schools or other difficulties from taking part in expeditions; also the possibilities of expeditions leaving England except in long vacation have so far been considered negligible. With this in view a group of members began in March to organize a hut scheme, in collaboration with the Oxford University Mountaineering Club; their object is to secure huts and bothies in various out-of-the-way places in the mountain groups and Great Britain and Ireland, which will serve as bases for walking and climbing. The first of these huts, under Craig-yr-ysfa, in Cwm Eigiau, has now been put into working order. With the annual report is given an account of the British Guiana expedition in 1929. The aim, it is stated, was not primarily to explore unknown territory, but to penetrate into the canopy of the tropical rain-forest, which offered the prospect of discovering a zone of life practically untouched by science. Publication of results has already begun, but will not be complete for some years, owing to the large number of species involved and the little that is known about them. It seems certain that more new species have been secured than by any previous Oxford expedition. The contributions to the general ecology of the rain-forest, to knowledge of territory and related problems in bird-life, to insect mimicry, to life-histories of wasps and bees, and to the elucidation of the still obscure dominant species of trees are likely to be especially notable.

DISCUSSION

METEOR CRATER IS NOT A LIMESTONE SINK

IN SCIENCE, January 9, 1931, Mr. F. S. Dellenbaugh suggests that the great pit of Meteor Butte, in Arizona, is a sink formed by ground water solution in the Kaibab limestone. If this suggestion were addressed to geologists only, there would be no need for a reply. The geologic facts speak for themselves; they are not merely unfavorable to Mr. Dellenbaugh's idea—they disprove it conclusively. Inasmuch as his article reached an audience made up in large part of non-geologists, a brief statement of the geologic evidence is in order.

Mr. Dellenbaugh is correct in saying that the Kaibab limestone contains many sinks, which receive much of the surface drainage on the Kaibab Plateau. These sinks, however, and especially those of large size, are located on wide flats or on the floors of large shallow basins, where they receive considerable run-off. Solution of limestone is a slow process, and its accomplishment on a large scale requires a large quantity of water. It would be a wonder indeed to find in a semiarid country a sink, almost circular in plan and nearly a mile in diameter, occupying the entire top of a hill, where the only water available for solution consists of the scanty rain that falls directly on the area of the pit. For Meteor Butte is a hill, as its name implies. On all sides the ground slopes away from the very edge of the circular rim, and hence no outside drainage can enter the central depression. From this general consideration alone a geologist would be very skeptical of the sink hypothesis for this feature. The following points are sufficient to remove the hypothesis from further consideration.

(1) A limestone sink does not reach deeper than the base of the soluble formation in which it is formed. This is a fact of observation, and is also an elementary deduction, since the material that once occupied the position of the sink had to be removed by solution. At Meteor Butte, however, the Kaibab limestone forms less than half the height of the walls. Beneath it is the Coconino sandstone, one of the most insoluble rock formations known, since it consists entirely of quartz grains cemented by silica. Any suggestion that this sandstone may have caved in owing to solution directly beneath it is ruled out, because the Coconino sandstone rests on red shales and sandstones many hundreds of feet in thickness.

(2) At the top of the great pit the slopes on all sides are littered with fragments of the Coconino sandstone. These fragments range in size from minute bits of broken sand grains to blocks of large size; and they are intimately mixed with similar débris derived from the Kaibab limestone. How were these pieces brought up from their normal position hundreds of feet below? Obviously by a great force that acted upward and was explosive in character, since it not only hurled the angular blocks in all directions but even smashed the individual sand grains to tiny bits. Examination of this pulverized quartz leads to the conviction that much more of the rock blown out to create the crater was blasted into dust, which mounted in a great cloud and drifted away to settle as a thin veneer on the wide surface of the plateau.

(3) Although the rock strata are practically horizontal beneath a wide surrounding area, in the walls of the crater these strata are tilted and otherwise disturbed. On the south side, where the wall is steepest, the beds dip directly into the wall, at a high angle. There is no haphazard arrangement, such as would be expected if the disturbance were due to slumping into a solution pit. The tilt is consistent in direction, and indicates that a powerful lifting force acted inside the pit, with concentrated action on the south side.

(4) In places the quartz sand in the Coconino sandstone forming the lower part of the walls has been fused to glass (lechatelierite). This is astonishing in view of the extremely high melting point of quartz (nearly 1500° Centigrade). Evidently the crater has been subjected to intense heat, such as could be generated only in some exceptional way. (See A. F. Rogers, "A Unique Occurrence of Lechatelierite or Silica Glass," *Am. Jour. Sci.*, vol. 19, 1930, pp. 195–202).

In brief, all the evidence indicates that a violent explosion played a prominent part in the formation of the crater. The weight of this evidence was appreciated by the earliest investigators, and naturally the idea of a gaseous volcanic eruption was given serious consideration. The abundance of meteoritic iron on and around the butte, however, has given strong support to the theory that the great pit was caused by impact of a close swarm of meteorites, and by an explosion after the swarm penetrated to considerable depth. Owing to the strength of this theory the butte acquired its present name.

Mr. Dellenbaugh sees support for his own hypothesis in the fact that both the inside and outside slopes of the crater show the effects of erosion. Whatever its origin, the crater has been outdoors since its formation, and modification of its slopes by erosion has been inevitable. This fate it shares with every other landscape feature.

Finally, Mr. Dellenbaugh "sees nothing . . . that substantiates in the slightest degree the meteor theory." If he has in mind the particular hypothesis that called forth his discussion—Professor Fairchild's suggestion of a stony meteorite—I quite agree with his view. Although Fairchild's idea has interest to a geologist, it appears to be wholly speculative, and creates difficulties more serious than those it purports to remove. There is strong observational evidence, however, in favor of the theory involving metallic meteorites. Some of this evidence is discussed by Mr. D. M. Barringer in SCIENCE for January 16, 1931. An excellent non-technical review of the facts about Meteor Butte, accompanied by fine illustrations, has been published by William D. Boutwell ("The Mysterious Tomb of a Giant Meteorite"; *National Geographic Magazine,* Vol. 53, 1928, pp. 720–730).

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BRANCHINECTA AT LEADVILLE, COLORADO

DURING the summers of 1929 and 1930, while engaged under the auspices of the United States Geological Survey in areal mapping and mine studies in Colorado, the writer found the phyllopod crustacean *Branchinecta coloradensis* (Packard) at 11,450 feet (3,500 meters) near Leadville, Colorado. The species has generally been regarded as alpine, and collections have been made nearby at Twin Lakes and Weston Pass in similarly elevated regions.[1] The occurrence is not surprising, but it raises again two perplexing questions.

In the upper part of Evans Amphitheater, due east about five miles from Leadville, are two larger lakes now serving as water reservoirs. Here is a well-developed recessional "kettle" moraine of late (?) Wisconsin glaciation. On the south side of the gulch near the reservoirs the moraine contains two small ponds, neither over 10 feet deep and both less than 100 feet wide. Both ponds, but the upper especially, are well separated from nearby water bodies. Indeed, it would require a valley flooding of at least a quarter of a square mile to a depth of 50 feet to connect the more isolated pool with a stream or with the reservoirs mentioned. Both pools are permanent, lasting throughout the short summer, but both are probably completely frozen during the winters at their elevation of 11,450 feet.

In these two pools the writer has found *B. coloradensis* during the past two summers. On July 18, 1929, *Branchinecta,* the females with brood pouches and eggs, were collected from the more easterly and isolated pond; by September 1, no live specimens were found, though a few remains of carapaces could be seen in the sediment. Again early in July, 1930, many *Branchinecta* were seen, the females again with eggs, this time in both pools; yet only a very few were in evidence by September 1. These observations are in general agreement with those of Shantz[2] near Pike's Peak, of Packard at Gray's Peak,[3] and of the latter especially in the case of related forms farther east,[4] where the disappearance is even earlier and is clearly not the result of lowered temperature. Shantz has suggested that the death of *Branchinecta* is related to parasitic plant forms, but the explanation does certainly not account for the Leadville records. It would seem that activity ceases in these Alpine species about September 1, and it would be interesting to develop an adequate explanation.

The other question is the unusual matter of "seeding" isolated ponds with *B. coloradensis,* or, for that matter, with other members of the family. The remarkable continuity of these phyllopods in a given pool, despite seasonal vicissitudes, is readily ex-

[1] A. S. Packard, U. S. Geol. Survey Ann. Rept. (Hayden), XII, Part I, 339, 1883; H. L. Shantz, *Biol. Bull.*, IX, 249, 1905; G. S. Dodds, U. of Colo. Studies, XI, 272, 1914–15; G. S. Dodds, U. S. Nat. Mus. Proc., LIV, 66–77, 1919.

[2] *Op. cit.*, pp. 256–258.

[3] *Op. cit.*, p. 339.

[4] *Op. cit.*, p. 342.