SNOW CREEP MOVEMENT IN THE SAN JUAN MOUNTAIN SNOWPACK RED MOUNTAIN PASS

Walter Walker
Coordinator of Outdoor Pursuits
Fort Lewis College
Durango, Colorado 81301
Phone (303) 247-7293, Fax (303) 259-1774

ABSTRACT

During the winter of 1992/93 and 1993/94 an attempt was made to measure and document the amount of snow creep on a north-facing slope near the St. Paul Lodge, on Red Mountain Pass in the San Juan Mountains of southwestern Colorado. Weekly measurements were taken of plates placed in the snowpack. The plates were placed in the surface of the snowpack at the start of each month. Significant movement was recorded in both years. When comparing creep movement to snow type, large amounts of movement (greater than 10 cm per week) did not occur until kinetic snow growth was slowed and surface snow remained in the equilibrium form. The movements have been recorded and correlated with SnowTel precipitation records and avalanche cycles on Red Mountain Pass/US Highway 550. An attempt was made to define the amount of movement required for "accelerated creep".

INTRODUCTION

On April 1, 1991 I observed the remains of a large slab avalanche. I was skiing with Chris George, owner of the St. Paul Lodge and we discussed reasons for the timing of this avalanche and were unable to correlate it to any recent precipitation, wind or temperature event. We speculated that accelerated creep was the culprit. We began discussing ideas on ways to measure accelerated creep. Our first thought was placing strain gauges in starting zones. After judging the safety of such an activity we looked for a safe location for the study. After looking at a variety of sites I choose a northwest facing slope, 36 degrees in steepness, at an elevation of 11,200 ft..

INSTRUMENTATION

Very simple instrumentation was used for the study. The metal plates placed in the snow were tethered to tape measures in plastic boxes. This method of measurement was chosen because it was the least expensive. The plates were tethered to the tape measures by small diameter steel cables.

READINGS

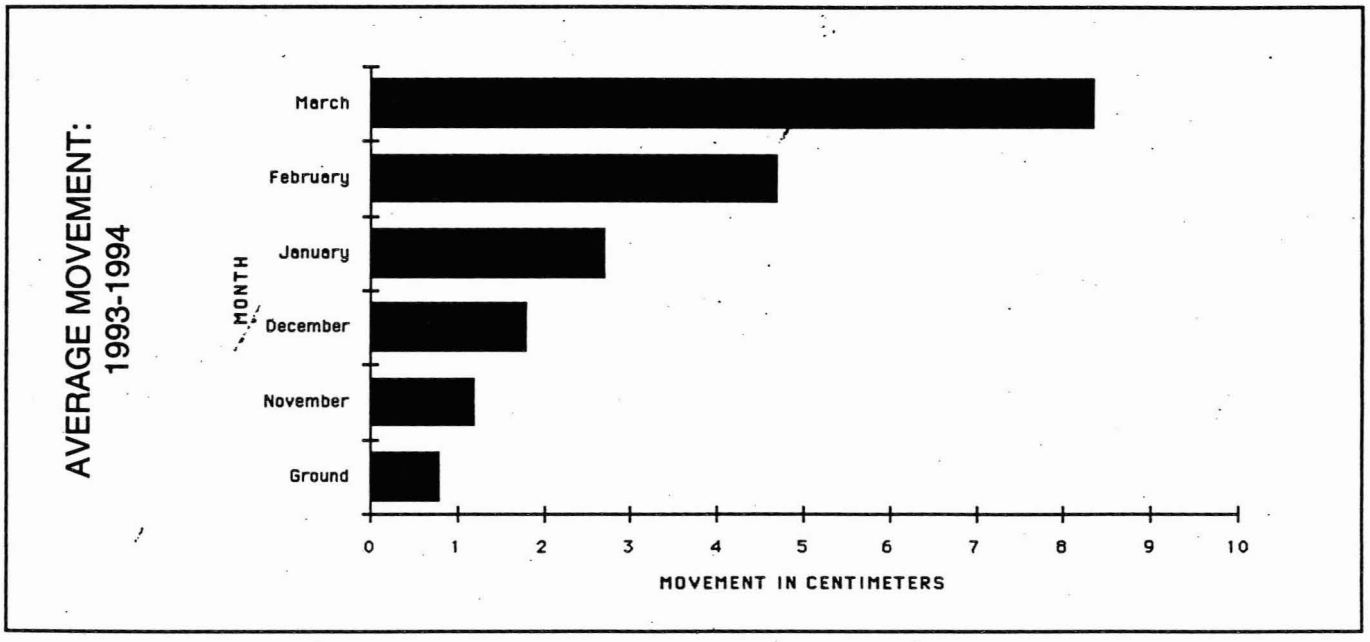
The goal of this study was to take readings once a week but, because of weather, road closures and work, readings were taken in six to eleven day intervals.

DATA

The amount of movement for each plate was recorded each time I visited the site. A metal plates was placed on the ground at the start of the winter and another one was placed on the surface of the snow at the start of each month. The data reflects the total amount of movement in the snow pack. No attempt was made to factor out glide movement. McClung and Schaerer (1993) have shown that on a 36 degree slope shear deformation is responsible for as much as 80% of the movement. There was some deformation noted in bowing of the tether cables but no formula was designed to factor out this influence.

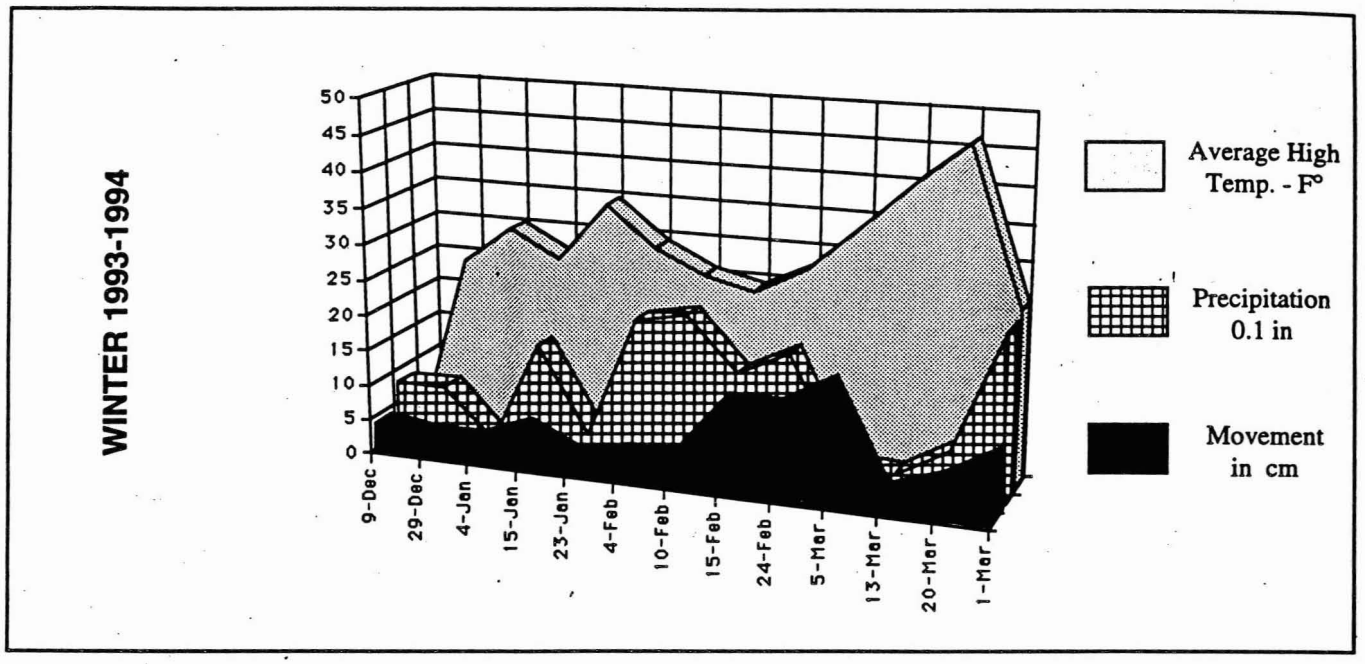
AVERAGE MOVEMENT

This chart show the average movement within the snow pack . There is very little deformation in the faceted ice grains near the ground. As density decreases and snow depth increases the total movement increases.



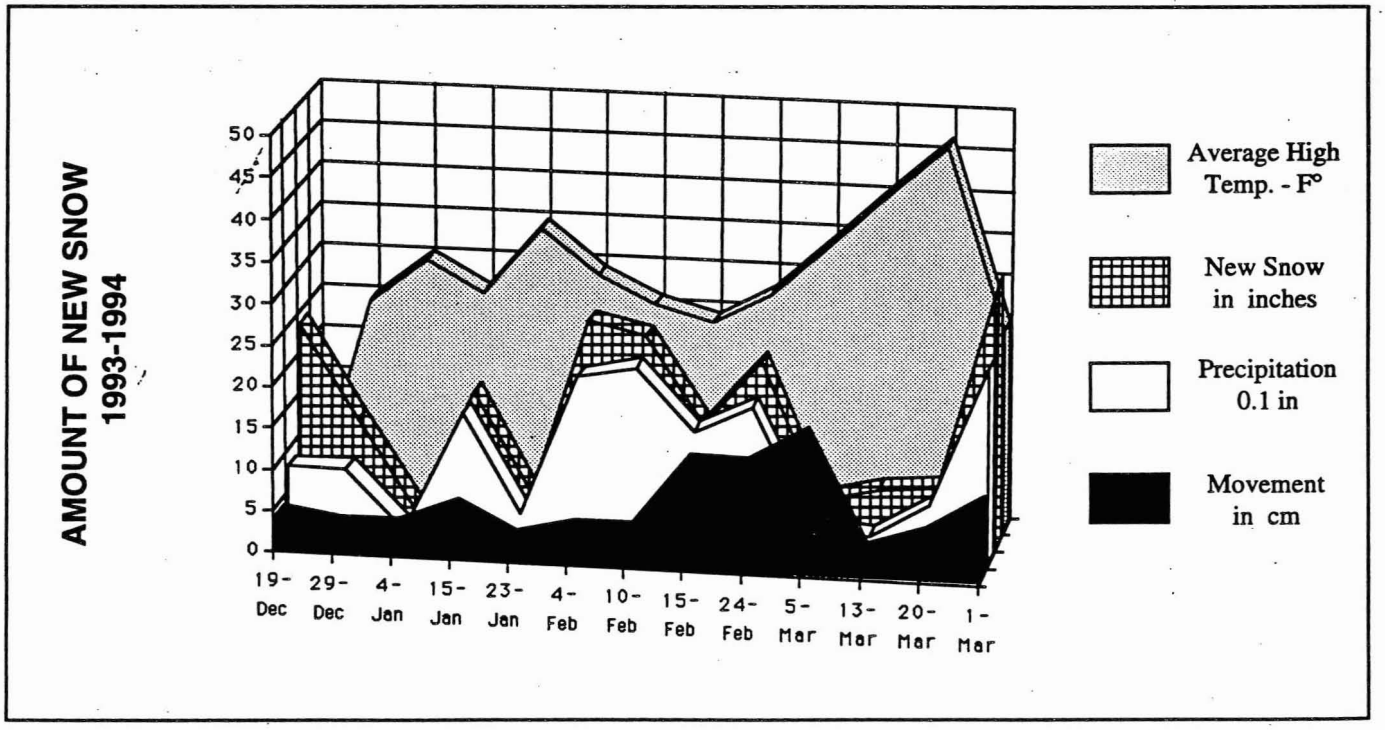
TOTAL SURFACE MOVEMENT WINTER 93/94

Small amounts of creep movement were recorded in the surface of the snow pack during the early winter. The 93/94 winter was a typical start to a San Juan Mountain winter: Cold temperatures and shallow snow quickly resulted in the formation of depth hoar. Rapid movement was not observed on the snow pack until February when heavy snows bridged the week, shallow snow. Movement within the snow pack increased substantially after early February.



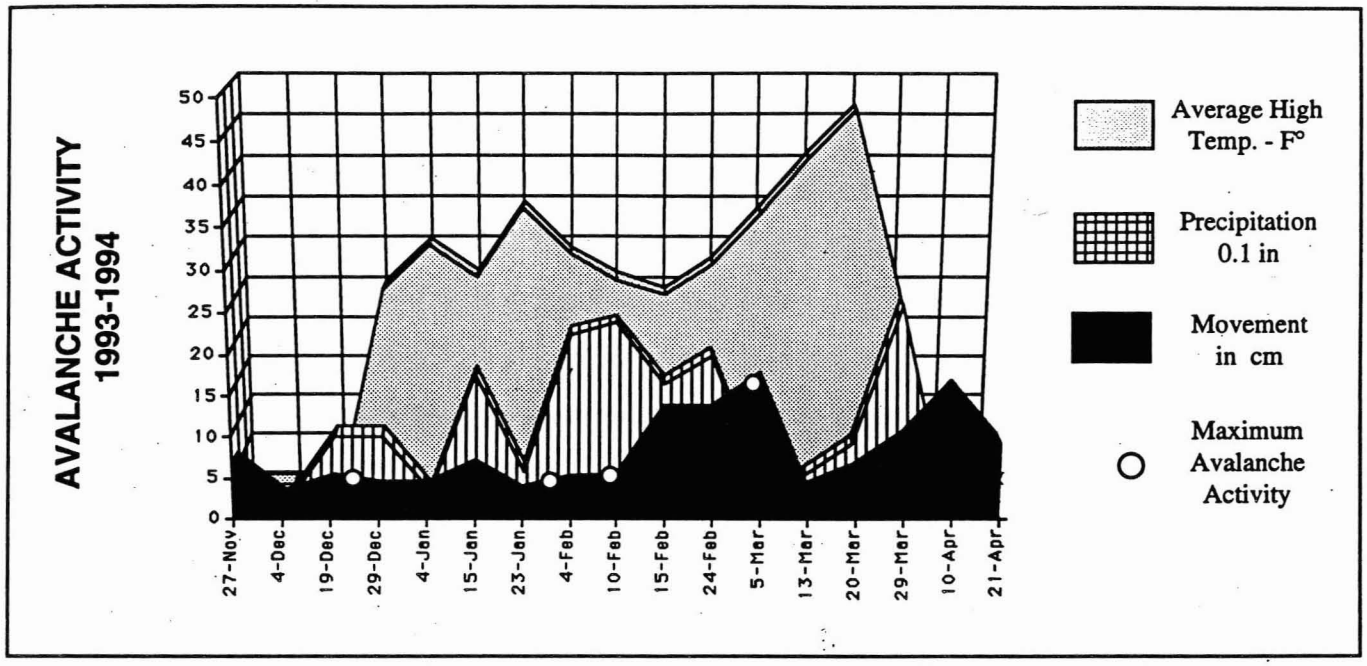
AMOUNT OF NEW SNOW

The amount of new snow and amount of water in the new snow provide some direct correlation to snow creep, but as the winter progresses, creep seems to follow precipitation with a lag in time.



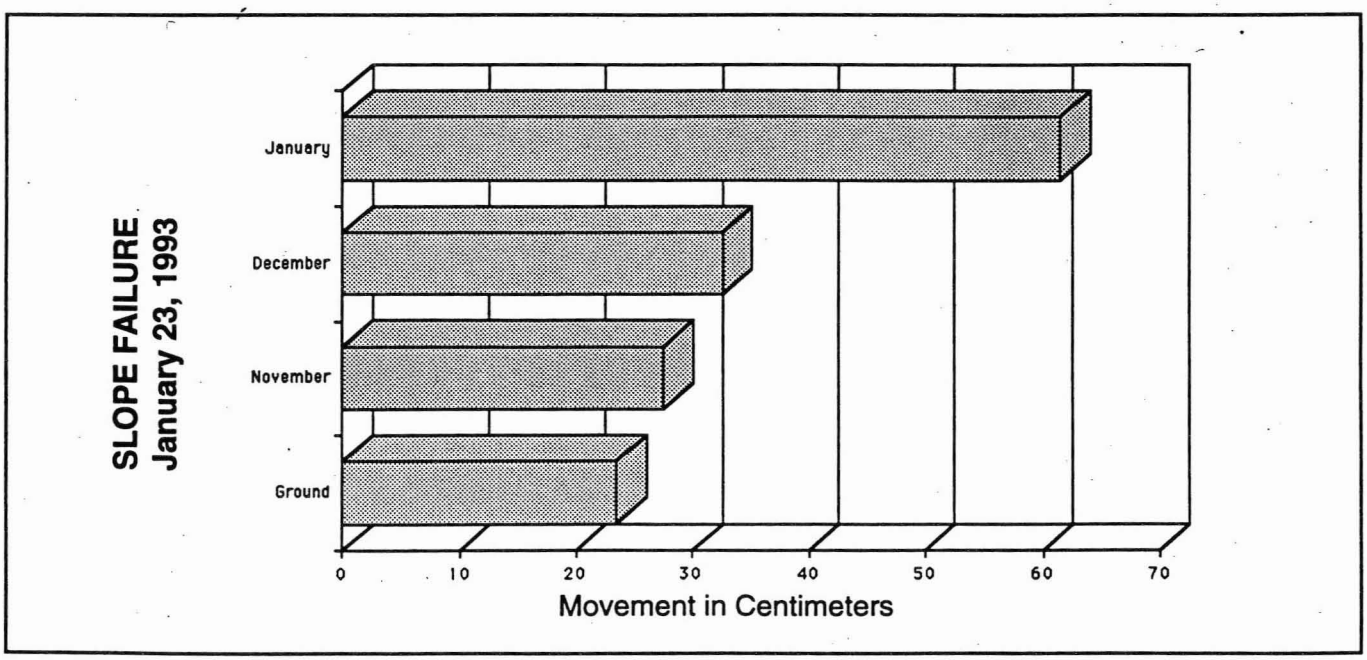
MAXIMUM AVALANCHE ACTIVITY PER /MONTH

The maximum avalanche activity per month is plotted on this chart. This activity has a close correlation to new snow until March, and then there seems to be some correlation to creep movement.



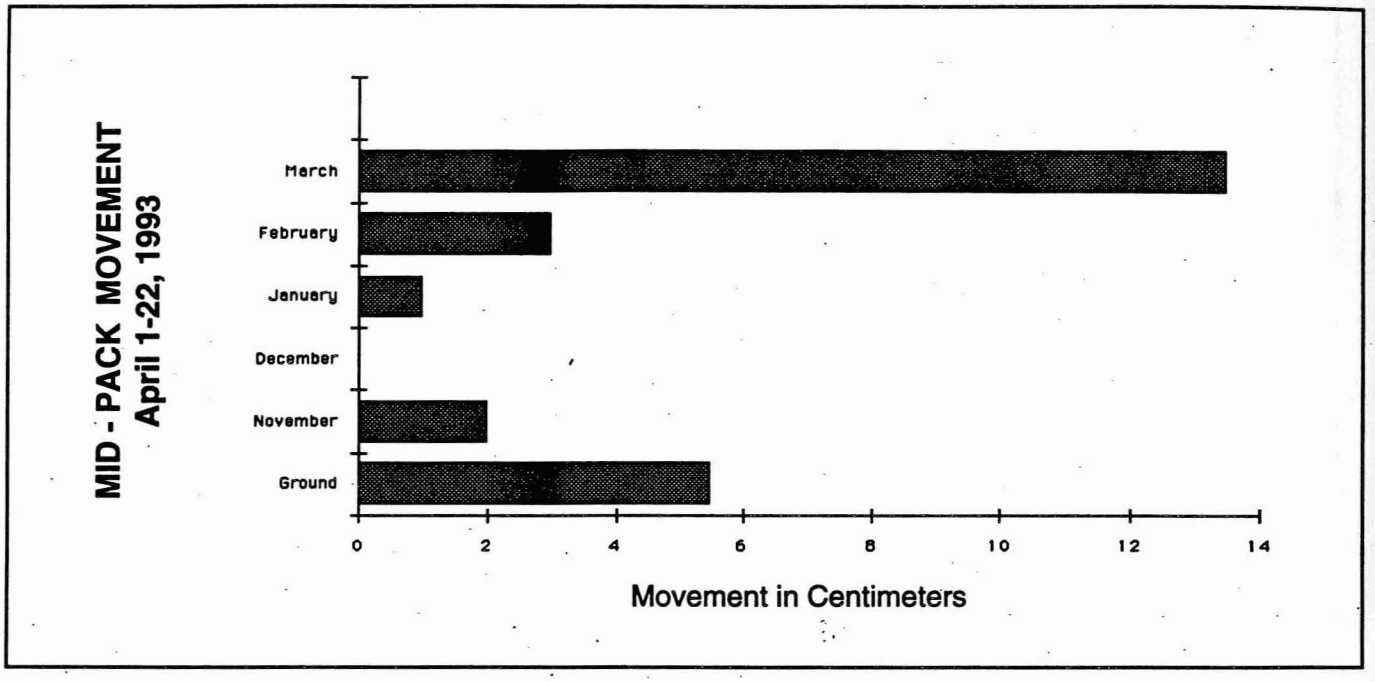
ANOMALIES IN THE SNOW PACK

On January 23, 1993 slope failure was recorded at the study site. The slope fractured and moved but did not avalanche. The adjacent slope to the north avalanched to the ground on mature depth hoar.



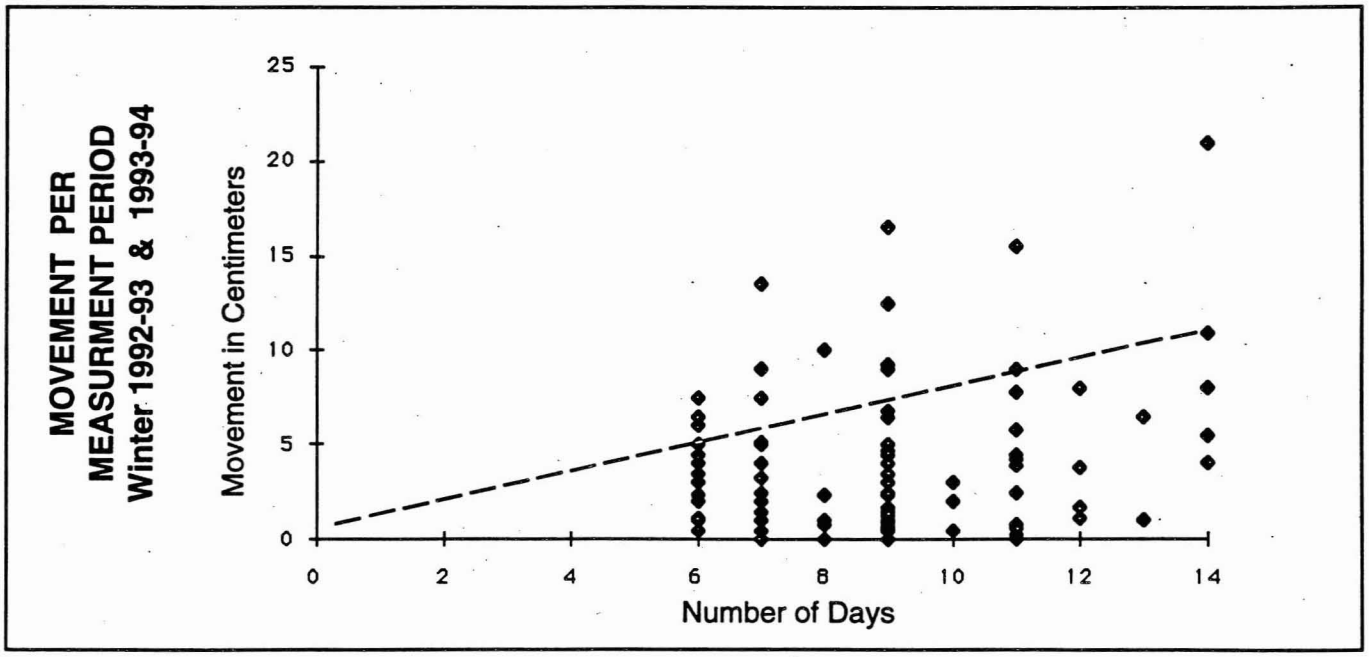
MID-PACK MOVEMENT

During the study on a few occasions data indicates movement on the surface and on the bottom of the snow pack. Little or no movement has been recorded in the middle of the pack. This may indicate that heat from the ground is allowing the snow pack to move by plastic flow.



ACCELERATED CREEP

Plotting all of the data over a two year period indicates that some movement is out of the norm. A line has been drawn on the graph to isolate above average movement in a general way. The data suggests that movement greater than 0.8 cm/day can be described as accelerated creep.



CONCLUSION

There is a general correlation between snow creep and major precipitation events in early winter. As the mid-pack increases in depth and strength snow creep lags behind precipitation events. This study defined a general threshold for accelerated creep. It is questionable whether the data is refined enough to truly depict an accurate timeline of movement within the snow pack. Future studies need to focus on real time creep data. This data needs to be compared to real time weather information. Such correlations would provide a much more accurate picture of deformation in the winter snow pack. It is also necessary to study a variety of slope angles and slope aspects before we can obtain comprehensive understanding of snow creep.

ACKNOWLEDGMENTS

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REFERENCES

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"Avalanche Notes", The US Forest Service Westwide Avalanche Network, Rocky Mountain Forest and Range Experiment Station, December,1993 to March, 1994.