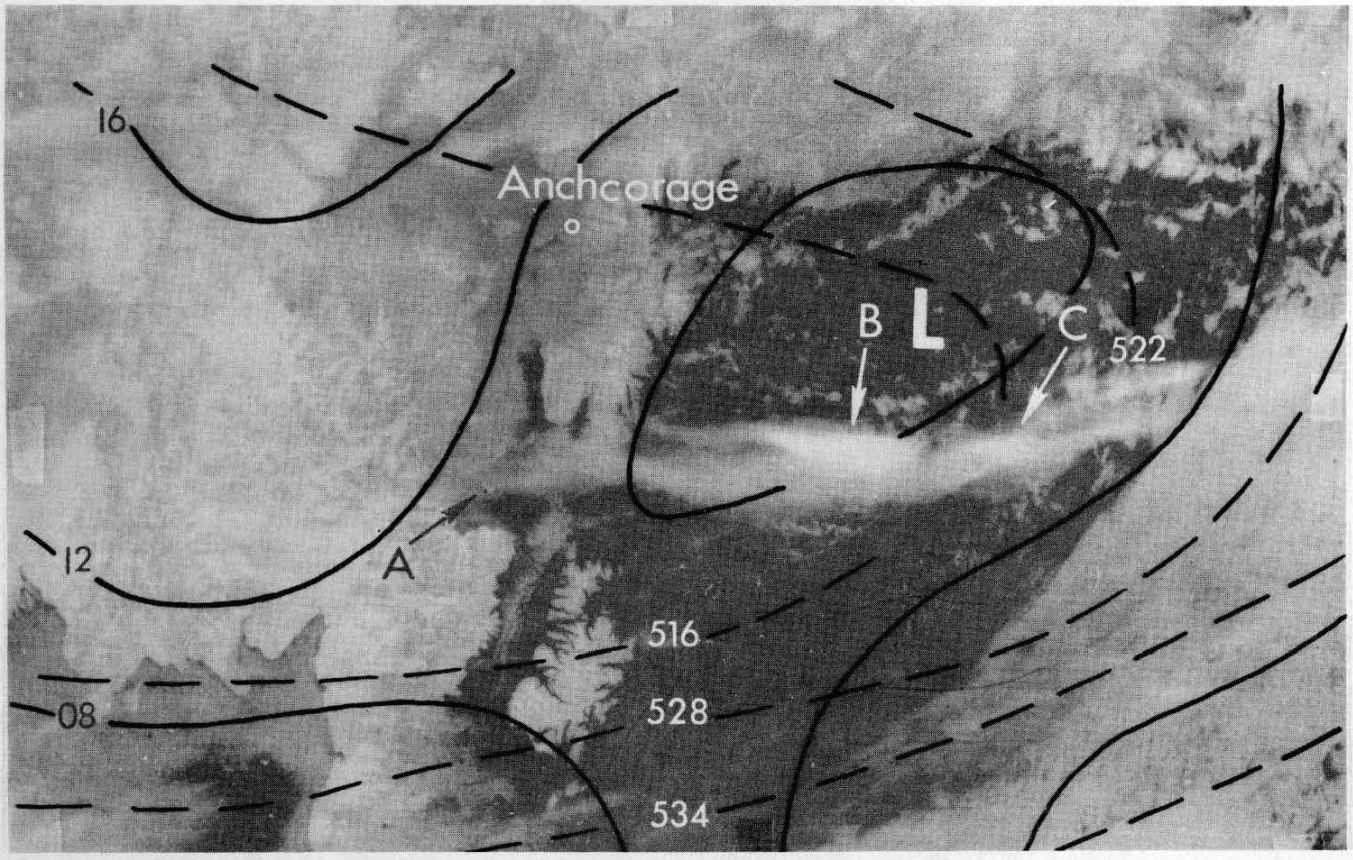

FIG. 3. Same as Fig. 2 with surface (solid lines) and 500-mb analysis (dashed lines) of 8:00 a.m., AST and 2:00 a.m. AST, respectively.

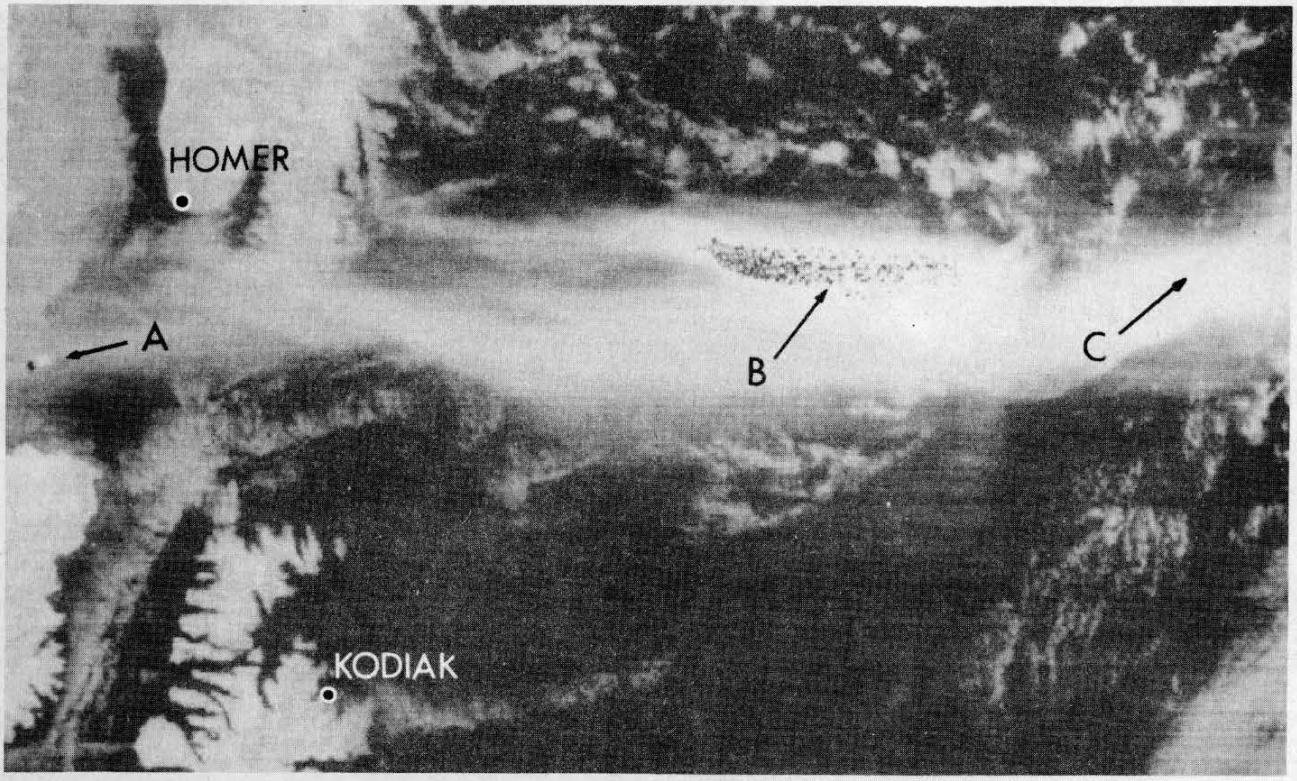

FIG. 4. Same as Fig. 2 with infrared enhancement. Gray and black areas within the plume are colder than -45°C.

Another interesting aspect of the photo is the rather vivid white (cold) cirrus plumes at Points B and C in figure 2. These plumes were apparently generated by steam released prior to and during the most significant eruption. The distance from the volcano to the rear and leading edge of the first plume (B) is 160 and 240 n. mi. The center of the second plume (C) is about 300 n. mi. downstream, suggesting an earlier steam release. To ascertain that both plumes were the result of convective activity associated with the eruption, the synoptic and upper air data for the period before and after the eruption were investigated.

The surface and upper air data superimposed on figure 3 (surface map for 8:00 a.m. and 500 mb for 2:00 a.m., AST) indicates the following conditions: at the surface a weak low pressure center was situated over the Gulf of Alaska near Middleton Island and weak surface wind flow existed in the immediate area of the volcano. A weak ridge of high pressure was situated to the south with a very deep storm situated to the west near Shemya in the Aleutian Chain. The upper wind flow was influenced by an upper high pressure ridge extending into southern Alaska; this produced a westerly flow from the 500-mb level up to near the tropopause level at 25 to 300 mb. Low-level flow from the surface to the 700-mb level was from the south and southwest and was slowly backing in response to the approaching storm center to the west. Wind flow for the volcano area, interpolated from upper air soundings at Anchorage, King Salmon, and Kodiak, indicated winds increasing from the west above 500 mb. to a maximum near the tropopause level. The three station average wind was 67 knots at 2:00 a.m., AST increasing to 81 knots at 2:00 p.m., AST from 6 to 7 hours after the eruption. The maximum wind level was near 25,000 ft. with a prevailing westerly direction. Analysis of the tropopause level data indicated there was a relative wind maximum near Kodiak at 2:00 a.m., AST which gradually shifted northward to near Anchorage by 2:00 p.m., AST. Anchorage reported the maximum wind speed at 94 knots at 2:00 p.m., AST. The wind flow appears to indicate that the two plumes were directly related to the eruption — assuming that the clouds reached the maximum wind level.

A series of infrared enhancements were made of the cirrus plumes to determine cloud top temperatures and the nature of the plumes. Figures 4, 5, and 6 are enhancements for temperature within the cloud top, using white for the cold cloud top temperatures and gray to black for successively colder temperatures. The gray or black areas in the three figures are colder than -45°, -48°, and -50°C respectively. In figure 4 only a small portion of plume number two (C) is colder than -45 (indicated by the small area of gray). Plume number one (B) has a much larger area colder than -45° (indicated by the large gray area within the plume). In figures 5 and 6, cloud top temperatures of -48° and -55°C were found in plumes C and B respectively. In each of the three enhancements it is evident that the strongest vertical motion and greatest cloud heights were located in the western portion of the cloud mass. The variation of cloud top temperature and height imply the convective nature of this activity. To determine the actual top height it was necessary to construct a temperature sounding for the volcano area.

The cloud top temperatures obtained from the enhancements were used in conjunction with an average estimated temperature profile to estimate cloud top heights. It was assumed that the warm convective air would rise initially to seek its own level by reaching equilibrium with the environmental temperatures. It was further assumed that 2 to 3 hours travel downstream would have dissipated most of the heat released by the volcano and convection would have nearly ceased. The selection of the proper sounding was difficult because of the relative wind maximum in the vicinity and the change in tropopause height across this maximum. In addition, the eruption occurred about midway between two upper level observations. A time-averaged Kodiak sounding was

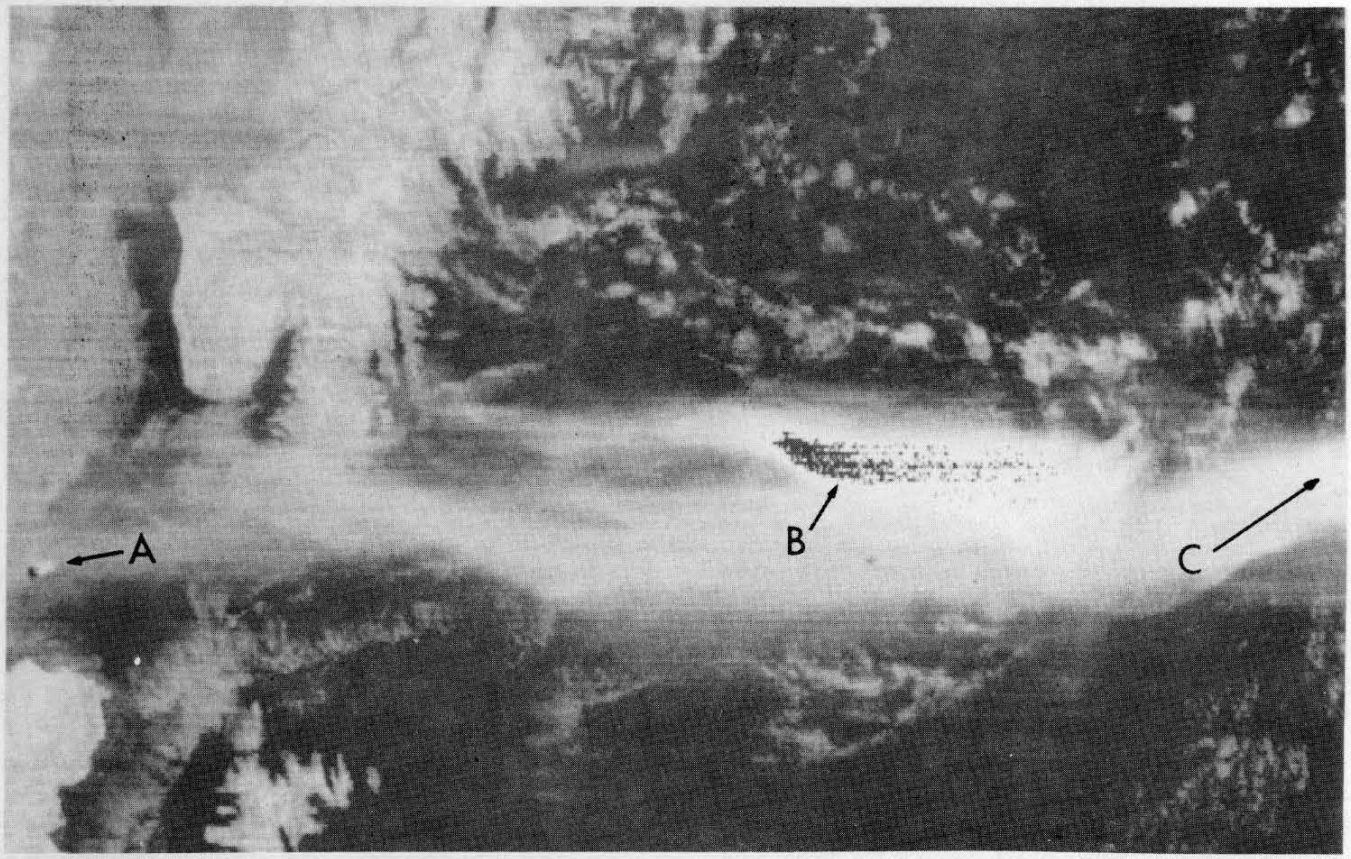

FIG. 5. Same as Fig. 2 with infrared enhancement. Gray and black areas within the plume are colder than -48°C.

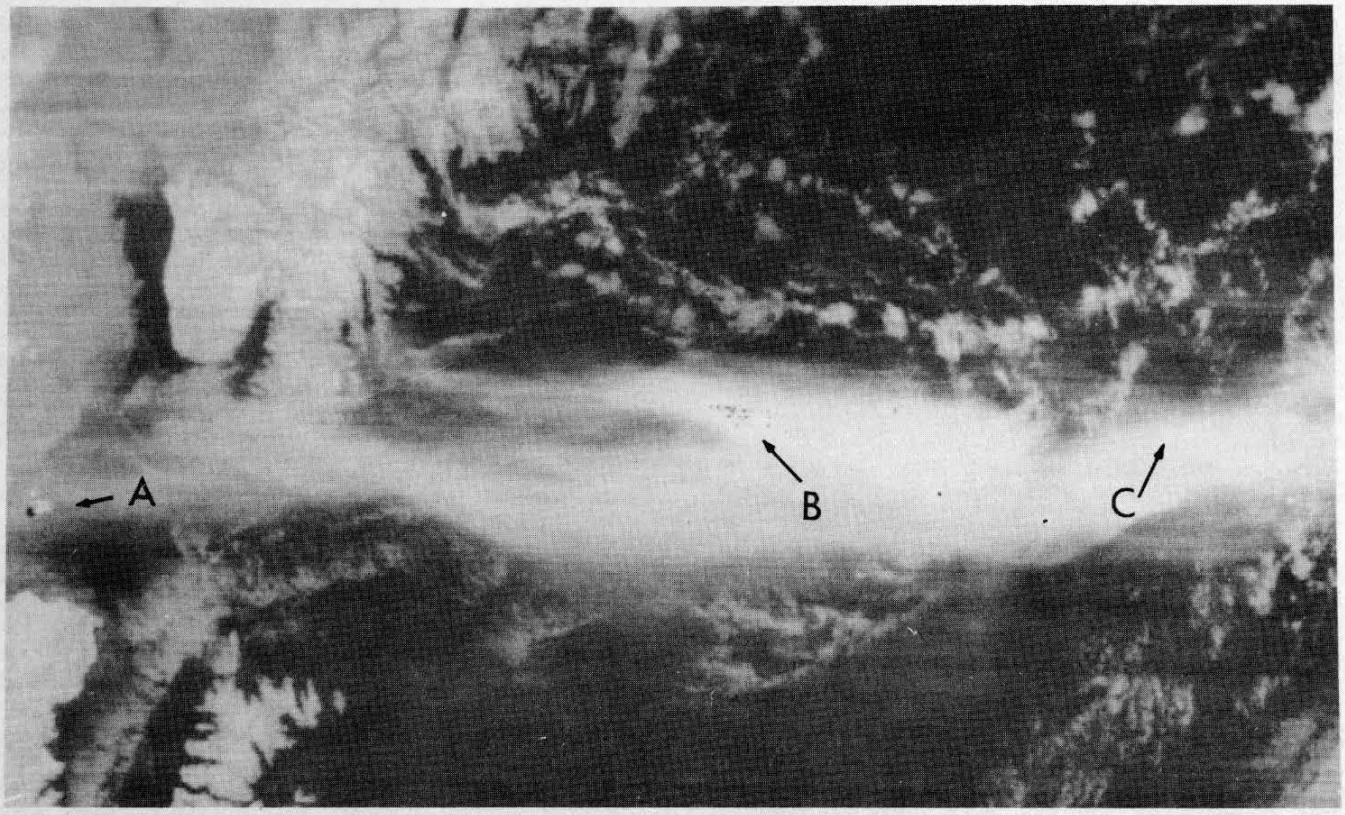

FIG. 6. Same as Fig. 2 with infrared enhancement. Gray and black areas within the plume are colder than -51°C.

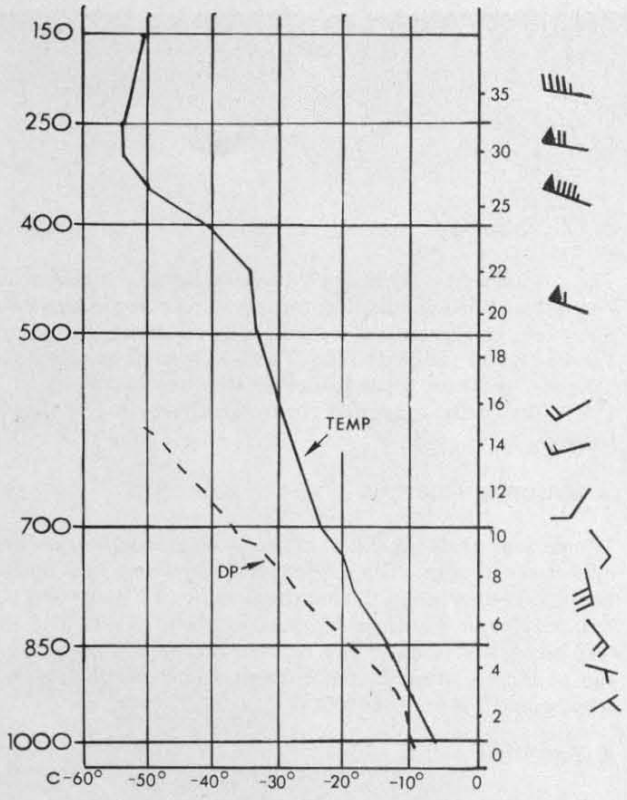

FIG. 7. Anchorage, Alaska Radiosonde Observation for 0000 GMT (2:00 p.m. AST) 23 January 1976.

compared with the Anchorage sounding for 2:00 p.m., AST (6 hours after the eruption) and found to be in fairly good agreement. The Anchorage sounding (fig. 7) was used as a basis for the temperature profile. The coldest temperature on the Anchorage sounding was -54°C at 31,000 ft. Plume number one (B) would have penetrated the tropopause and risen to heights greater than 31,000 feet. Plume number two (C) would then be estimated to have reached about 27,000 feet.

In summary, both plumes would have reached the maximum wind level and in all probability were considerably higher during the initial convective stages near the volcano. One further indication of the relatively strong wind flow through the volcano area was the report of some ash fall in the Sitka area over 500 miles to the east as early as 6:00 p.m. the same evening. If it were assumed that the ash came from the initial release, an average transport wind of 56 knots would have been required. In conclusion, the evidence shows that both plumes probably were associated with convection initiated by volcanic steam releases.