Geomorphology--The Science of Today's Geology

By ROBERT P. SHARP

IN the popular mind geology is a science of antiquity, and the geologist's nonchalant use of millions and billions of years brings only incredulity to the layman. However, geology is not entirely a science of ancient things, for one of its branches, geomorphology, is concerned with matters at the top of the geological time scale.

Geomorphology is defined as the science of landforms dealing particularly with their genesis and evolution. It has a major interest in geologic processes currently acting on the earth's surface and in events of the last 10 to 20 thousand years which, on the geological time scale, correspond to happenings of about 9 or 10 o'clock this morning.

Geology has been criticised by its more exact sister sciences for lack of an experimental approach. Spurred on by such criticism and aided by those sister sciences, geologists have turned to laboratory experimentation with some good results. Unfortunately, the tremendous difference in scale between laboratory experiments and natural phenomena and the impossibility of duplicating the physio-chemical environment attending activities deep within the earth's crust detract from the value of some geological experimentation. Geomorphology is more fortunate in being blessed with the cooperative assistance of an able laboratory technician who daily operates thousands of geological experiments to scale and in proper environment. That experimenter, of course, is nature, and it is largely through observation of natural processes that the geomorphologist unravels the problems of his science. This is not a new approach, nor is it unique to geomorphology, but it finds one of its best developments in that field. Admittedly, some natural processes are too slow to be suited for observation within a man's lifetime, but our newspapers readily attest that this is not a universal handicap. The thorough reader will find mention of an earthquake, volcanic eruption, flood, landslide, or other current geologic activity somewhere in the world almost every day of the year. These recorded events are but a small fraction of the total, for only those of catastrophic nature are reported. Newspapers give ample proof that geology, and more specifically geomorphology, is not wholly a science "of the dead" or, as ungracious critics sometimes remark, "a dead science." Actually, geology is much like a fascinating detective game in which the geologist ferrets out clues of crimes committed oftentimes hundreds of millions of years before. Such ancient clues are naturally obscure, and it is largely by observing similar current crimes that progress is made.

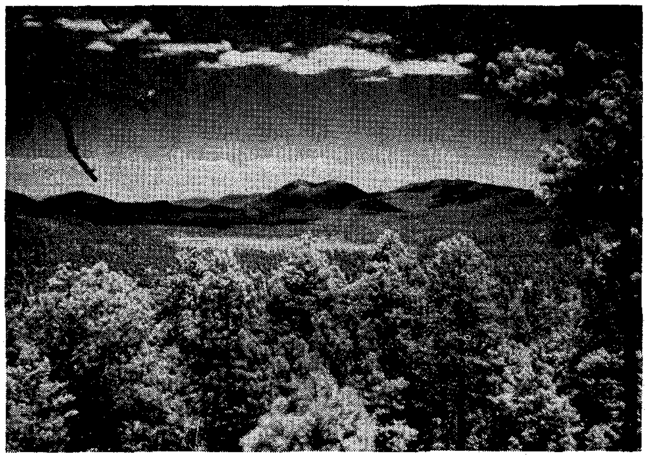


Fig. 2 Sunset Crater and volcanic cones of the San Franciscan volcanic field, Arizona. Features currently under construction at Paricutin can be observed here in a decadent but not too greatly altered state. Latest activity from Sunset Crater was an ash eruption about 1070 A.D.

This is the approach of the geomorphologist. By studying the activities of live glaciers in Alaska (Fig. 4) he is better able to interpret features in canyons of the Sierra Nevada, the Tetons, or the Rockies, which 25,000 years ago were filled with similar streams of ice. For example, high on one wall of a Sierra canyon may be a bedrock bench looking not unlike an abandoned

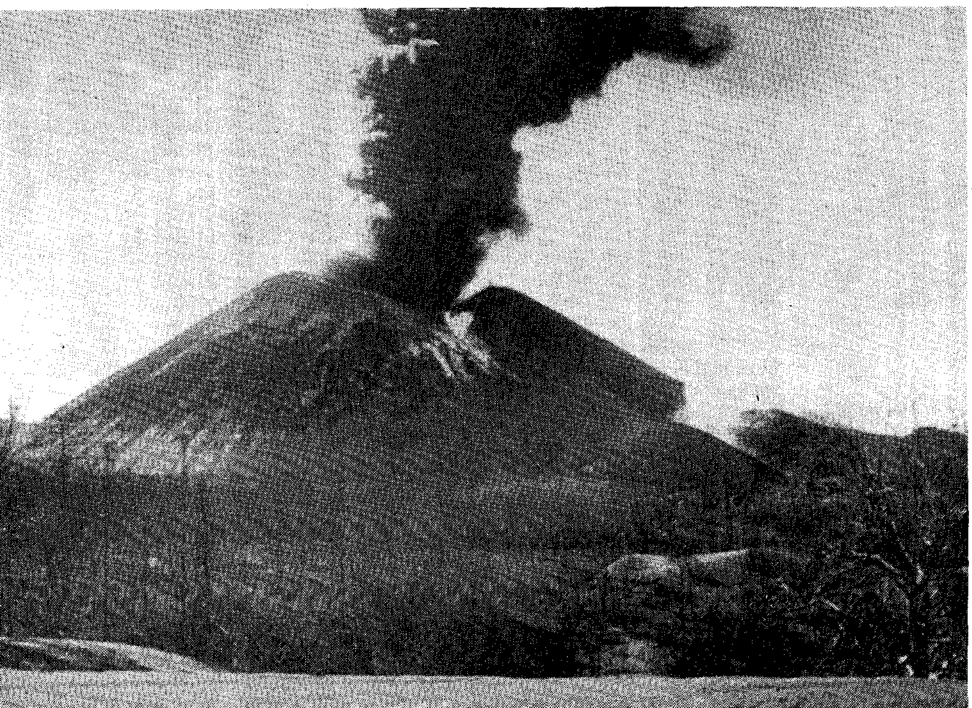
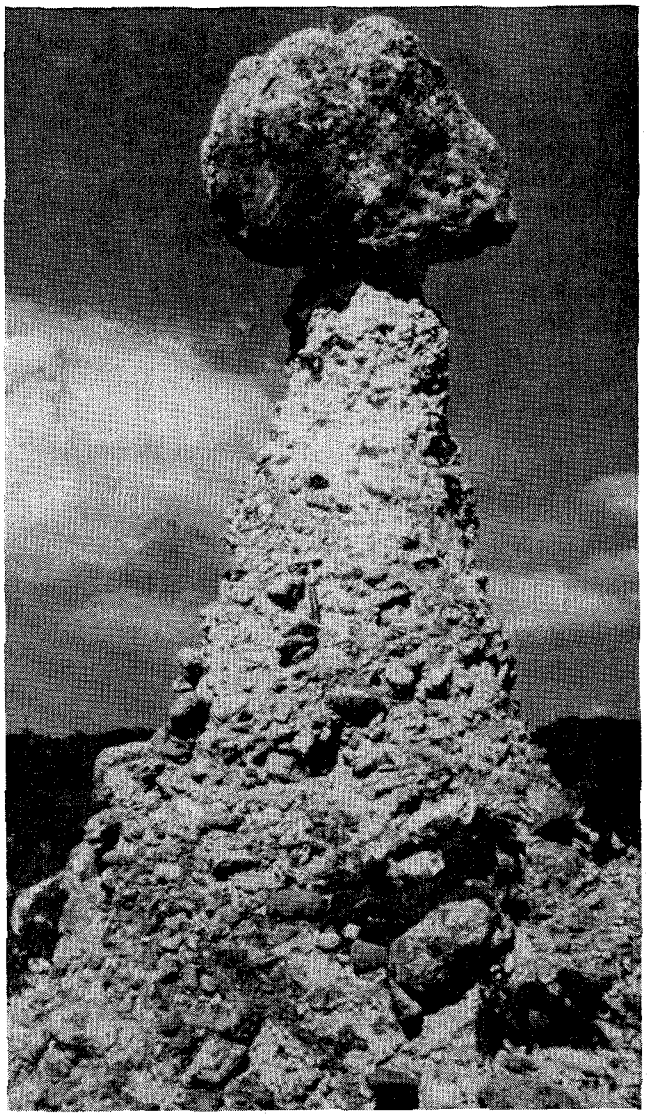


Fig. 1 Paricutin, the currently active volcano in west-central Mexico where nature is busily engaged in operating numerous experiments in volcanism, much to the delight of onlooking geologists. Photo by Donald B. Lawrence.

Fig. 3 Perched boulder on a pedestal about eight ft. high, *just east of the Big Horn Mountains, Wyoming. Similar* features formerly credited to cutting by wind-driven sand are now attributed largely to differential weathering, one of nature's relatively slow processes not too satisfactory for short-time observation.

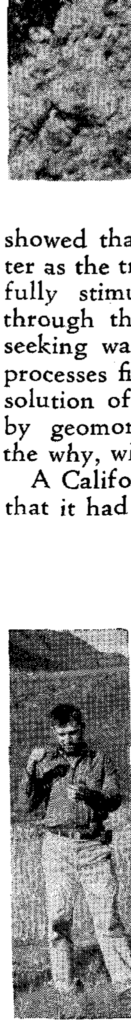


highway grade. The genesis of this bench is puzzling until one stands on the edge of a living glacier and sees a powerful stream of melt water rushing down-valley between the valley wall and the edge of the glacier. This stream rapidly carves a narrow channel with the floor and one wall of rock and the other wall of ice. When the glacier shrinks by melting, the ice wall is destroyed and the stream diverted to a lower course, so that its old channel is left as a bedrock bench high on the wall of the main valley. The imaginative scientist may reconstruct this sequence of events in his mind's eye, but it is eminently satisfying to confirm such reconstruction by observing the process in action. Likewise, construction of the imposing lateral moraines near the mouths of glaciated canyons along the east base of the Sierra or in other western mountain ranges is more easily understood when one has camped for a week or two along the margin of a glacier engaged in building such moraines. Signs reading "Slow, Glacier at Work" are not needed, at least in summer, for the constructional activities of the ice are well advertised by the constant sound of falling or sliding debris which piles up along the margin of the glacier to form a sloping apron. This apron becomes a ridge when the ice retreats, and one readily sees that lateral moraines are formed not by the pushing action of a glacier but by accumulation of debris dumped from the ice. Other examples of advantages derived from study of glaciers in action could be cited, but let us turn attention to a warmer subject.

In the province of Michoacan in western Mexico, the volcano Paricutin (Fig. 1) was born on February 20, 1943. In the short space of three months it built a cone 1100 feet high and flows of red-hot lava issued from its base. Geologists of all varieties hastened to this shrine of current geologic activity, and none derived more satisfaction from such a pilgrimage than the geomorphologist. Here he could see in the process of construction many landforms over which he had puzzled in volcanic fields near Flagstaff, Arizona (Fig. 2), the Craters of the Moon in Idaho, or the Lava Beds of northern California. The small "hornitos" or cones built of lava spatter and the curious forms and structures of lava flows are more easily comprehended when one sees them being made. Many persons doubted that the entire side of a large volcanic cone could be floated away on the back of a lava flow until the process was actually observed at Paricutin. The old adage that "*seeing is believing*" applies to many aspects of volcanic and other geologic activities.

Geomorphology is eminently a pure science. Most of its investigations are motivated by the desire to add to the general fund of human knowledge. A geomorphologist may expend much time and effort in determining why a mountain range has its present form, in proving that perched boulders (Fig. 3) were not "made by the Indians," and in explaining Half-Dome, Yosemite, or Rainbow Bridge, Utah (Cover), to the satisfaction of an itinerant tourist. However, like most pure sciences, geomorphology has many practical applications. For instance, the disasterous Montrose flood of 1934 brought realization to thousands of people that they were living on great alluvial fans built up in large part by floods of the Montrose type. This flood showed that interest in such a mundane scientific matter as the transporting power of running water is powerfully stimulated when a 10-foot boulder is rolled through the living room. The flood control engineer seeking ways to provide protection from fan-building processes finds basic information needed for intelligent solution of this problem in studies made years before by geomorphologists interested only in determining the why, wherefore, and characteristics of alluvial fans.

A California oil company discovered some years ago that it had unfortunately located a number of wells on



Robert P. Sharp describes himself as a "second-phase freshman at the California Institute, having reappeared here in September of 1947, after graduating in 1934." His years between 1934 and 1947 were spent at Harvard, the Universities of Illinois and Minnesota, and in the Army Air Forces. Army activities took him chiefly to Alaska and the Aleutians, included studies of survival procedures and tests of emergency equipment.

Prior to his return to the Institute, Dr. Sharp served as professor of geology at the University of Minnesota, working largely in the fields of geomorphology and glacial geology. In his present capacity of professor of geomorphology he is engaged in setting up research projects which will involve studies of existing glaciers in Alaska and investigations into the products of ancient glaciers in our western mountains.

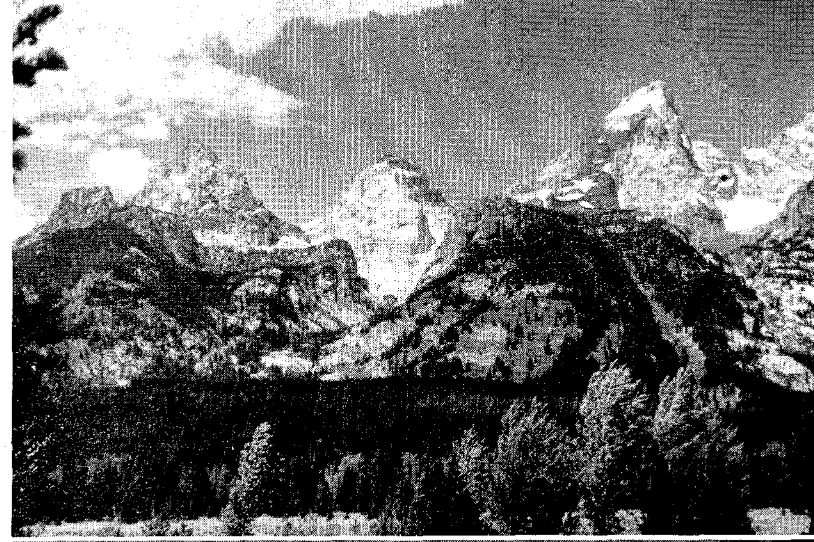


Fig. 5 UPPER: The Grand Tetons, Wyoming. This spectacular bit of American scenery was produced by an uplift on a fault, much in the same manner as the Sierra Nevada or San Gabriel Mountains. Subsequent dissection by streams and glaciers has given the range its present detail and character. Running water and, to a smaller extent, moving ice can still be observed at work in this area.

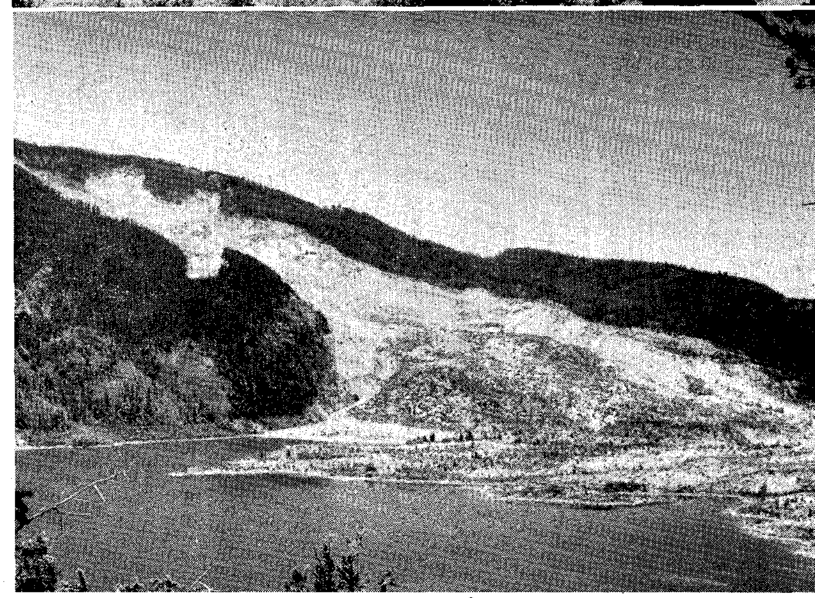


Fig. 6 LOWER: The Gros Ventre landslide just east of Jackson Hole, Wyoming. Although this slide occurred in 1925, it may be classed as a current geological experiment, for the conditions under which it occurred are known and the products are obvious. The lake formed by damming of Gros Ventre River was three miles long and 200 ft. deep. Part of the dam collapsed in 1927, and the ensuing flood largely demolished the town of Kelly and drowned six or seven people.

a landslide, old but by no means dead. Renewed sliding sheared off well casings, displaced roads, broke pipe lines, tilted derricks, and in general made the oil company unhappy. A student of landslides (Fig. 6) could have foreseen this costly occurrence, and the ultimate means of controlling the slide is to be found in a Ph.D. thesis published simply as a scientific paper dealing with landslides as a natural phenomenon having a hand in shaping many landforms on the earth's surface.

During World War II the U. S. Army was suddenly faced with problems attending operations in Greenland, 85 per cent of which is covered by ice. Glaciologists, a relatively small group of pure scientists operating chiefly within the field of geomorphology, were suddenly at a premium. They were eagerly sought by the armed forces and plied with questions. Can we put weather stations on the Greenland ice cap? What is the bearing strength of ice on rivers, lakes, the ocean? Can we land a large aircraft on a frozen lake near an isolated outpost in order to evacuate a man stricken with appendicitis? Answers to such questions were not always immediately available, but from his purely scientific work the glaciologist had the know-how to get the answers.

When a coastal California city builds a breakwater the natural shoreline processes are disrupted so that the famed bathing beaches of a neighboring city are attacked by waves and currents and partly or wholly destroyed. The neighboring city is unhappy if not distinctly bitter about the entire matter. Solution of this problem is primarily an engineering task, but the basic explanation of what has happened and the key to a proper remedy may be found in an 1890 classic of geomorphological literature dealing with high-level abandoned shorelines of a great lake that once covered much of northwestern Utah.

Thus, the geomorphologist pursues his science by assiduously watching nature perform her everyday geological chores. From these observations he is able to interpret the landforms constituting our present landscape and in so doing provides information fundamental to the solution of problems attending man's constant struggle with his physical environment.

Fig. 4 Muldrow Glacier, Alaska, flowing east from Mt. McKinley, the high skyline peak. Here nature is operating one of her most impressive geological experiments.

The results of similar experimentation performed some 25,000 years ago can be seen in the Sierra and other high western mountain ranges. Photo by Bradford Washburn.