PEDESTAL ROCKS IN STREAM CHANNELS.

By KIRK BRYAN.

INTRODUCTION.

Isolated masses of rock, especially those of unusual shapes, excite much interest and are commonly regarded with some little awe—a relic, perhaps, of those feelings and impulses which caused the erection of the great stones of the Druid monuments. The fanciful or mythical names that are almost spontaneously applied to such rocks testify to this popular interest, but the origin of these masses has received only scant notice by scientific men. This attitude is no doubt justifiable on the ground that there are more important matters for study. However, the type of isolated rock consisting of a larger mass above supported on a more slender pedestal has been used as a criterion in the study of larger problems. Such pedestal rocks have been cited as a measure of weathering since glaciation[1] and also as proof that an area was not covered by continental ice.[2] That pedestal rocks may be formed by the sand-blast action of winds seems probable, but that such rocks in arid regions are necessarily proof of wind scour has been denied in a previous publication,[3] in which a fairly complete list of papers on the affirmative of this question may be found.

The object of this paper is to call attention to some examples of pedestal rocks of well-developed form that stand in stream channels and are produced by a process which bears no causal relation to wind erosion, yet that, if found in some other environment, might easily be confused with pedestal rocks resulting from wind scour.

Two of the examples cited have not been seen by me. One is described from a photograph and notes by Willard D. Johnson, whose untimely death cut short the career of a keen observer much interested in the minutiae of erosive processes. The other was called to my attention by my friend and colleague, H. T. Stearns, who has allowed me to use his photograph and notes. William Donahue, of Spokane, furnished the photograph of the Devils Top.

[1] Hughes, T. M., On some perched blocks and associated phenomena: Geol. Soc. London Quart. Jour., vol. 43, pp. 522–539, 1886.

[2] Alden, W. C., The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, p. 41, pl. 16, *A*, 1918.

[3] Bryan, Kirk, Pedestal rocks in the arid Southwest: U. S. Geol. Survey Bull. 760, pp. 1–11, 1923 (Bull. 760–A).

DEVILS TOP AND SIMILAR ROCKS NEAR SPOKANE, WASH.

Spokane, Wash., lies at the eastern margin of the Columbia Plateau, which terminates here in black cliffs and crags of basalt that front on the broad valleys of Spokane and Little Spokane rivers. In these valleys stand outlying portions of the plateau bounded by similar cliffs. Spokane River within the city plunges over ledges of basalt in Spokane Falls and about 7 miles below the city enters the long canyon that forms the northeastern boundary of the Columbia Plateau. The basalt flows that form the top of the plateau, known as the "rim rock" flows, have an altitude of about 2,400 feet. The flows that crop out in the bed of Spokane River and in the immediately adjacent cliffs are a younger series that attain an altitude only slightly above 2,100 feet. They lie within ancient valleys eroded in the plateau. These valley flows, though younger than the flows of the plateau, are thought to belong to the same general period of volcanism, in Tertiary time.[4] The lavas of this series, at least in the immediate vicinity of Spokane, do not have the columnar jointing normal to basalts but are divided into great blocks by widely spaced joints. In consequence they yield on erosion large masses, many of which have peculiarly striking forms. Some of the most interesting of these masses are to be found in the canyon traversed by the lower course of Deep Creek, a stream that rises on the plateau and flows northeastward about 15 miles to Spokane River, which it enters 8 miles below Spokane. The stream plunges over the "rim rock" basalt and has cut a deep and narrow gorge in the younger basalt flows, which form a shelf along Spokane River. The lower part of the canyon is at one place only about 50 feet wide, and here is the Devils Top, one of a number of blocks that have fallen from the cliffs above. As shown in Plate XXXI, *A*, this block tapers from a rounded top to a narrow base. The rock would fall but for the fact that it rests against the side wall. It is nearly circular in plan and about 30 feet in greatest diameter. It is about 28 feet high and the tapering base is about 3 feet in diameter where it rests on the bedrock of the stream channel.

The rounded form of the upper part of the Devils Top is a characteristic weathering form of the basalt of this locality, and similar rounded domes cap the cliffs from which this block has undoubtedly fallen. The minutely and irregularly fractured surface is also characteristic and may be ascribed with some assurance to frost action. Only in shape does the rock differ from adjacent blocks.

[4] Pardee, J. T., and Bryan, Kirk, Geology of the Latah formation in relation to the lavas of the Columbia Plateau near Spokane, Wash.: U. S. Geol. Survey Prof. Paper 140–A (in press).

The undercut sides seem, however, to be due to the erosive work of the stream. Deep Creek has strong freshets each spring, and during these freshets the velocity of the water around the rock must be high, because of the reduction in the width of the channel. The driftwood on the top of the rock, plainly visible in Plate XXXI, *A*, shows that the rock is at times overtopped by the stream, but the action of the stream is more prolonged and effective on the lower part of the rock. Here the force of the moving water, with its contained débris, removes the small blocks already loosened by frost, and perhaps the freezing of the water in winter facilitates such loosening. That direct scour does not seem to take much of a part in this process is shown by the lack of polished surfaces.

Undercutting by streams is hardly a common phenomenon in this region, and there are cliffs and individual rocks along Spokane River and elsewhere in the region that are not notched. On the left bank of Columbia River below China Bar, however, there are a group of rocks of which some are loose blocks and others are portions of a lava flow isolated by weathering along widely spaced joints. The lava is part of the great series underlying the Columbia Plateau but resembles in its lack of columnar joints and method of weathering the flows on Deep Creek, which are doubtless somewhat younger. Some of these blocks have vertical walls, and others are notched near low-water level. The rock shown in Plate XXXI, *B*, approaches the form of a pedestal rock. The minutely and irregularly fractured surfaces of the block indicates weathering by mechanical forces, but examination of the interior of these fractured pieces shows that there has also been some chemical action. Apparently the effect of the river water is to speed up mechanical erosion and remove partly weathered fragments. Doubtless the undercutting would be more marked if the river held a nearly constant level, so that its action affected only a small zone. But Columbia River is subject to a prolonged annual rise of 30 to 40 feet. The maximum estimated discharge of the river at Wenatchee and Vernita, the nearest stations downstream, was 710,000 second-feet, on June 7, 1894, and the minimum discharge 23,900 second-feet, on January 31, 1917.[5] During such floods the water doubtless has the same effect on all parts of the rock. In the rise and fall also the surface of the water occupies every position on the rock. Not only do these conditions tend to diminish the relative intensity of the notching action, but it is obvious that on a river subject to such floods pedestal rocks with slender pedestals would be snapped off, and there is thus a limit to the development of such forms.

[5] Parker, G. L., and Lee, Lasley, Summary of hydrometric data in Washington, 1878–1919: U. S. Geol. Survey Water-Supply Paper 492, p. 118, 1923.

ROCK IN OWENS RIVER, CALIF.

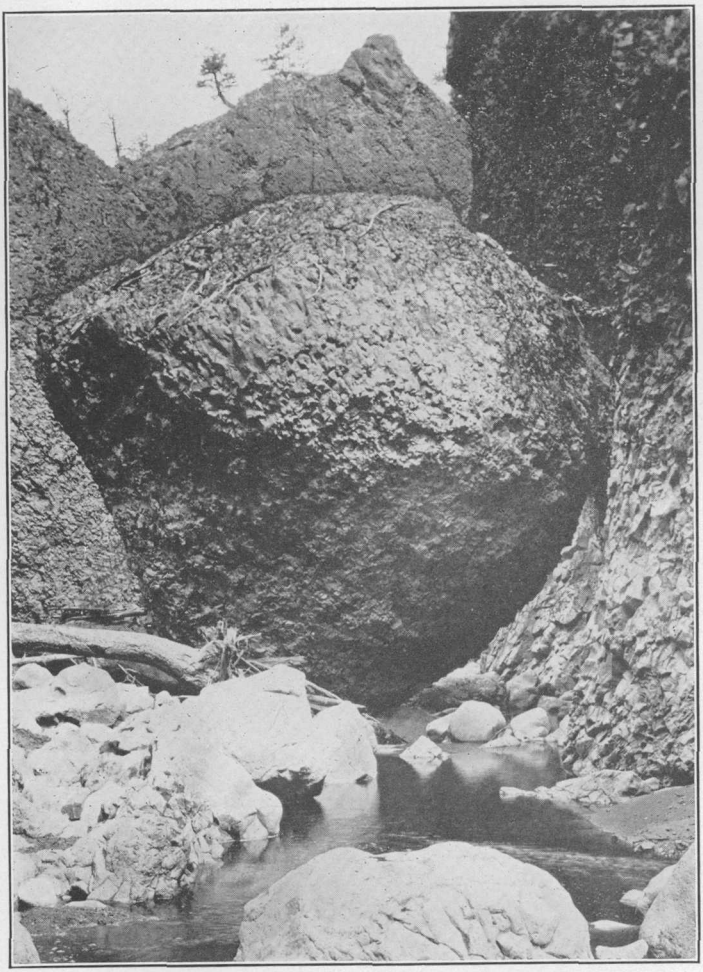
The photograph reproduced in Plate XXXII, *A*, was taken by Willard D. Johnson in the canyon of Owens River, Inyo County, Calif. According to his notes the locality is "just above the junction of Burcham Canyon and 'The Bridge'"; the rock is rhyolite of the "exfoliating type" found thereabouts and contrasting with a neighboring type which yields to weathering largely by solution. Johnson records also that the boulder is said to have developed the neck or pedestal in the 20 years that it had been under observation by ranchmen in the neighborhood.

At this point Owens River runs in a deep canyon and, as indicated in Plate XXXII, *A*, is swift and turbulent. However, as shown by the records of the United States Geological Survey gaging station near Round Valley, just above the junction of Rock Creek, at the lower end of the canyon, the flow of the stream is relatively steady. The yearly mean discharge has ranged from 181 to 380 second-feet. The maximum recorded discharge of 1,190 second-feet occurred in June, 1907, and the minimum of 100 second-feet in February, 1919. Evidently the ordinary flow, fluctuating over a narrow range, has eroded the neck of the rock, and the flood flows are not severe enough to break it off.

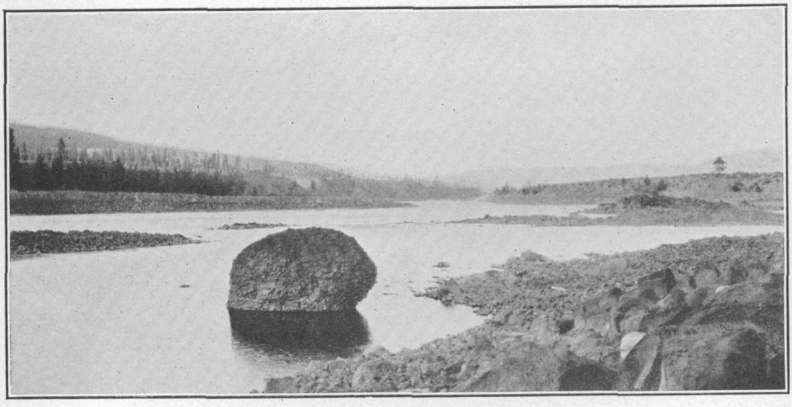
The region has an arid climate and might even be called a desert. The river in the canyon descends from an altitude of 6,700 feet to 4,400 feet, and the climatic conditions are similar to those at the nearest towns, Bishop and Laws, which have an altitude of about 4,100 feet. The 16-year rainfall record at Bishop, as compiled by Lee,[6] shows an annual mean of 5.61 inches, and the 14-year record at Laws, 4.40 inches. Even if allowance is made for an increased rainfall in the locality of the pedestal rock on account of its greater altitude, it may still be considered in an arid region.

Though the statement of the local ranchers recorded by Johnson that the shape of the rock was developed in 20 years can hardly be true, it is evident from the photograph that stream abrasion operating against the surface of a rock already divided into small flakes by exfoliation has produced the notch that forms the neck. The neck is excentric, and the greater overhang on the upstream side may be due to greater wear on that side. The rock appears also to have been slightly polished by the water and its contained suspended matter.

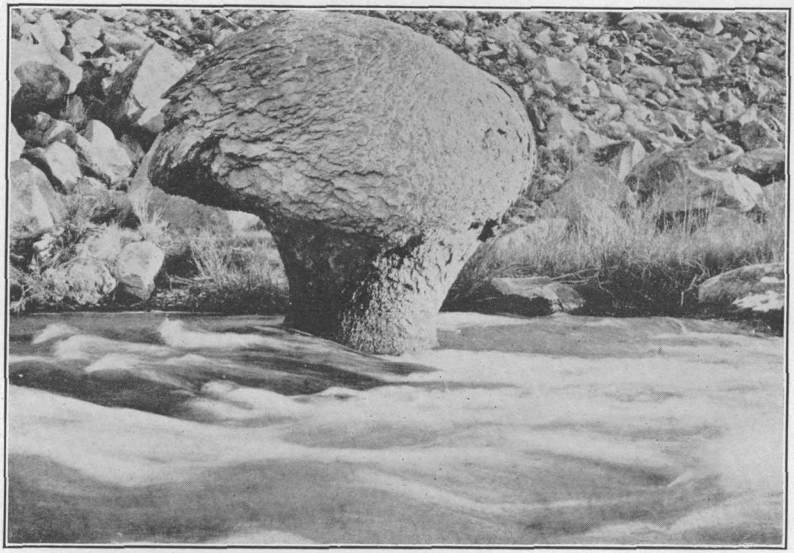
[6] Lee, C. H., An intensive study of the water resources of a part of Owens Valley, Calif.: U. S. Geol. Survey Water-Supply Paper 294, p. 91, 1912.



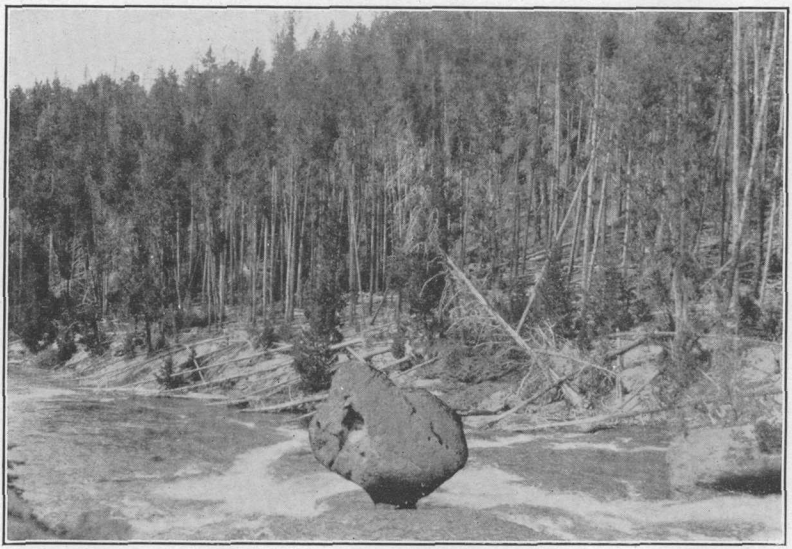
A. DEVILS TOP, DEEP CREEK CANYON, 8 MILES NORTHWEST OF SPOKANE, WASH.



B. INCIPIENT PEDESTAL ROCK, COLUMBIA RIVER BELOW CHINA BAR, 9 MILES DOWNSTREAM FROM JUNCTION OF SPOKANE RIVER, WASH.



A. PEDESTAL ROCK IN OWENS RIVER, INYO COUNTY, CALIF.



B. PEDESTAL ROCK IN GIBBON RIVER AT CHOCOLATE CASCADE, YELLOWSTONE PARK, WYO.

ROCK IN YELLOWSTONE NATIONAL PARK.

The pedestal rock illustrated in Plate XXXII, *B*, is one of the features of Chocolate Cascade, a small rapid in Gibbon River 3 miles southwest of the well-known Norris Basin, in Yellowstone National Park. According to H. T. Stearns, who visited the locality in 1923, the rock is composed of rhyolite. As is evident from the photograph, it is a remnant of a ledge, and the notched rock, or incipient pedestal rock, on the right, once belonged to the same ledge. Doubtless at one time there was at this place a considerable fall. The stream has eroded the ledge in such a way as to leave remnants which, though obstructing the flow, were strong enough to resist being carried entirely away.

Gibbon River at the United States Geological Survey gaging station 4 miles above its mouth has a drainage basin of only 117 square miles and a minimum recorded discharge of 62 second-feet. No gagings have been made at high water, but the maximum discharge is probably not much over four times this amount. The incomplete record indicates that the stream has a relatively steady flow, such as might be expected of a stream rising in well-wooded mountains and having a number of meadows and swamps along its course.

On account of prevailing low temperatures the climate of the area is relatively humid, although the mean annual precipitation shown by a 32-year record at the Weather Bureau station at Yellowstone is only 18.70 inches. Much of this precipitation falls as snow, and the result is that the vegetation and most of the erosional features of the area are those of a humid country.

CONCLUSIONS.

The rocks described in the foregoing paragraphs are, so far as form alone is concerned, typical "mushroom" or pedestal rocks. They are composed of material of almost equal hardness from base to top and have attained their form as the result of differential scour rather than differential weathering. Thus they differ in composition and origin from the pedestal rocks described in a previous publication.[7]

Save for the fact that these rocks occur in stream beds, they might be mistaken for rocks formed by wind scour. It is also entirely possible that rocks in arid regions formed by stream scour may have been mistaken for rocks formed by wind scour. Such confusion is the more likely in that the areas in which the examples cited in this paper occur have no great similarity in climate. Eastern Washington, in which the Devils Top and the rock in Columbia River were formed, has a subhumid or semiarid climate, typified by that of

[7] Bryan, Kirk, op. cit.

Spokane, which has a mean annual precipitation of 18.85 inches and a cold winter. The Owens River canyon lies in a warm arid region with an annual rainfall of only a little more than 5 inches. Yellowstone Park, on the other hand, has a cold humid climate. The character of the stream flow and the original form, position, and physical characteristics of the rocks are probably more influential than climate in producing these remarkable forms.

NOTE.—The rock in Gibbon River, Yellowstone Park, has also been described by E. A. Martel, who visited the locality with the International Congress of Geographers in 1912. His note, illustrated with three excellent photographs, was published in the Comptes Rendus des Séances de l'Académie des Sciences de Paris, vol. 159, pp. 87–89, 1914. Martel has also described a large number of pedestal rocks in other localities, which he attributes to the action of both surface and underground streams.

INDEX