THERMAL STRUCTURE OF THE DRYLINE
A CASE STUDY

by

Roberta A. Marshment
Department of Meteorology

Submitted in Partial Fulfillment of the Requirements of
the University Undergraduate Fellows Program

1976 - 1977

Approved by:

Phanindramohan Das

Phanindramohan Das

May 1977

ABSTRACT

The dryline is a phenomenon of the southern Great Plains region where thunderstorms are known to develop. The dryline occurs when maritime tropical air from the Gulf of Mexico encounters continental tropical air flowing off the Rockies producing a discontinuity in moisture. The purpose of this study is to examine the thermal structure of the dryline on the meso-scale. This was done by plotting and analyzing isobaric charts of temperature, dew-point depression, potential temperature, mixing ratio, and moist-static energy, and from these, constructing cross sections through the dryline, which were then analyzed.

ACKNOWLEDGMENTS

I would like to extend my appreciation to Dr. P. Das of the Department of Meteorology, without whose guidance and seemingly limitless patience, this project would not have been completed.

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INTRODUCTION

Observations have shown that an area favorable to severe storm development in the southern Great Plains region is along a dryline, sometimes called a "dew-point front" or "Marfa front" (Henry & Thompson, 1963). It occurs when maritime tropical air originating on the Gulf of Mexico encounters continental tropical air flowing off the Rockies (Schaeffer, 1974). The discontinuity is thus one of moisture as opposed to temperature. It occurs approximately 45% of the time during April, May, and June, and is characterized by a dew-point difference between the air masses of at least 10°F and a wind shift from southerly to westerly flow (Rhea, 1966). Previous studies have examined the dryline on the synoptic scale, but since the dryline and its associated thunderstorm systems are smaller, it would be appropriate to examine the dryline on a smaller scale.

The purpose of this study is to describe the thermal structure of the dryline on the meso-scale.

PROCEDURE

The data for the study came from the meso-scale network of the National Severe Storms Laboratory (NSSL) in Norman, Oklahoma. The general method employed was to construct cross sections of various parameters through the dryline. Time limitations allowed only one case to be studied.

<u>Selection of case</u>

The criteria used for selecting the case to study are the following: the presence of a dryline over NSSL, the availability of data, and the general synoptic situation.

By comparing lists of dates on which a dryline was present over the NSSL network and dates on which NSSL was taking observations, three dates were selected. One date was eliminated due to the complicated synoptic situation in the Oklahoma region which obscured the dryline. The choice between the remaining two dates was based on the slope of the dryline (Beckman, 1973). The date selected was April 29, 1967.

On this date, NSSL took radiosonde soundings at 3-hourly intervals for 6 hours and to an average maximum height of approximately 14,000 meters. The locations of the stations are shown in Figure 1. The synoptic situation is shown by the 0600Z surface map in Figure 2. The time selected for study was 1100 CST.

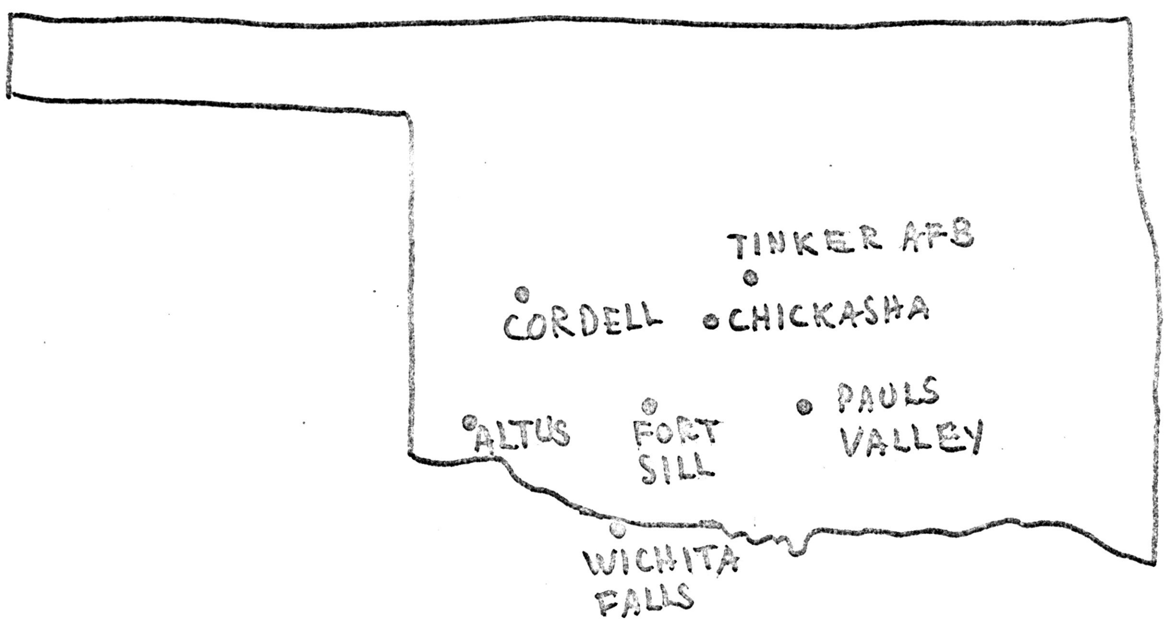

FIGURE 1
NSSL stations

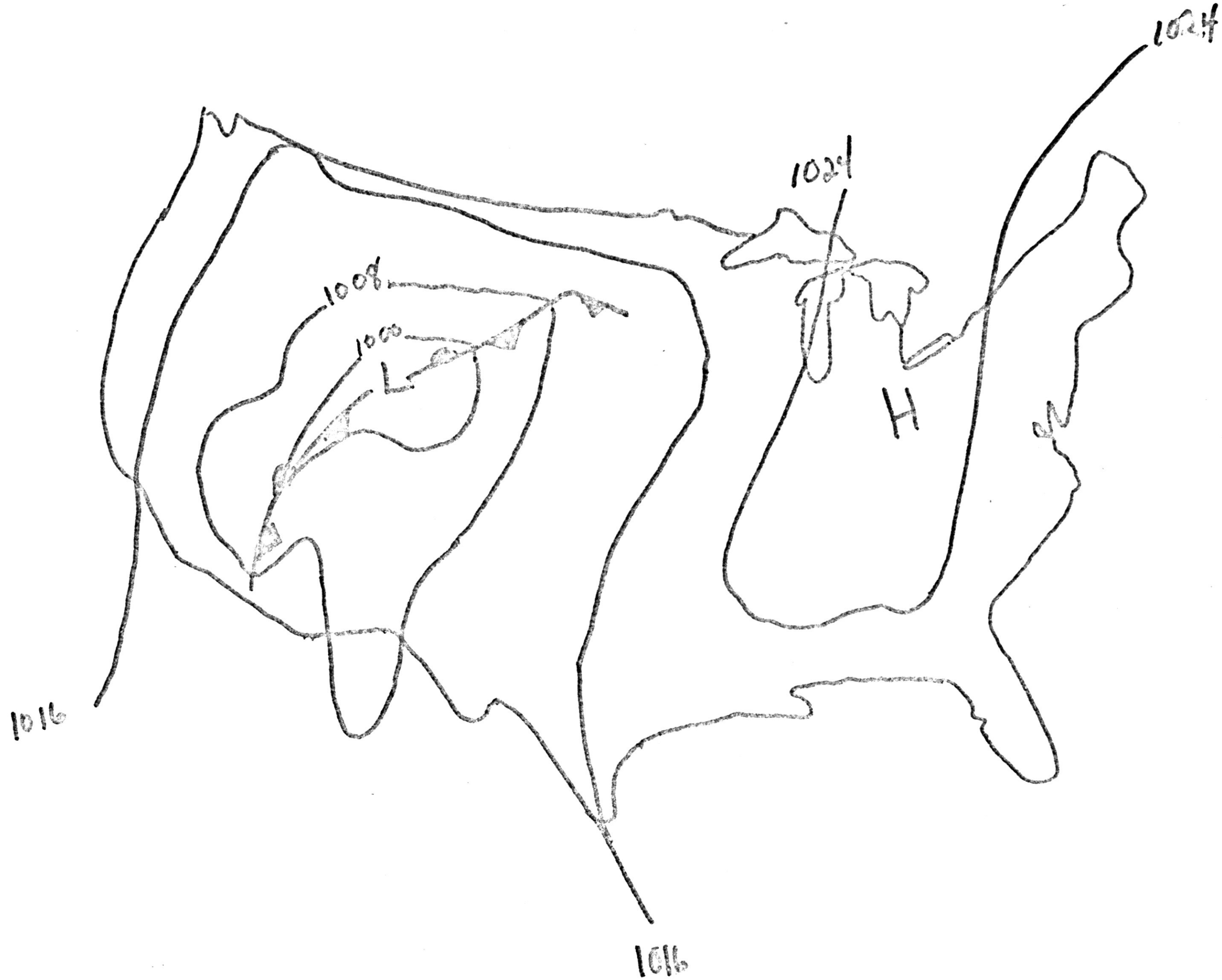

FIGURE 2
0600Z Surface pressure analysis (mb)
April 29, 1967

Selection of the cross section line

To select the cross section line, isobaric maps of dew-point depression were plotted and analyzed. The analysis for 825 mb is shown in Figure 3. An area of strong gradient of dew-point depression, indicative of the dryline can be observed between Altus and Cordell. A line joining Altus, Fort Sill, and Pauls Valley was selected for the cross section primarily because of its central location among the stations. The fact that this line is nearly straight and crosses the area of strong gradient further supported its selection. The distance between Altus and Pauls Valley is 264 kilometers.

Parameters

The parameters chosen for the investigation are temperature, dew-point depression, potential temperature, mixing ratio, and moist-static energy.

The temperature difference between the two air masses is relatively small, if one exists at all. The moist air is capped by an inversion, however, making a temperature analysis useful in determining the location of the dryline. Dew-point depression, while having little dynamic significance, is a useful tool for delineating the moisture difference between the air masses.

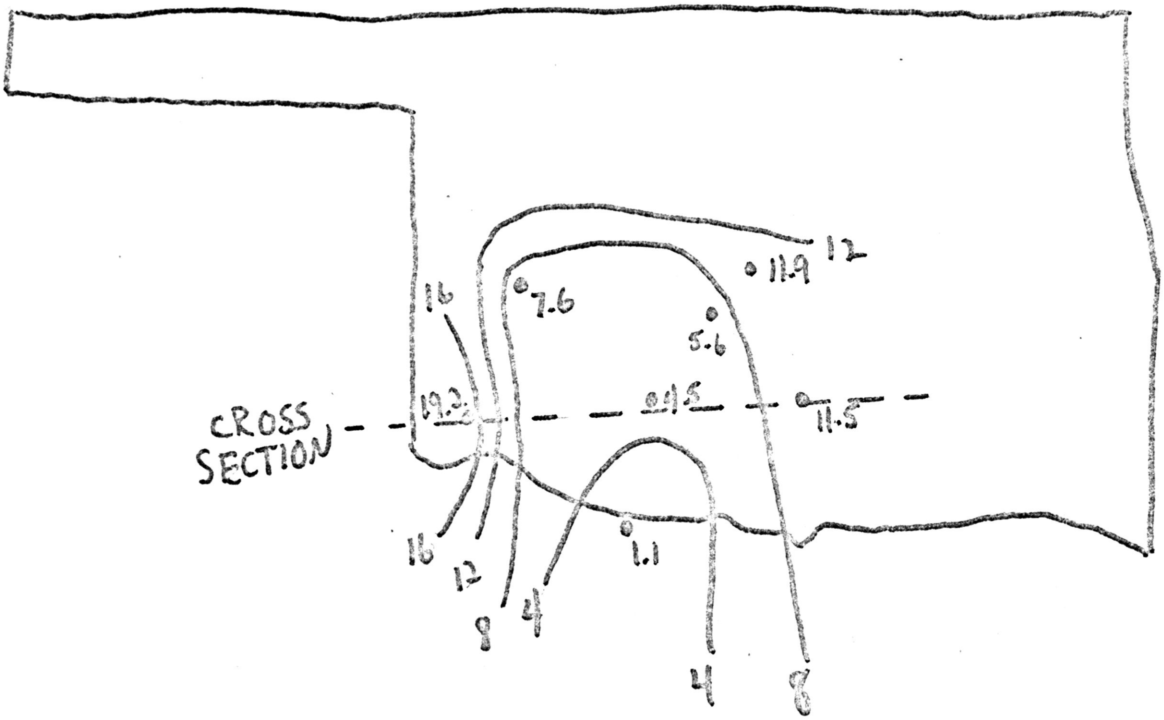

FIGURE 3
Dew-point depression analysis (^{o}C)
825 mb

Since neither temperature nor dew-point depression are conservative properties, potential temperature and mixing ratio were analyzed to identify the dynamic properties of the air masses. Mixing ratio had already been computed by NSSL. Potential temperature was computed by:

$$\theta = T(1000/P)^{.286}$$

where:

θ = potential temperature

T = temperature

P = pressure in milibars

Moist-static energy is related to wet-bulb potential temperature. It is conservative in all adiabatic processes, meaning that only non-adiabatic processes can cause it to change. It was computed in ergs/gram using the following formula:

$$h = c_pT + L\omega + gz$$

where:

h = moist-static energy

c_p = specific heat at constant pressure

T = temperature in degrees Kelvin

ω = mixing ratio

L = latent heat of vaporization

g = acceleration due to gravity

z = height

Construction of the cross section

All parameters were analyzed in the same manner. First isobaric charts for each variable were plotted and analyzed. The levels were selected by examining the individual soundings to determine which levels were significant. These usually corresponded to a base or top of an inversion. If a data point at a selected level was not available in a sounding, it was determined by linear interpolation. The selected levels were 950 mb, 900 mb, 875 mb, 865 mb, 855 mb, 845 mb, 830 mb, 825 mb, 815 mb, 805 mb, 800 mb, 790 mb, 775 mb, 750 mb, and 725 mb.

Data points for Altus, Fort Sill, and Pauls Valley were transferred from the isobaric maps to the cross section chart. In addition, data points between these stations which could be determined from the isobaric analysis (i.e., where an isoline intersected the cross section line) were also plotted. After all the values were plotted, the cross section was analyzed.

RESULTS

The cross sections for temperature, dew-point depression, potential temperature, mixing ratio, and moist-static energy are shown in Figures 4 through 8 respectively.

The dew-point depression cross section and the

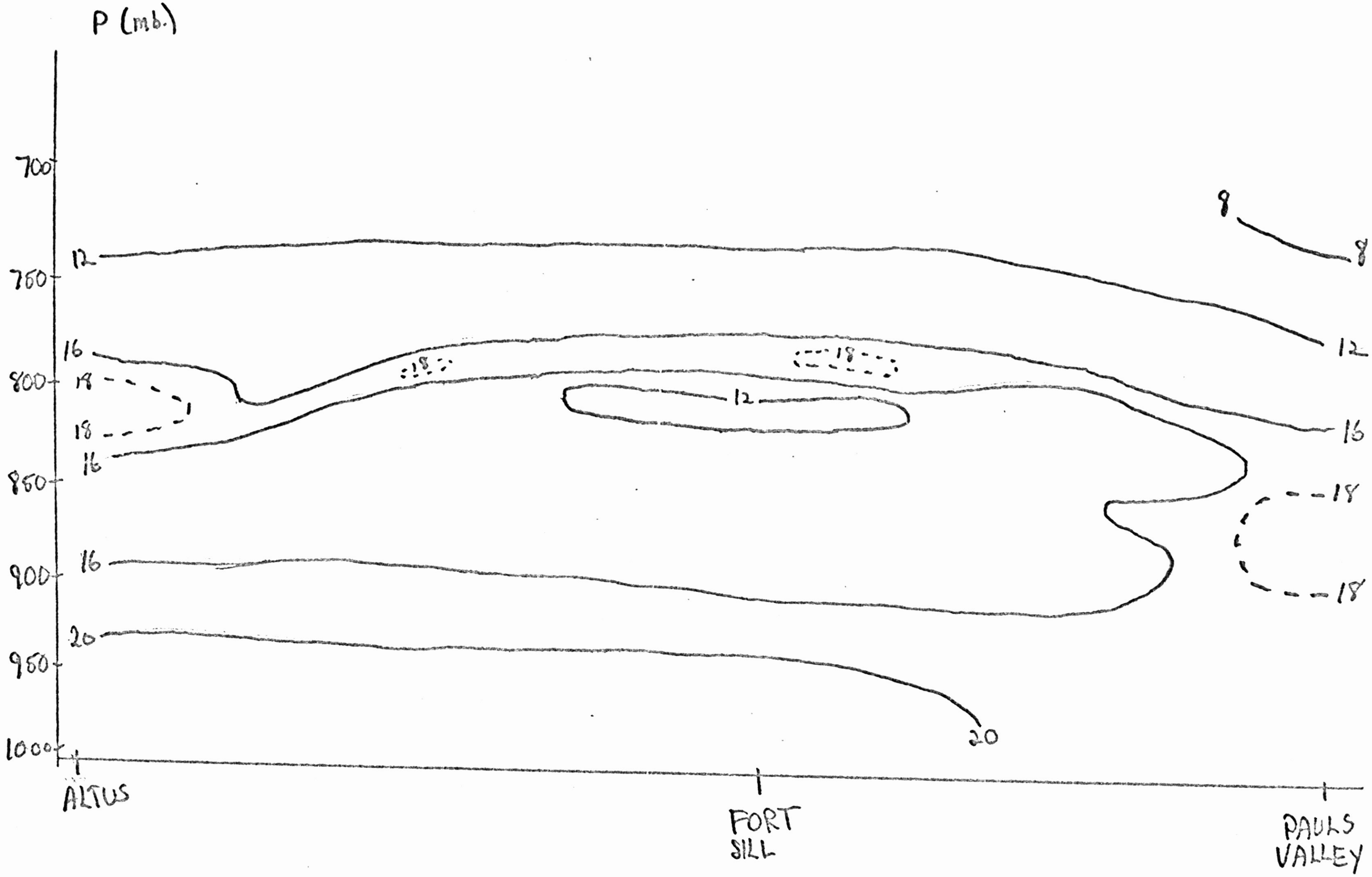

FIGURE 4
Temperature cross section (°C)

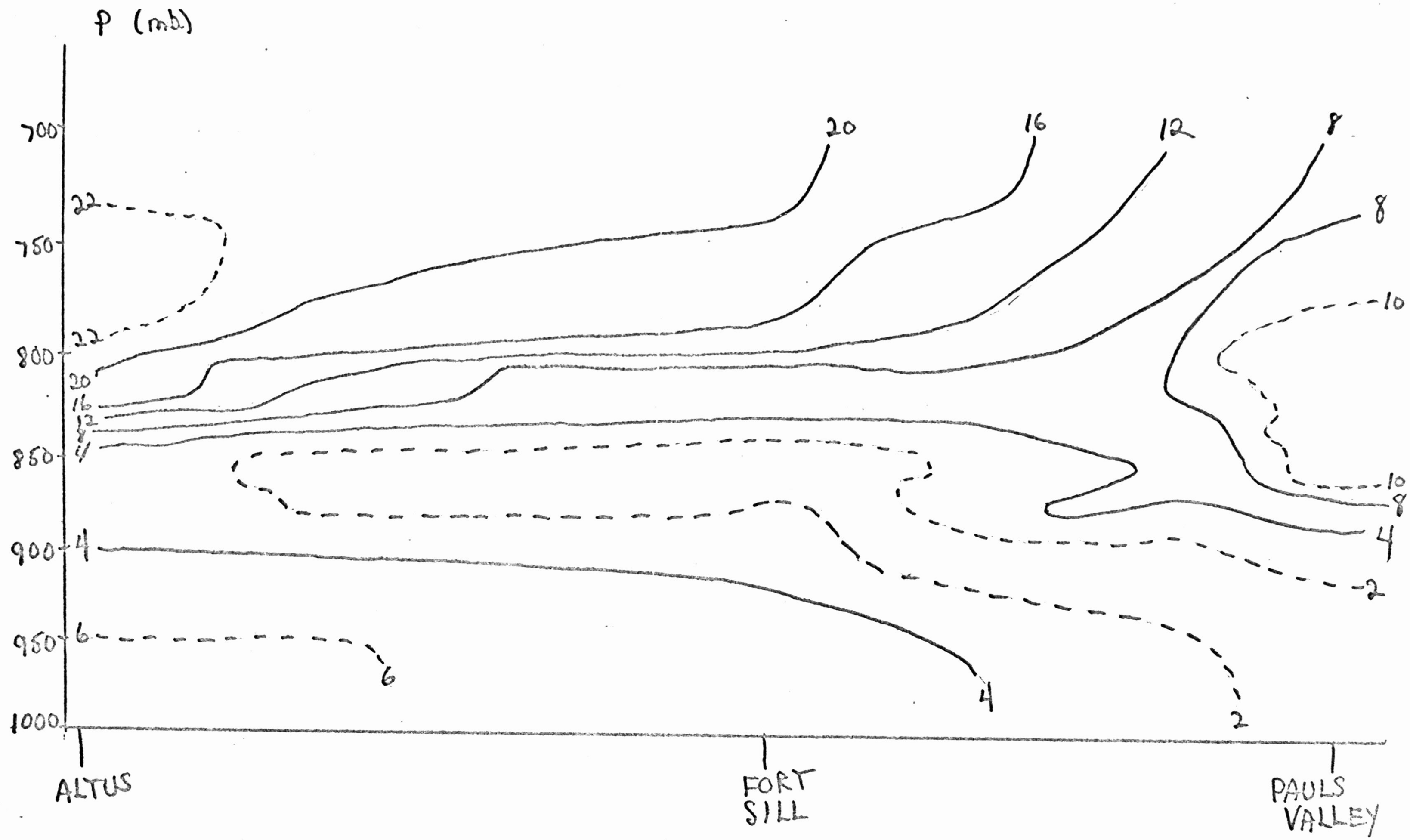

FIGURE 5
Dew-point depression cross section (^{o}C)

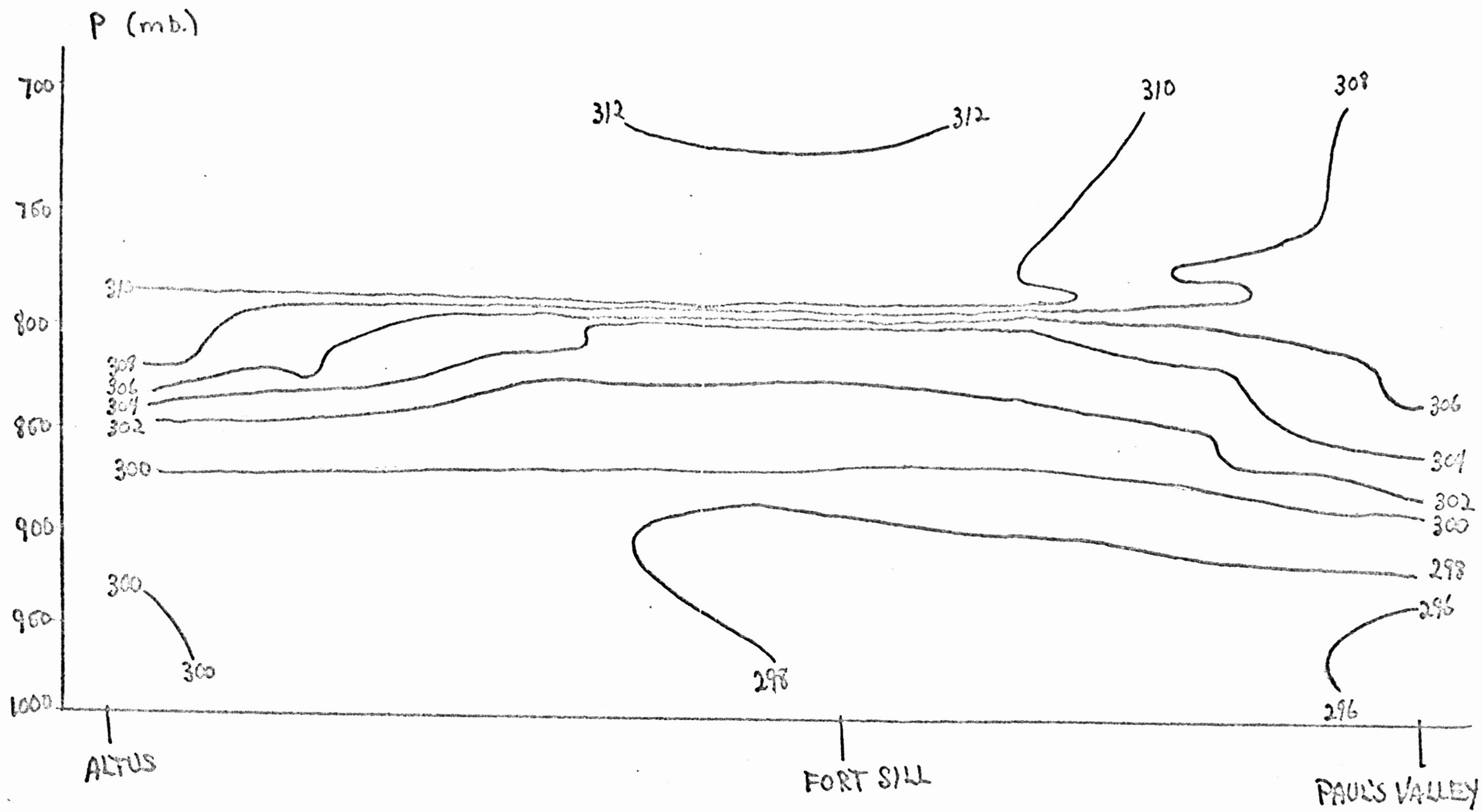

FIGURE 6
Potential temperature cross section (°K)

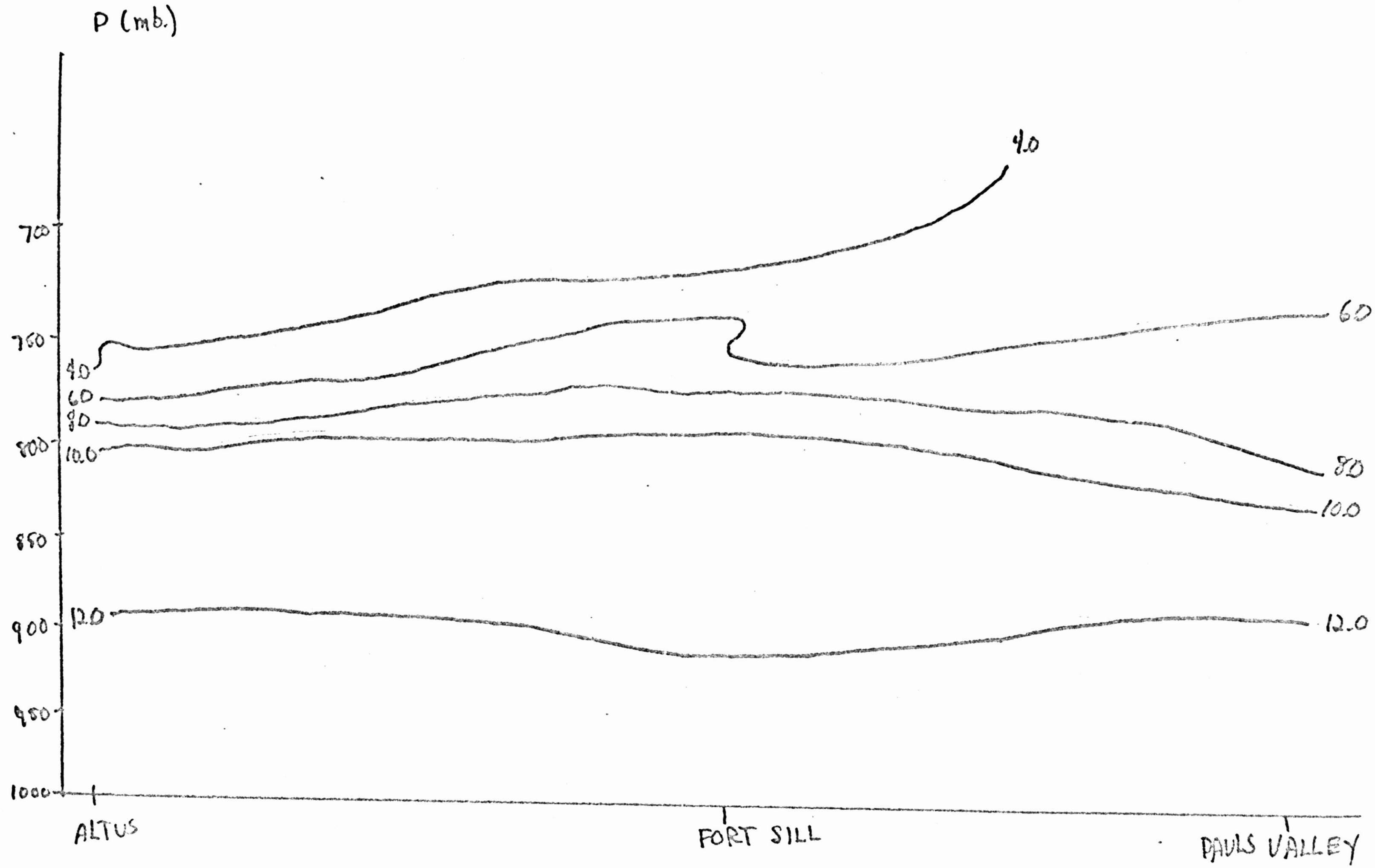

FIGURE 7
Mixing ratio cross section (gm/kg)

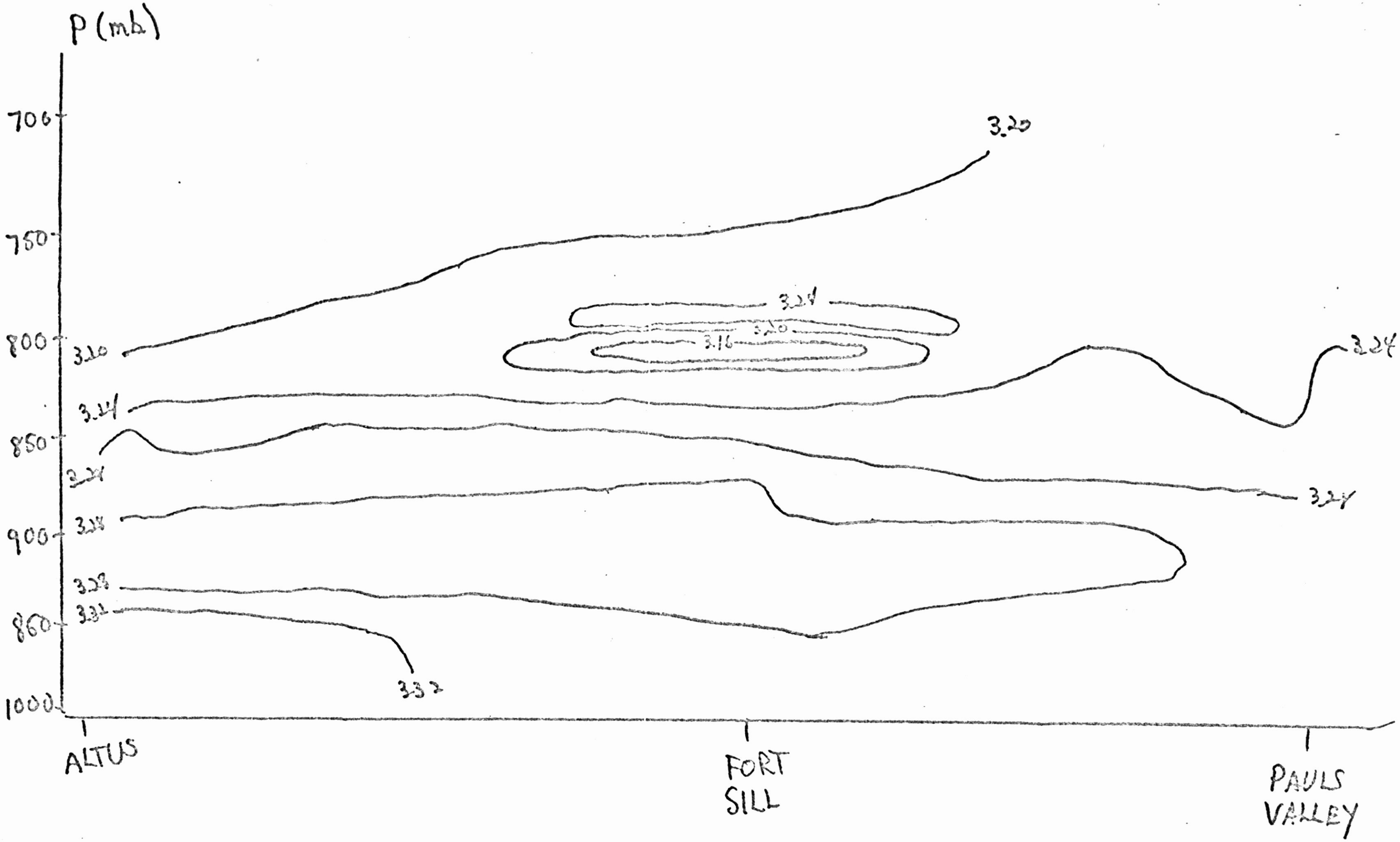

FIGURE 8
Moist-static energy cross section (10^9 ergs/gm)

mixing ratio cross sections are similar in that relatively strong gradients are apparent over Altus between 850 and 800 mb, becoming less evident farther east. The potential temperature cross section shows two distinct air masses, with the lower (moist) layer being fairly well mixed. The temperature cross section shows inversions over Altus and Fort Sill, but the inversion becomes indistinct over Pauls Valley. A closed-off area of low temperature is evident over Fort Sill at 825 mb, corresponding to an area of low moist-static energy. Aside from this area, moist-static energy decreases with height.

CONCLUSIONS

The low temperature and low moist-static energy area over Fort Sill at 825 mb cannot be readily explained by the dryline. One possible explanation is that a band of clouds formed the previous afternoon or evening, having their vertical development limited by the base of the inversion. During the night, the cloud tops experienced radiative cooling, deepening the inversion. The next morning, the sun began to evaporate the clouds, and at the time of the sounding, this had prevented any substantial change in the temperature structure.

Aside from this area, the cross sections are consistent with each other and provide information concerning the meso-scale variation of temperature and moisture through the dryline. More cases need to be examined before any definite conclusions can be made. Possibilities for future research include comparing the structure of the dryline at various stages of development and comparing the structure of a dryline that produces thunderstorms to one that does not.

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