of the country, and the placing its control in the hands of those who have made astronomy their life-work. The navy will be provided, if the recommendations are carried out, with an observatory well suited to its special needs, and would be relieved from the task of supervising work in which it has no interest aside from that felt in scientific work in general.

CRATER LAKE, OREGON, A PROPOSED NATIONAL RESERVATION.

IN the heart of the Cascade Range there is a little sheet of water which is destined to take high rank among the wonders of the world. It is a unique phenomenon, taken as a whole, though some of its component features, taken singly, may not be unexampled. The lake is about seven and one-half miles long and five miles wide. Its shape is very nearly elliptical, without bays or promontories. It is girt about by a complete circuit of cliffs, nowhere affording an outlet. These cliffs rise to altitudes varying from 900 to 2,200 feet above the water, and, though generally too steep to be either ascended or descended, have in some places an inclination low enough to render such a feat possible, though difficult. They plunge at once into deep water, and never afford a wide margin for standing or walking room at the water's edge. In a few places, however, the rains have scoured gulleys in the wall; and, where these debouch upon the lake surface, may be found narrow spaces for lodgement. No considerable stream or brook has been discovered flowing into the lake as yet; but a few springs yield little rills of water in the faces of the walls. Others and larger ones may come to light when the lake is more minutely explored. Neither is there any visible outlet. It is certain, however, that there must be a mode of escape for the water; and, as it is not above ground, it must needs be below ground, for the evaporation here is less than the precipitation.

Near the south-western margin, about half a mile from the shore, there rises out of the water a cinder-cone. Its height is between 600 and 700 feet. It is quite perfect and typical in form, having the usual cup or hopper in its summit, and as yet it is not perceptibly eroded. It is well covered with timber, and, notwithstanding its perfect preservation, it cannot be regarded as being, in the historic sense, a recent creation. From its base two streams of lava stretch out towards the great wall, but do not reach it. The insulation of the cone and its lavas is still complete.

The beauty and majesty of the scene are indescribable. As the visitor reaches the brink of the cliff, he suddenly sees below him an expanse of ultramarine blue of a richness and intensity which he has probably never seen before, and will not be likely to see again. Lake Tahoe may rival this color, but cannot surpass it. It is deeper and richer than the blue of the sky above on the clearest day. Just at the margin of the lake it shades into a turquoise, which is, if possible, more beautiful still. Ordinarily the water surface is mirror-like, and reflects an inverted image of the surrounding cliffs in detail. Very majestic, too, are the great environing walls. On the west side they reach their greatest altitude, rising almost vertically more than 2,000 feet above the water. It is difficult to compare this scene with any other in the world, for there is none that sufficiently resembles it; but, in a general way, it may be said that it is of the same order of impressiveness and beauty as the Yosemite valley. It was touching to see the worthy but untutored people, who had ridden a hundred miles in freight-wagons to behold it, vainly striving to keep back tears as they poured forth their exclamations of wonder and joy akin to pain. Nor was it less so to see so cultivated and learned a man as my companion hardly able to command himself to speak with his customary calmness.

To the geologist this remarkable feature is not less impressive than it is to the lover of the beautiful; for, almost at the first glance, it reveals something which would probably escape the eye of the mere tourist. This broad depression was once filled and occupied by a large volcanic cone, rising far above the loftiest point of its encircling walls.

The proof is simple and conclusive. Whoever has studied a large volcanic cone, composed of lavas piled sheet upon sheet around a central orifice, and which has been subject to long-continued erosion, will be able to recall some general facts as to the ravines and water-courses which have been scoured in its flanks. As we approach such a mountain, we observe the ravines opening upon the plain, or gentle slope, around its base, with huge buttresses between them, sometimes rounded and broad, sometimes narrow and knife-edged, according as the spaces between ravines are great or small. As we ascend the bed of any one of them, we observe that it grows deeper and deeper, while the intervening buttresses rise higher and higher, until a maximum depth is reached. Farther up, the declivity of the bed becomes greater, lateral streams come in, the ravine branches repeatedly, and up near the summit it resolves itself into a plexus of small rills, all embraced in an amphitheatre,

above which the culminating peak rises sharply. Each portion of the length of the ravine has its characteristic features or habitus; and, however irregular these minuter details may be, they seldom mask or obscure the characteristics of the larger ones.

Imagine, then, a great volcanic cone, on which erosion has made considerable though not extreme progress, to be truncated at about one-third to one-half the height above the base, the upper half or two-thirds of the altitude removed, and a vast depression excavated in the remaining portion. The steep wall-faces of this excavation would cut the buttresses and ravines a little below the maximum depths of the latter. The crest-line at the edge of the pit, as we followed around its periphery, would rise sharply to go over the buttresses, and descend as sharply to cross the beds of the old ravines, making it a jagged edge. It is so at Crater Lake. As we ascend the ravines, we find them growing deeper and steeper, until at last their upper courses are suddenly cut off at the brink of the great pit. On either hand rises the old buttresses many hundreds, sometimes more than a thousand, feet above us. The imagination only can picture the restoration of the missing pile and the upward continuation of the great ridges and furrows now ending so strangely, and otherwise unaccountably, upon the brink of this deep gulf. Whether the mountain culminated in a sharp and lofty cone like Mt. Pitt and Mt. Scott to the south of it, and Mt. Thielson to the north, or was a somewhat flatter structure like Union Peak to the east of it. is more doubtful. The general configuration of the ravines, and the absence of large masses of tuff, or fragmental ejecta, in the original pile, indicate the flatter, or dome-like form; and this is decidedly the prevailing form of mountains in the Cascade Range, though many sharp peaks are scattered among them. What dire catastrophe has destroyed this cone?

Great pit-craters, or, as I have termed them elsewhere, 'calderas,' are not very common. Still they exist in several parts of the world; and of some of them we know the history, or may infer it with considerable confidence.

There are three or four large ones in the Hawaiian Islands. One is on the summit of Mauna Loa; a second is the famous Kilauea; and the largest and most wonderful of all is the immense caldera of Haleakala, on the island of Maui. But none of them are so large as Crater Lake, nor so deep. The origin of these I have endeavored to explain in a paper on the Hawaiian volcanoes, published in the 'Fourth annual report of the U.S. geological survey.' In the correctness of this explanation I feel great confidence. The evidence of it is summed up in the paper referred to. These 'craters,' or calderas as they are there called, appear to have been formed gradually, through the melting of the cores of the mountains by superheated lavas (i.e., lavas of higher temperature than is necessary for the fusion of their materials), rising from great depths in the earth through volcanic pipes. The peculiarities of the Hawaiian lavas are the absence or rarity of explosive or violent action, their high temperature and great liquidity. They rise in the volcanic pipes, and remain stationary at a certain altitude; and in Kilauea they maintain large lakes of lava open to the sky in a state of continuous fusion. But beneath the floor of the caldera they form lakes of still greater extent. Eruptions occur from time to time; but the lavas, instead of overflowing from the summit of the volcanic pile, burst out miles away from it, and far down the gently sloping sides of the cone at levels thousands of feet lower than the crater. The lavas beneath the caldera are drained; and the upper portion of the mountain, robbed of the liquid support which has held it up, sinks in. The surface-rocks, being vesicular or spongy, are light enough to float on the liquid lava so long as the latter maintains its level in the stand-pipe; but, when the liquid is tapped off through a lateral vent in the mountain-side, the upper crust settles, as would the ice in a pond when the water is drained from beneath it. The evidence of this action at Kilauea, on Mauna Loa, and still more emphatically on Haleakala. is very clear and unmistakable.

But there is another class of calderas, formed by a mode of volcanic action which is in the strongest possible contrast with the foregoing; and we are not left in any doubt as to its general nature, for it has been witnessed and reported upon by competent authority. In the islands of the East Indian archipelago, stretching from the Straits of Sunda eastward to the island of Timor, is found a chain of volcanoes comprising hundreds of individual cones. During the period of occupation of these islands by the Dutch, numerous eruptions have occurred; and the most characteristic feature of them has been their terrible and devastating energy. Some of the volcanoes are truncated cones, with large calderas in their summits. Two of them have been formed within the historic period, and accounts of their formation have been preserved. One of these, in the summit of the volcano Papandayang, on the island of Java, was formed in 1772, by an explosion rivalling in destructiveness and energy the outbreak of Krakatoa in 1883. The other is found in the summit of the volcano Tomboro, on

the island of Sumbawa, and the date of its formation was 1815. The incidents of this last eruption were investigated by Dr. Junghuhn, whose work on the volcanoes of the East Indies is now a classic one in the annals of volcanism. Judging from his account, this must have been the most energetic and destructive explosion of which any authentic account has been preserved, surpassing greatly that of Krakatoa. Prior to the outbreak, Tomboro was a shapely cone, rising a few miles from the shore to an altitude of more than 9,000 feet. In a single night the upper 5,000 feet was blown into fragments, which were scattered over thousands of square miles of sea and land; while the volcanic dust darkened the air over a million square miles of island and ocean. Many months afterward, when the scene could be visited, Tomboro was a mere stump of a mountain, with a large crater in the place of the cone which had been blown away. Other instances of a similar nature might be mentioned, but the foregoing may suffice.

We have, then, examples of depressions similar to that of Crater Lake produced by two very different modes of action. To which of them may we refer the origin of the magnificent crater of the Cascades? Just at present a confident answer cannot be given; for the ground has not been sufficiently studied. The facts brought to light by the first hasty reconnaissance seemed to indicate the explosive action, rather than the quiet method of subterranean fusion. But it is best to await the results of a more critical examination before committing ourselves to any opinion. It may be well, however, to state such facts as have already come to light, as well as some general considerations pertinent to the subject, and let them pass for what they are worth.

1°. In the Hawaiian calderas the evidences of sinkage are conspicuous. They are not confined to the deeper floors of the pits, but are also seen in the partial subsidence of great blocks or slices of the walls immediately enclosing them, and in irregular sunken spots in their vicinity, also in the marks of powerful shearing or faulting action in the walls themselves. They appear to be correlated to the remarkably quiet habits of the Hawaiian volcanoes, to their habitual modes of eruption, and to the special structure of the volcanic piles, which do not rise in steep conical peaks, but are very broad and flat. At Crater Lake, neither in the walls themselves, nor in the immediate neighborhood back of the crest-line, have any traces of sinkage been observed as yet. Nothing can at present be pointed out which suggests the Hawaiian mode of origin, beyond the fact that a vast crater is before us. The general structure and habits of the Cascade volcanoes are indicative of a more vigorous style of volcanic action than the Hawaiian.

2°. Crater Lake is the centre, and, without much doubt, the source, of an extraordinary quantity of andesitic pumice and tuff, which is scattered far and wide over a circle of country ranging from 40 to 60 miles in diameter. It often lies in beds several hundred feet deep, and covering hundreds of square miles. This pumice is not such as is often seen in some lava streams, but consists of rounded masses and pellets which seldom exceed a cubic foot in volume, and grade down to fine, light sand. It is the kind which is blown violently from a volcano during eruption, and projected high in air, to fall in showers over the surrounding country. It is found on the loftiest peaks and mountains anywhere within 20 miles of the lake, and assuredly did not emanate from the peaks on which it now lies. Vast quantities of it have been gathered up by the rains and streams (for it is lighter than cork), and swept eastward into the broad basins of Klamath Marsh and Klamath Lake, or carried westward through the Rogue River into the Pacific. The finer lapilli and sand have been consolidated into beds, which flank the eastern slope of the Cascades, and are also found west of its divide in the flatter spaces beyond the base of the truncated pile which holds the crater. These are well exposed in the walls of little box-cañons two or three hundred feet deep, and the tuff weathers out into pleasing columnar forms. The tuff is older than the pumice, for, wherever the two were seen together, the tuff was undermost. This light fragmental material, its wide distribution in every direction, with the lake as the centre of dispersion, the very light and highly vesicular character of the pumice,—all indicate that at some time Crater Lake has been the scene of some sort of very energetic volcanic action.

3°. But there is a weak point in the argument. If a large cone, composed of solid lavas such as are now seen in the walls of the lake basin, has been blown into rubble, and the fragments hurled far and wide over the surrounding country, ought we not to be able to recognize them in vast abundance in the vicinity? Most certainly we ought to. And yet in close proximity to the lake no fragments were noted, except such as we always expect to find at the foot of steep spurs and ridges of volcanic rock, and which have broken down from them in the ordinary course of weathering. This absence of the *corpus delicti* is a serious difficulty in the way of a speedy conclusion that the mountain was blown up by any such summary proceeding as Tomboro or Krakatoa, and indicates

the importance of further search after evidences of ingulfment.

Regarding the age of the caldera, it would be premature to offer any opinion, beyond the vague and general statement, that it is certainly many thousands of years old. There is abundant reason to hope, however, that further examination will throw some light on this question. We cannot, indeed, expect to reach any estimate of its age in terms of years and centuries; and our hope must be confined to that of fixing its relative age in terms of the geological calendar. Viewed in that relation, it may be said with equal confidence that its age is not great. C. E. DUTTON.

THE FISH-CULTURAL STATION AT GLOUCESTER, MASS.

WE are informed that it is the intention of Professor Baird, the U. S. commissioner of fisheries, now that methods and apparatus for hatching successfully the buoyant eggs of the cod, halibut, and other marine species have been devised, to prosecute the work on as extensive a scale as the means at the command of the commissioner will permit.

Gloucester, being the centre of the cod and halibut fisheries, furnishes unusual facilities for procuring an abundant supply of eggs within easy and convenient reach of the station, and has therefore been selected as the most advantageous location, for the extensive fish-cultural work with the marine species, now projected by the U. S. commissioner. The commission steamer, the Fish Hawk, thoroughly equipped for hatching-work, has been ordered to Gloucester, and will take her position in the outer harbor, at some convenient point where the anchorage is safe, the water pure and free from sediment, and of sufficient density to insure the buoyancy of the eggs during incubation.

All the usual methods for collecting eggs will be resorted to, and, in addition, it is expected to interest the fishermen themselves in the work of collecting by paying a reasonable price for impregnated eggs delivered at the station. Experimental investigations will also be made to determine the practicability of forwarding impregnated eggs from Gloucester to Wood's Holl and other stations to be hatched. The species which will chiefly engage the attention of the experts of the commission are the cod, halibut, haddock, herring, and the mackerel.

The results of the work with the halibut will be watched with special interest, both by fish-culturists and by those who are engaged in the fisheries. This fish is even more prolific than the cod-fish. Once in extraordinary abundance in Massachusetts and Ipswich bays, it has, within the memory of man, been almost exterminated in the area referred to. Have the conditions changed so as to determine the migration of the species to more congenial waters, or has man, by his direct agency in the fisheries, effected the extermination, over a given area, of a marine species of such marvellous fecundity? This is a question to which the work of the commission promises, in a few years, to furnish a satisfactory answer.

GREELY'S THREE YEARS OF ARCTIC SERVICE.

THE name and fame of Lieut. A. W. Greely of the U. S. army now belong to the history of geographical research and of undaunted heroism. The pages of this journal have so often referred to his arctic explorations that it would be superfluous to review again the thrilling incidents of his perilous voyage. The scientific world is well aware that he was sent by the U. S. government as the leader of an expedition which was to co-operate with many kindred parties in the observation of physical phenomena in the extreme north; that this arduous enterprise was not for the gratification of personal or national pride by extending the coast-lines of the northern chart, or by carrying the flag a little nearer to the pole than it had ever been borne before; that it was not for the purpose of adding renown to the army, or glory to the explorers, but to help in solving important problems in terrestrial physics by a series of exact, patient, long-continued, and carefully recorded observations in the ice-bound regions of the north.

As long ago as 1875, Lieutenant Weyprecht of the Austrian navy, who had won experience and distinction in arctic researches, succeeded in calling the attention of the civilized world to the idea that future voyages should not be planned with reference to the increase of our knowledge of geographical boundaries, but rather to the ascertainment of scientific facts, by contemporaneous observations in well-chosen stations at the north, under the concerted actions of the most experienced men and the most enlightened governments. As a result of the acceptance of this idea, fourteen stations were established by eleven co-operating nations; namely, Austria, Denmark, France, Germany, Great Britain, Holland, Norway, Russia, Sweden, and the United States. Many astronomical observatories in different parts of the globe lent their aid to the project, so that the number of

Three years of arctic service. An account of the Lady Franklin Bay expedition of 1881-84, and the attainment of the farthest north. By ADOLPHUS W. GREELY. 2 vols. New York, *Scribner*, 1886, 8°.