near the bottom of the bank were fine large poplar trees, with a few spruce, while Service or Saskatoon berries and cherries were growing in great abundance. The banks of the valley were rocky, delighting the heart of the geologist who was sated with the undulating grassy plains, but it was too late to examine them that night.

The next day, however, I walked up the bank close to camp, and at an elevation of between forty and eighty feet above the creek found a number of Dinosaurian bones in an excellent state of preservation, though very brittle. Most of them were heavy and massive, such as those of the limbs, etc., but among these was a large and fairly perfect head of Laelaps (Dryptosaurus) incrassatus, a gigantic carnivore. We spent the afternoon excavating these bones from the rock, but unfortunately we had no appliances but axes and small geological hammers. We worked with all the care that the tools and the time at our disposal would allow, but in spite of all we could do some of the bones, teeth, etc., were broken. Then after we had managed to get them out of the rock, we had no proper means of packing them, and no boxes but the wagon box to put them in. However, we got together the skull and some of the best of the leg and other bones and then found that we had a heavier load than we were able to carry with us. We were therefore obliged to leave a small pile of bones at the bottom of the bank just north of the creek, on the chance that we might be able to pick them up at a later date, which fortunately we were able to do two months afterwards when returning from another expedition. After completing this work, and packing up our precious collection as well as we could, we started in a cold drizzling rain on our way to Calgary. First we were obliged to climb up to the top of the bank of the valley and it was so steep that with three horses we were not able to haul up much more than the empty wagon, while the fossil bones that we were able to take with us were packed up to the top of the bank on the backs of the horses.

Our journey to Calgary took us a week, for we were obliged to drive slowly and carefully, both on account of having the poor spruce axle in the wagon and because we were anxious not to jar the brittle Dinosaurian bones any more than necessary, though the riding could not be made very easy, since our course for the most of the way was over the rough unbroken prairie, and not on a road or trail. Our regular geological survey of the country passed through was also carried on as usual, for an exploring geologist rarely ever has the opportunity of seeing a particular place or tract of country twice. This survey included an examination of the banks of the valley of Knee Hills Creek from our Dinosaur camp upwards, for they furnish an excellent series of sections of the Edmonton and lower Pascapoo rocks. While making this examination of the valley, and when at a point about five miles above Dinosaur camp, we found one end of a large limb bone, the piece preserved being twenty-six inches long, four and a quarter inches across the middle of the shaft, and eight and one half inches across the end or head.

At Calgary the bones were packed in boxes and shipped to the director of the Geological Survey in Ottawa, whence they were sent to Professor Cope in Philadelphia for examination and description. The skull, along with another similar one obtained by Mr. T. C. Weston in 1889, who was sent out on my suggestion and solicitation by the director of the Geological Survey of Canada, for the especial purpose of collecting Dinosaurian bones in the same vicinity, was described by Professor Cope, and afterwards with illustrations by Mr. L. M. Lambe, but the other bones were probably not sufficiently perfect for identification, and as far as I know have never been described.

After the collection was shipped, I started back with the little party of men and horses to continue the exploration of the district allotted to me.

J. B. TYRRELL

EXPLOSIVE ERUPTIONS OF KILAUEA

OWING to the spectacular character of the fire fountains of Kilauea, but little attention seems to have been given to the evidences of explosive eruptions of the genuine Vesuvian type, and this volcano has become known for quiet, well-ordered activity. Some recent field studies of the writer indicate that there are evidences of four explosive eruptions, probably separated by considerable time intervals,

two of the centers of activity being in the northern and two in the southern sections of the great crater. The fire pit of Halemaumau seems to serve as a safety valve for the escape of the gases held in solution by the molten lava, but when this pit freezes over and these gases accumulate, sufficient pressure beneath the crust is violently shattered and the more or less comminuted fragments and effervescing lava are hurled into the atmosphere. The coarser blocks and bombs settle first and for the most part nearer the vent, while the finer fragments making up the gravel, lapilli, sand and dust are deposited in succession, giving rise to a more or less well-defined stratification as viewed in vertical section. If the wind is active at the time of the eruption, the lighter and finer materials will be drifted to considerable distances and each stratum will show the heavier and coarser material toward the vent, passing radially into the lighter and finer deposits, thinning more or less gradually and finally becoming indistinguishable from the subjacent deposits.

In addition to the four above mentioned explosive eruptions there is evidence of a fifth of very minor character supplied by witnesses who furnished the earliest written descriptions of this volcano (Ellis, Loomis, Stewart, 1823-1825). The activity seems to have culminated in 1825 about the time of the visit of Lord Byron, when "red-hot stones, cinders and ashes were also propelled to a great height with immense violence." The records since this date indicate no such explosive activity, but a welling up of the molten lava, accompanied often by much vigorous fountaining and ending in an overflow over the floor of the great crater (1844, 1849, 1868, 1918 and 1921), an escape into adjacent minor craters (1832, 1922), an outbreak through fissures in the sides of the Kilauean mass (1840, 1868) above sea level or as a submarine flow as apparently occurred in 1849 and 1884. Only once in the entire history of the volcano has it been known to overflow the rim of its crater and this to only a trifling extent as recently as March, 1921.

The first of the series of explosive eruptions of which we have any present evidence took place so long ago that nearly 500 feet of successive lava flows overlie the stratum of fragmental matter ejected at the time. Judging from the present slow rate of pericentric outpourings and the small average thickness of these overlying layers, this would call for a great period of time as measured in years. But conditions may be readily imagined under which this time would be greatly reduced. This eruption began apparently with the ejection of dust and sand and was followed by lapilli, some bombs and large and small blocks. No trace was found of the dumb-bell or Indian-club droplets or of that peculiarly light form of pumice known locally as "limu," or the "thread lace scoria" of Dana. This stratum is to be seen only in the northwest quadrant of the crater wall, and in the last few years much of it has been covered by recent outpourings from Halemaumau. Between this first of which we have record and the above mentioned fifth, which left nothing of a recognizable nature, we find evidence of three other violent eruptions.

The number four of the series was the locally well-known eruption of 1789-90 which annihilated a division of Keoua's army bivouacing in the vicinity. Native eye witnesses reported that the eruption was preceded by violent earthquake shocks, terrific thunder and lightning, when a dense cloud of darkness rose from the crater and enveloped the entire region. Showers of sand and cinders soon began to fall and these were followed by coarser fragments, some of which were glowing and occasionally bursting with loud report. The deposit from this eruption was concentrated mainly about the southeastern quadrant of the crater and appears to have not come from Halemaumau, but from somewhat nearer the center of the main crater. The maximum thickness observed was about 12 feet, and the deposit contains little dust and sand, consisting in the main of unconsolidated material which would ordinarily pass as gravel. The direction of the wind seems to have been mainly from the northwest, finally shifting around to the northeast, and carrying south-westward quantities of limu. Bombs ranging from the size of unhulled walnuts to the size of a head are found rather abundantly, and the eruption ended apparently with a terrific shower of lava blocks which fell upon a crusted sur-

face which to this day retains the impact basins resulting from their fall.

Lying unconformably beneath this relatively recent material and separated from it by erosion surfaces and in some cases thin lava flows, we find the deposits of two apparently separate eruptions which we designate as second and third in the series. They were both characterized by the ejection of quantities of volcanic ash, concentrated about the northeast and southeast quadrants of the crater respectively and extending some three or four miles beyond the rim so far as appreciable deposits are concerned. The older of the two started with a small amount of fine ash and then with quantities of the thread-lace scoria of the most perfect type and a peculiar type of dumb-bell and Indian-club droplets; so far as known formed only at this time, probably because of some peculiar consistency of the magma. This deposit is that seen about the Volcano House and the roadway leading east and west. In the crater itself the deposit attains a thickness of twenty-five to thirty feet. Wherever observed the basal layer was found to carry more or less of the perfect type of thread-lace scoria, quite readily distinguished under the magnifier from that ejected in 1789, as well as the recent samples collected by Jaggar from Mauna Loa. This eruption closed as did that of 1789 with the discharge of many volcanic blocks, large and small, directed mainly to the northwest for a distance of two to three miles from the rim. Superficial field observations indicate that these blocks have been longer exposed to the weather than have those of 1789, and that they bear a relationship to the dike material found in the adjacent crater wall.

The deposits of the third eruption of the series are for the most part fine and very perfectly stratified. Bombs and blocks are rarely seen and no limu or droplets characterize the sections. The eruption began apparently with the ejection of a black sand, which fell upon a weathered and rusted surface of pahoehoe. This was followed by clouds of fine dust, attaining a maximum thickness about the southeastern quadrant of the crater of some forty-five feet. Along the extended minor, or east-west axis of the crater, these deposits overlap those of the second eruption, if we are justified in attaching correlation value to the true thread-lace scoria. However, in the crater they are much more firmly indurated than the latter, through the action of steam and other gases and hence have the appearance of greater age.

During certain stages of this eruption, as well as that of the second and fourth in our series, rain drops falling through the hot, dust-laden atmosphere became completely charged with the fine dust, arranged in concentric shells and slightly cemented and dropped into the soft ash layer beneath without undergoing appreciable distortion. Some of these are still firm enough to be rolled along and segregated like pebbles by temporary rills. Similar bodies fell abundantly in the vicinity of Naples on the morning of April 8, 1906, Vesuvius being then in eruption (Bassani and Galdieri). Specimens from Kilauea were photographed by Perret in 1914 and referred to by Friedlander under the term "pisolites." Is there any serious objection to calling them fossil rain drops? During the closing stages of the second eruption these pellets grew to the size of one's thumb, as in the case of ordinary hail stones, as suggested by Lane, and were slightly flattened by their fall or possibly manner of formation. To the west and northwest of the main crater, beyond the limits of the coarser debris, these remarkably preserved structures may be collected by the bushel.

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SCIENTIFIC EVENTS

THE PI MU EPSILON MATHEMATICAL FRATERNITY

IN these days of the extreme emphasis on and acclaim accorded to athletic prowess, it was but natural that scholars in their different fields should establish honors and emoluments for the recognition of mature and successful scholars and for the encouragement of younger aspiring scholars that should challenge, encourage and reward their intellectual prowess. Among such means of honor and encouragement are honorary national fraternities in special fields of scholastic endeavor. The basis of membership in these fraternities is scholarship.