[AMERICAN JOURNAL OF SCIENCE, VOL. 258, DECEMBER 1960, P. 744-751]

REPEATED AVALANCHES AT CHAOS JUMBLES, LASSEN VOLCANIC NATIONAL PARK

JAMES P. HEATH

Department of Biology, San Jose State College, San Jose, California

ABSTRACT. The Chaos Jumbles is an avalanche deposit covering more than two square miles. At least three separate avalanches descended at intervals of many years from the volcanic domes of Chaos Crags. All three flows are surprisingly similar as to extent and direction.

INTRODUCTION

The Chaos Jumbles is an avalanche deposit of dacite blocks and fragments strewn over more than two square miles in the northwestern part of Lassen Volcanic National Park. It has the typical hummocky topography of mudflows, but exhibits evidence of dry avalanche flow. A comprehensive study made by Williams (1928, 1932) showed that the deposit originated from the northern dome of the Chaos Crags as the result of explosions near the base. The resulting avalanche after moving downslope for about a mile swept upward for 400 feet on to the slopes of Table Mountain, more than two miles from the source.

Studies made by Heath (1959) indicated the age of the most recent avalanche as being roughly 270 years and suggested several older ones.

ANALYSIS OF AVALANCHES

The evidence which suggests that several avalanches occurred at widely different times is both qualitative and quantitative. The distinctly lighter portion of the aerial photographs (fig. 1)[1] can be readily noted in the central region of the deposits, and the traveler, having seen this, can distinguish it in the field though the difference is much more subtle than the photograph would suggest. Differences in the density of vegetation are not readily seen when the observer sights parallel with the terrain unless he makes a point of looking for them. Because of the subjective factor involved, an effort was made also to derive quantitative evidence to indicate the separate nature of the flows in an impartial manner. Each of these types of evidence will be considered in turn.

QUALITATIVE EVIDENCE

Examination of a great deal of the Jumbles area points to three separate avalanches that took place at quite different times. The most recent avalanche (fig. 1, boundary C) shows a paucity of trees and almost no shrubs at all. The dacite fragments are sharp and essentially unweathered and soil pockets of any kind are rare. This avalanche, which appears light in the photograph, produced a terminal mound roughly 120 feet high that served as a barrier to deflect the avalanche westward. Near the terminus, the avalanche deposit tends to blend with earlier ones but at least a mile of the north and east boundaries are traceable with great accuracy.

The middle avalanche deposit (fig. 1, boundary B) is characterized by taller and more numerous trees, in some parts by a distinctive cover of bitterbrush (*Purshia tridentata*) and some other shrubs, and by dacite which is

[1] U. S. Forest Service CWX 11-143 and 22-119.

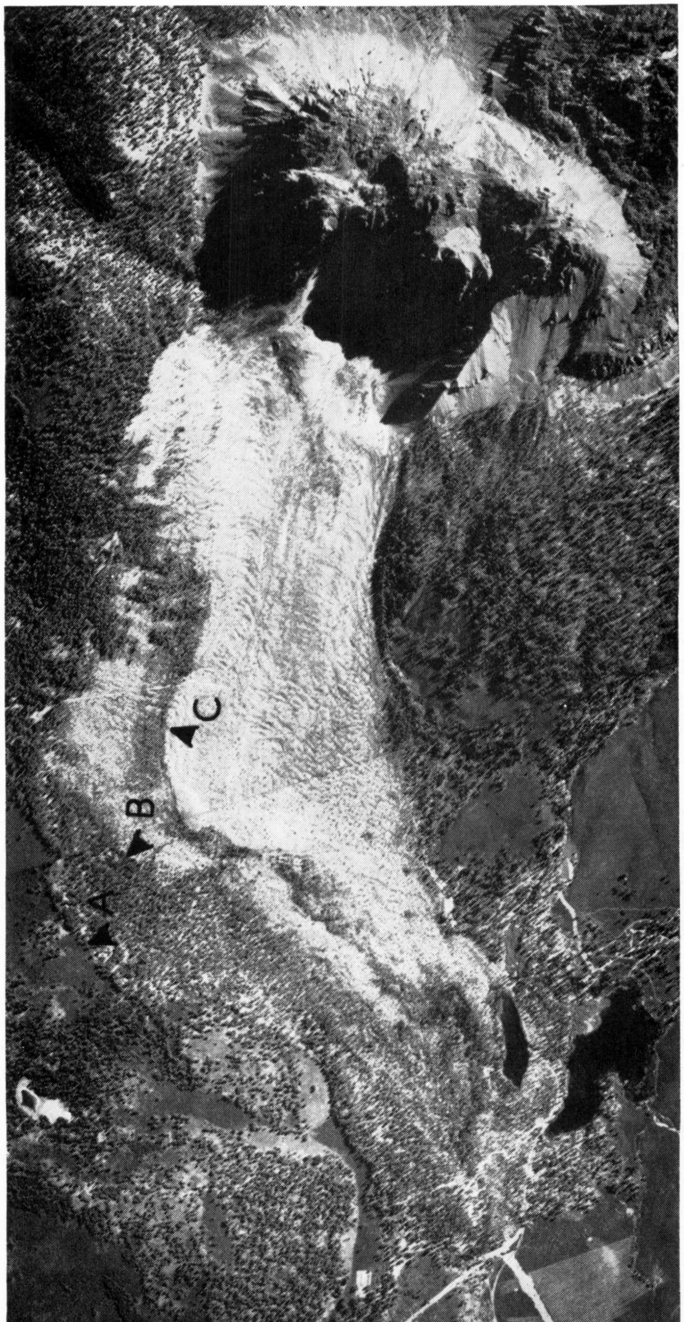

Fig. 1. Aerial photograph of Chaos Crags and Chaos Jumbles. The scale is the same as that for fig. 2. A is the edge of the most recent avalanche, B is the border of the middle avalanche and C is the edge of the oldest deposit near the area of maximum rise on Table Mountain.

definitely grayer and exhibits many weathered fragments. In many parts of this avalanche deposit, soil has developed in the interstices so that in the areas of heaviest cover there is an actual mat of needles and soil. The terminal ridge for the main course of this avalanche is not as high as that of the other two but it can be followed rather easily along the portions where it is highest. Early emigrants were sufficiently aware of this topography to run their road entirely to the north of this border, coming close at times but always remaining on the earliest avalanche deposit (see emigrant trail, fig. 2).

The first of the three avalanche deposits (fig. 1, boundary A) shows primarily on Table Mountain (fig. 2) and it was this one which extended nearly 400 feet up the slopes. Only in a few other areas is this deposit still well exposed although strips 50 to 100 yards wide appear around much of the periphery of the Jumbles. This deposit exhibits the greatest difference from the others; its cover is that of a nearly mature or sub-climax forest and most of the surface is mantled with soil. In addition, the hummocks on the surface are much more rounded and flatter than those elsewhere in the Jumbles, their slopes departing much farther from the angle of repose. Furthermore, scattered pieces of the Table Mountain lavas have drifted over the avalanche deposit in many places. Such transport much have required a long period of time.

Specific details on cover will be dealt with under quantitative evidence but certain peculiarities can best be noted here. Yellow pines (*Pinus ponderosa* var. *jeffreyi*) on the youngest avalanche deposit are usually dwarfted and distorted. On the second deposit, these trees are often normal in pattern but have sharply conical trunks that indicate exceedingly slow growth. On the oldest avalanche deposit, the yellow pines are magnificent specimens with no evidence of anything but the most normal growth. Another pine, the Western White (*P. monticola*). is also informative. Numerous specimens on the two youngest deposits are well developed, but the species is all but absent from the oldest deposit (table 1). It is typical of raw areas that they may be invaded by a variety of species so long as the primary competition is with the elements. Once soils have formed. competition becomes that of the biotic environment. These avalanche deposits demonstrate exactly this principle in operation.

TABLE 1

Average occurrence per 1000 feet of trees at least ten feet tall. Species: Pc, *Pinus contorta*; Pl, *P. lambertiana*; Pm, *monticola*; Pp, *P. ponderosa* var *jeffreyi*: Ac. *Abies concolor*; Am, *A. magnifica*; Ld, *libocedrus decurrens.*

Area	Newest	Middle	Oldest	Original
Based on	4000 feet	3000 feet	3000 feet	1000 feet
Pc	0.25	16.33	0.0	0.0
Pl	0.0	1.66	0.33	0.0
Pm	4.25	3.66	0.0	0.0
Pp	0.75	9.33	12.66	3.0
Ac	1.25	3.00	3.33	59.0
Am	0.75	2.0	0.0	0.0
Ld	0.0	0.0	0.33	0.0
Total	7.25	36.0	16.66	62.0

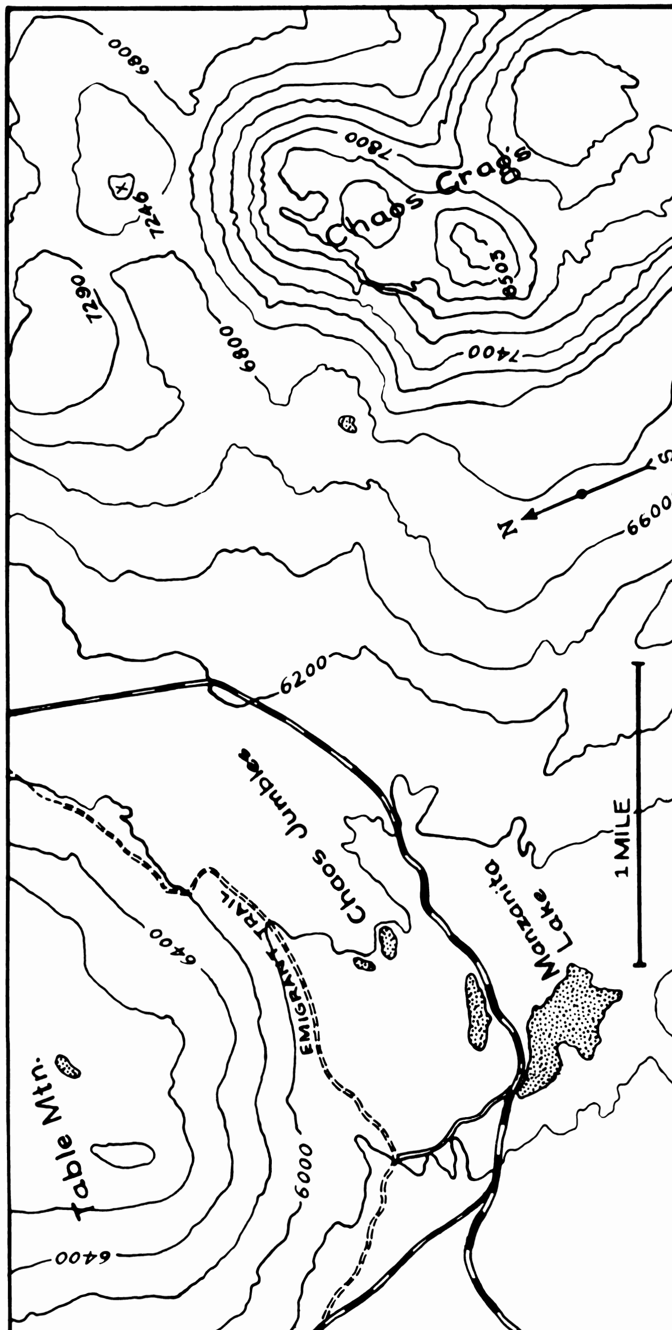

Fig. 2. A portion of the Manzanita Lake quadrangle (1956) which covers the same area as the photograph of fig. 1. Contours are at 200 foot intervals.

Another difference observed among these deposits is correlated with the severity of the environments. In the youngest deposit, there are many very small trees about six inches to four or five feet in height. These show a great deal of distortion and cores of some of the larger ones indicate that growth has been exceedingly slow. Some of these small trees and most of the larger ones demonstrate a gain of less than two inches of increment to the radius in a century. Cores from trees on the oldest avalanche deposit show very rapid growth (as much as two inches in less than ten years), the reduced rings appearing only as the trees gained maturity.

QUANTITATIVE EVIDENCE

The foregoing description of qualitative evidence has indicated some features readily noted by the field observer. However additional evidence of a quantitative nature is based on the effects of edaphic differences on cover. Plants are exceedingly sensitive to variations in soil quality and development. One of the standard methods of cover analysis is the line transect (Bauer, 1943) in which all plants which would touch a vertical plane along a particular line are recorded. The trees of the Jumbles indicate soil features and are relatively uninfluenced by short-term climatic fluctuations which could modify annuals or even perennial herbs with short life-histories.

A number of transects were run across the boundary of two deposits. Figure three displays to scale the considerable differences in the heights and numbers of trees on two of these 1000′ transects. Table 1 shows vast differences in tree cover on the different flows. Not only do the species differ, but the density varies markedly between flows. On the most recent flow, trees are few with the Western White Pine by far the most important species. The second deposit has many more trees with Lodgepole Pine dominant and with Jeffrey Pine a strong contender. On the oldest avalanche, the trees are very large and fewer in number. The Jeffrey Pine has the dominant position and the species dominants on the other flows do not even appear in the 3000′ of transects. A transect on the older soils adjacent to the avalanches shows strong dominance by White Fir. This suggests that even the oldest avalanche deposit is a very long way from being completely weathered to a mature soil.

Nearly one hundred cores were taken from the largest trees on the most recent avalanche deposit. These showed the oldest trees from an area of well over a square mile to be about 262 years old (Heath, 1959). Random sampling of but three of the trees on the oldest Jumbles indicated one tree to be 284 years old. Four trees close together on the second deposit all gave dates of more than 200 years and one was 261 years old. On the most recent avalanche, the dates show a rather sudden development of trees as could be expected on a relatively recent surface. Cores in the other areas where the oldest trees may have died and been destroyed cannot be used to date the time of origin of the deposits but they do serve to demonstrate their greater age.

OTHER FEATURES OF CHAOS JUMBLES

Williams' (1932) study was extensive and there is little point to reiteration of his report. However, the recognition of the separate flows does modify

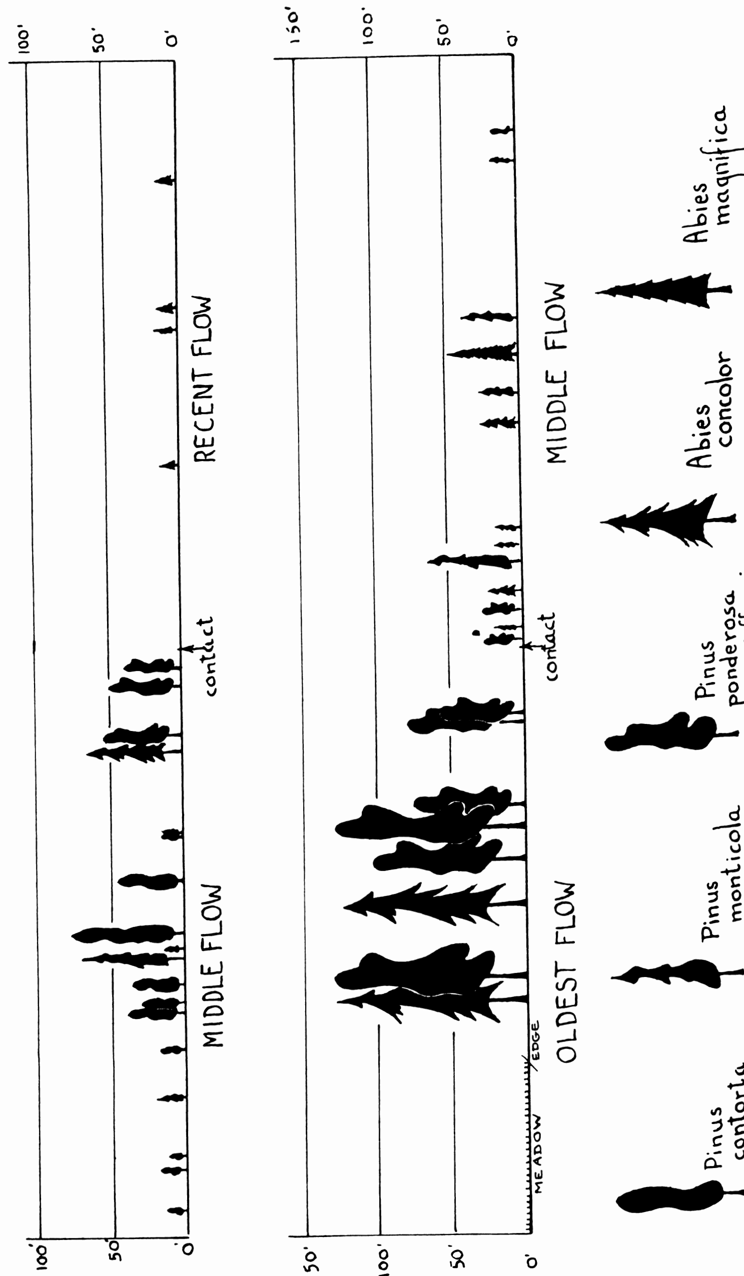

Fig. 3. Two 1000 foot transects from areas of contact between deposits. These are actual cases; not summaries.

some aspects of his interpretation. For one thing, the large moraine-like ridges so notable on the western border of the deposits are not the borders of the last flow but appear to be derived from the earliest one. The most recent flow built lower ridges parallel and nearby to these which accentuate the steepness and height of the old ridges.

Williams states,

> There is no marked increase in the size of the larger blocks as the flow is traced toward its source. All that can be said is that the sand-like fraction increases in amount toward the distal ends of the deposits.

This certainly applies well to the latest avalanche deposit. However, there are some larger rocks in the general area of the "crater" rims—perhaps due to being less subject to the battering received by rocks farther along. The "sand-like fraction" is a prominent feature of the region of the terminus and contributes greatly to the difficulty of determining this border which is so distinct in the mid and upper areas. The main linear flow built ridges some 120 feet high and these deflected the remaining rush to the westward. The increasingly smaller size of the material and the suggestion of braiding shown on the aerial photograph (fig. 1) along with the ill-defined terminal border imply a high moisture content and fluidity in these terminal portions. The gradient in these deflected materials is considerably less than that of the main linear flow and this also implies a well lubricated mass. These features tend to reinforce Williams postulation that a high water content was involved in the formation of the avalanche deposit.

Williams describes tumulus-like mounds which he postulates were derived from the crumbling of large blocks subjected to gases and steam before emplacement and subject to rapid disintegration after it. Three features would seem to deny this origin. Firstly, there is the paucity of large blocks in almost the entire deposit. Certainly a rock large enough to produce these mounds would be out of all proportion with the general mass of fragments composing the majority of the area. Secondly, various small areas of what might be termed "boil-ups" appear frequently in some parts of the newest Jumbles. These rather flat areas appear to be similar to mud mounds squeezed up in a bog. It can be assumed that some portions of the flow were wetter than others and in the churning mass were squeezed up in heaps. The small size of the materials leads to rapid leveling of the mounds so that lesser ones are almost flat. Thirdly, in all but one observed case, the nature of the materials, except for size, appears to be consistent with the rest of the flow. There is no excessive weathering of the fragments nor do these show particular evidence of steam or gas action.

A peculiar feature of the avalanches is the highly specific direction of flow of each. On three widely separated occasions, the dome must have risen enough to provide not only the huge mass of material but also the momentum required. Added to this is the requisite of some explosions on the north side of the dome such that the materials would topple in only one direction. There is no evidence of anything but very localized talus around the rest of the base of this northern dome so very violent explosions can be ruled out. Thus, we can accept the idea of the steam explosions Williams postulates but we must add to this that they occurred not just once but three times. The "crateriform depressions" at the dome base would certainly appear to confirm this origin for the last flow. However, flow patterns of the avalanche materials can be traced to some extent by observing streaks of rock of slightly different color or grade (slightly visible in fig. 1). Some streaks are nearly half a mile long and consist of rock which appears to have been somewhat discolored by gases; others are merely streaks of consistently coarser or finer debris that can be traced over the highly irregular surface of the Jumbles, even into the inner rim of the "craters". Had the explosions thrown out such material, these flow streaks would not be present. Furthermore, there is little evidence on the surrounding tuffs, of dacite fragments blasted out onto the surface. In whatever manner the explosions occurred, the process must have stopped shortly before the avalanche ceased its flow and must never have been violent enough to do more than clear two pockets at the base of the dome. One is forced from all of this to postulate some rather improbable events. First, that the steam explosions each time were almost horizontal in their force since they did not cast debris onto the lateral tuffs. Second, on the last avalanche the explosions must have stopped just prior to the end of the movement since the craters are preserved yet the flow streaks extend into them. Third, we must postulate that similar blasts took place twice before in an almost identical manner.

A particularly interesting problem is posed by these separate avalanches with respect to the surrounding territory. On the west, as Williams notes, the deposits overlie tuffs from what appear to be rather recent explosions from a series of craters between Lassen Peak and Chaos Crags; craters which apparently extended over the older southern dome. These deposits must be a good deal older than was originally supposed.

There does not seem to be any present way to date the older flows. One can only note that soils form exceedingly slowly at these altitudes. Strictly from a biologist's estimate, it would appear that the second avalanche took place not less than 700 years ago and the oldest one not less than 1000 years earlier than that, but these are strictly subjective estimates.

ACKNOWLEDGMENTS

Dr. Gordon Macdonald was most helpful in the field in discussing the evidence. The National Park Service personnel and particularly Superintendent E. P. Freeland, Park Naturalists V. R. Bender and Richard Prasil and District Ranger Lester Bodine were most helpful in providing suggestions and encouragement, facilities and transport of equipment. Dr. Howel Williams read parts of the manuscript and offered many helpful suggestions.

REFERENCES

Bauer, Harry L., 1943, The statistical analysis of chaparral and other plant communities by means of transect samples. Ecology, v. 24, p. 45-60.

Heath, James P., 1959, Dating Chaos Jumbles, an avalanche-deposit in Lassen Volcanic National Park: Am. Jour. Sci., v. 257, p. 537-538.

Williams, Howel, 1928, A recent volcanic eruption near Lassen Peak, California: Univ. of Calif. Publ. Dept. Geol. Sci., v. 17, p. 241-263.

———, 1932, Geology of the Lassen Volcanic National Park, California: Univ. of Calif. Publ. Dept. Geol. Sci., v. 21, p. 195-385.