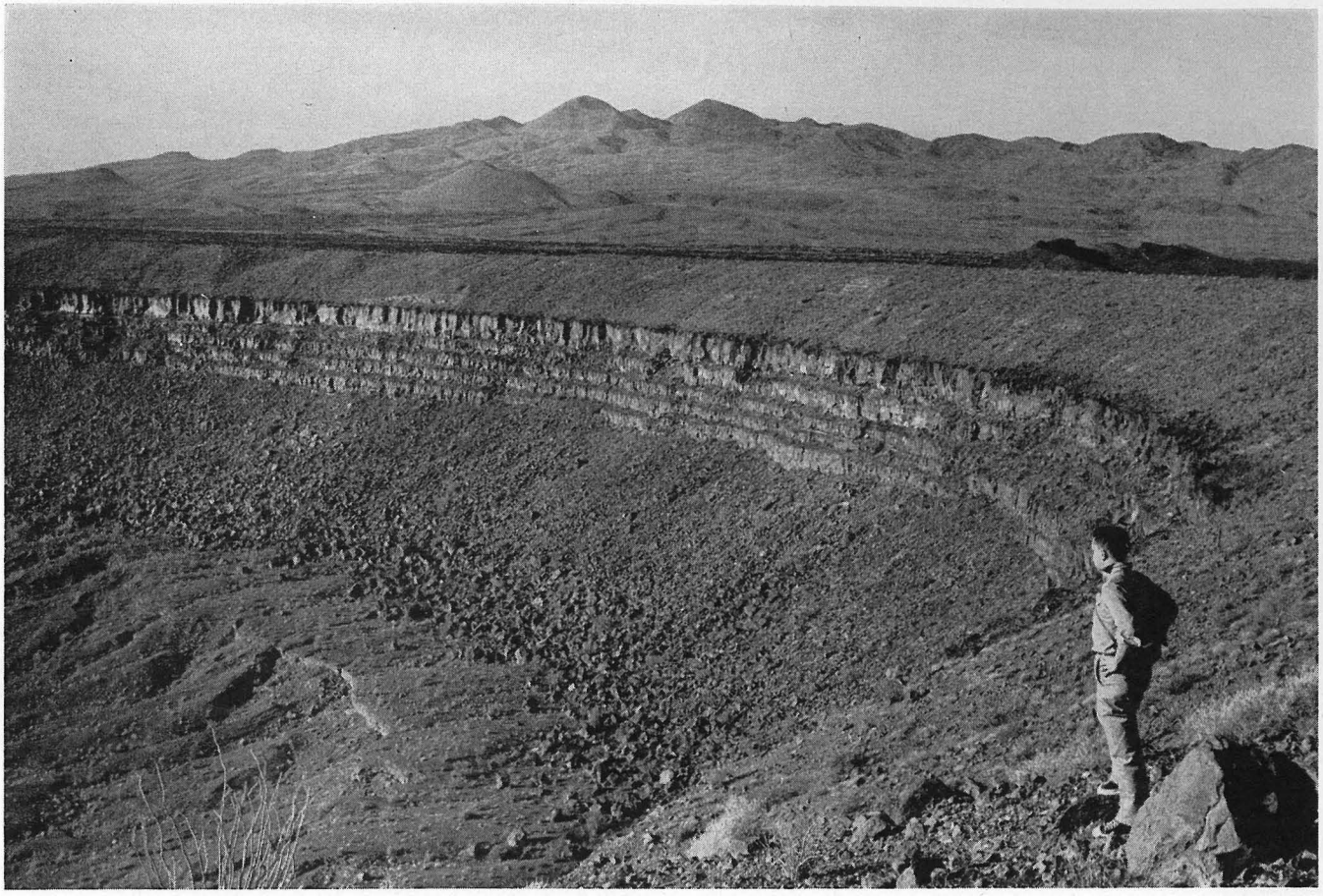


Jesus Ruiz Elizondo, geology graduate student at Caltech, on the rim of Crater Elegante, in his native Mexico.

COLLAPSED VOLCANO

Caltech geologists reconstruct the history of Crater Elegante, a mile-wide chasm in the Mexican wastelands

A MILE-WIDE HOLE in the ground in the uninhabited wastelands of Mexico is furnishing Caltech scientists with invaluable information about the surface features of the earth on which we live. From it may also come a better understanding of how rocks form and how large crystals grow.

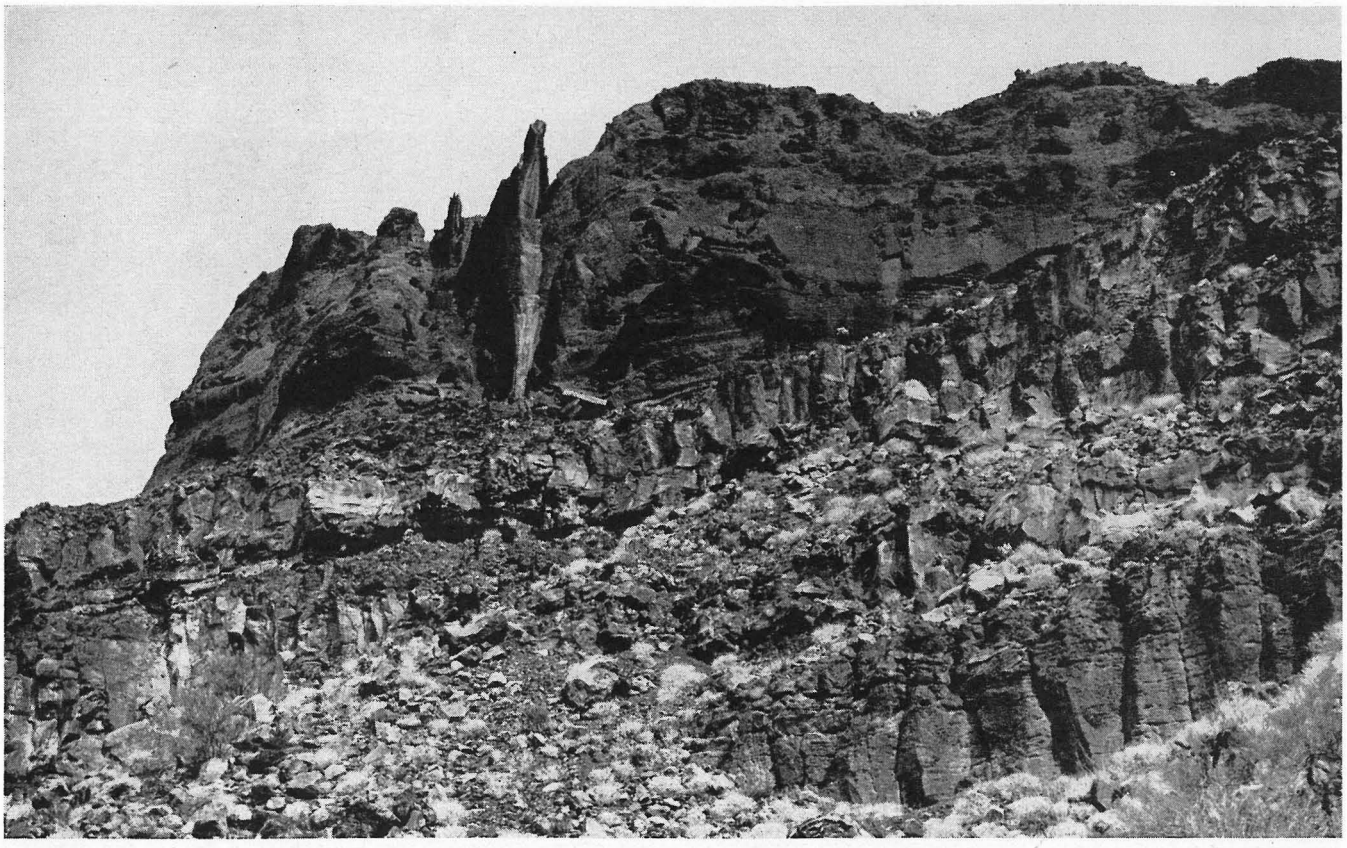
Known as Crater Elegante, this huge pit is about 30 airline miles south of the Arizona-Mexico border, near the Pinacate Range of Sonora State, Mexico. Once it was a great volcano which grew from the earth and spewed its hot lava and cinders over the surrounding countryside. Then, many centuries ago and more quickly than it was born, the towering peak disappeared from the skyline. It dropped back into the earth to become a caldera, or collapsed volcano.

After the shock and thunderous roar of its collapse subsided, Elegante lay quietly, a huge, desolate hole seen only by an infrequent traveler. The raw materials for a reconstruction of its life history were etched in its deep walls and strewn about in its vicinity, but Elegante was essentially an unread book until Dr. Richard H. Jahns, Professor of Geology at the Institute made his first field trip to the area last year. He has made three further trips to Elegante since then.

Jahns found it an outstanding model of a caldera. Such striking examples of the reaction of the earth's outer crust to changes in its physical environment, along with other crustal adjustments, form an important part of our geological record. Their origins and mechanisms have posed some of the most challenging and fundamental problems to be found in the earth sciences.

Perhaps the best known example of a caldera in the United States is the Crater Lake depression in southern Oregon. Some details of its history, however, are masked by debris and the water covering its floor and obscuring much of its walls.

The unusually graphic Elegante looks from the air like a gigantic pockmark in an undulating plain. It is



nearly circular and about a mile in diameter. The maximum depth of its flat floor is about 800 feet. From its rim the ground slopes gently outward in all directions. Neither water nor the mantling of debris usually found on the walls of other calderas obscures the significant past of Elegante. Conspicuous on its walls is a great thickness of cliff-making basalt flows, above which are other revealing strata.

The layers of lava are topped first by black and red cinders. These in turn are covered by sedimentary beds rich in small pieces of porous basalt. Larger chunks of this dark rock and of granite are scattered through the sedimentary beds. They evidently were deposited from the air as volcanic bombs.

Deep within the caldera are aprons of coarse debris from the basalt cliffs and some finer-grained sediments deposited as a delta in a lake that once filled the lower one-quarter of the depression.

All these materials clearly document the life story of Elegante.

It may have begun, Jahns believes, with the shallow rumblings of earthquakes and the appearance of fractures in the ground through which boiling springs and clouds of dust and cinders poured forth. Later, as he reads Elegante's autobiography, very fluid basalt lavas flowed through the fissures, formed a major vent and slowly built a domelike hill several hundred feet high.

Dome building apparently lost momentum for a time as the subterranean pressures were relieved and the central vent became clogged with hardened lava. Cinders were blown out along the perimeter of the vent and formed small cones dotting the dome. Alternately, lavas poured sporadically from cracks on the slopes of the cones and added their bit to the dome. A small cone exposed in cross section on one side of the caldera provided many details useful in reconstructing this complex sequence of explosive episodes and hot lava flows.

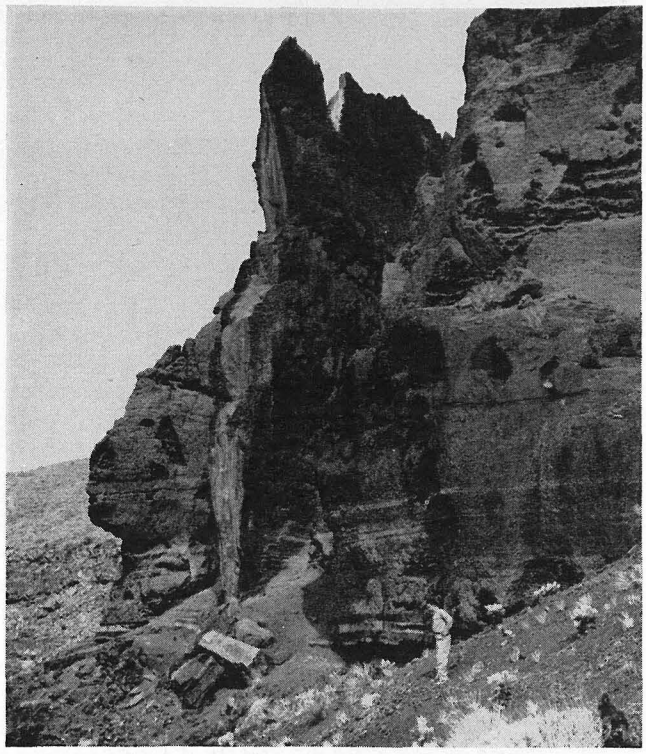
This sequence preceded the construction of a vastly larger central cone, in part by explosive activity as internal pressures again built up, the investigators found. They observed that much of the cone was made up of broken masses of the earlier rocks. These apparently were exploded out of the vent as volcanic bombs when the old, partly choked-up volcano cleared its throat. The rest of the cone was essentially new material, chiefly small pieces of cellular lava, transparent crystal fragments of feldspar and vast quantities of glassy froth.

The life of the now-towering volcano reached an abrupt climax after the tall cone was built. Its entire top and adjacent parts out to a radius of one-half mile vanished from the landscape. Elegante fell into the earth like a piston dropping in an almost circular cylinder.

Subsidence carried the floor of the newly-formed caldera well below the general level of underground water in the area, and a lake about 200 feet deep formed. Erosion carved bits of the soft, broken rock from the caldera walls and a narrow delta was built up along the shore of Lake Elegante. In some places the bottom of the caldera continued to sink. But there was no further outpouring of lava, no further ejection of clouds of cinders. Only fumaroles and hot springs remained as evidence

Left, a view of the upper part of the east wall of Crater Elegante. The lower cliffs are basalt flows, the upper ones thin-bedded "cinders." The spine-like protuberance in the cinders is a dike of highly vesicular basalt which evidently was injected laterally from the volcanic vent that once lay where the void of the caldera now is.

Right, a close-up of the dike shows some of the layering inside it. In addition to the many cavities it contains glassy crystals of feldspar.



of the once great activity—but it is quite probable that even these expired not long after the collapse.

When this occurred is not definitely known, although Elegante is thought to be many thousands of years old. Institute geologists will attempt to find organic materials, such as fossil wood or charcoal, at the caldera which could be used in carbon-14 radioactive dating procedures in an effort to establish its age. The lake which formed in it, at a level considerably higher than the present water table, appears to indicate it existed during a period when the climate was considerably wetter than today. This may have been during or after the close of the Pleistocene epoch some 25,000 years ago when glaciers covered portions of the northern United States.

Change of climate

As the centuries passed the climate gradually became drier, for the level of Lake Elegante slowly dropped, as evidenced by the narrow beach deposits formed at successively lower levels. Longer ago than the beginnings of any known records of man in this area, Elegante dried up completely.

From the arid cavity which remains, Dr. Jahns was able not only to document the life cycle of the volcano but also to determine the mechanism of its destruction. His field studies were augmented by chemical and microscopic examinations of rock samples in the laboratory.

Chemical analyses demonstrated that the glassy froth from the upper walls of the caldera had significant characteristics in common with the basalts found at the lower levels. These studies confirmed that its manufacture was the final stage in a single cycle of volcanic activity.

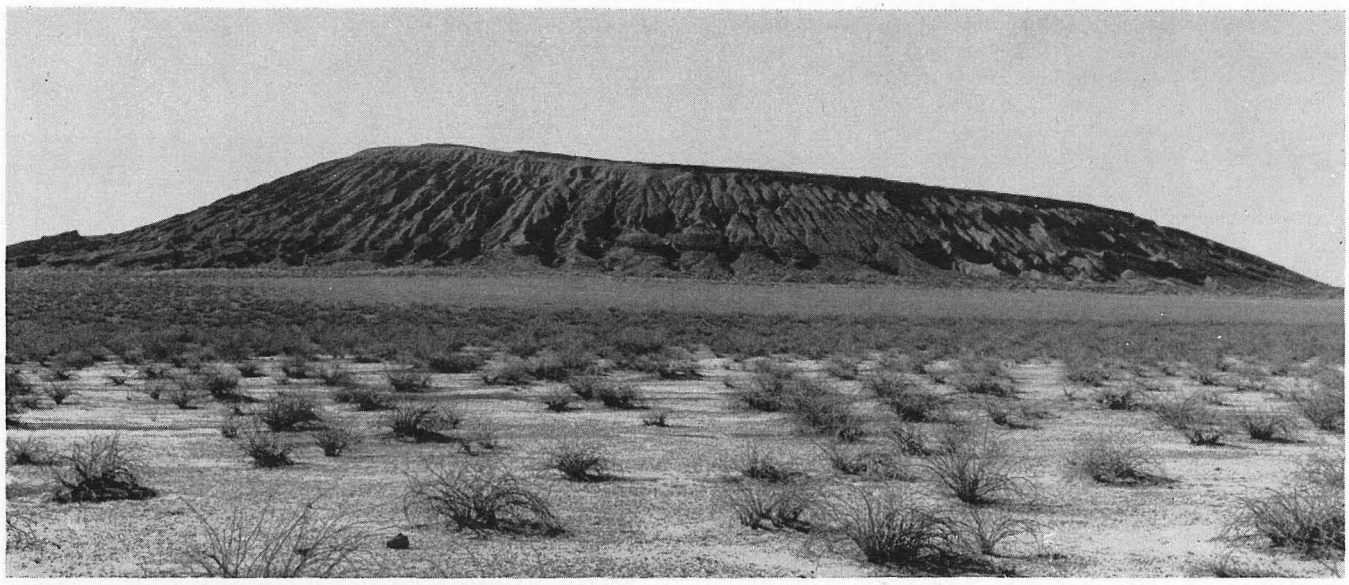
Microscopic examinations of tissue-thin sections of the froth showed that tremendous quantities of gas had been involved in its formation. In minute detail the microscope revealed a foamy structure throughout the partly devitrified basaltic glass. Scattered about in the open, spongy mass were large crystals of feldspar, some as much as three inches across. The finer structures of the froth clearly showed that the feldspars had been tossed about violently during their journey to the surface.

This, then, is the reconstructed picture of the collapse of Elegante:

Its superstructure was not blasted away—such a cataclysmic series of explosions would have strewn a billion tons or more of volcanic material over the area. Rather, this vast rock heap shuddered and dropped on a grand scale into a void which had grown larger as the central cone grew taller. Its very growth sealed its doom.

The top of the cone was built with materials brought up from a closed source chamber deep underground. In it lava bubbled and seethed, ever more furiously, until eventually the underground pressures became so great that this cauldron began to effervesce. Feldspar and lava bubbles were carried upward through the volcano's throat with the escaping gasses and hardened into the glassy froth at the surface. So much unreplenished lava frothed away in this fashion that a great void grew in the subterranean chamber. And when enough of its support had thus been withdrawn, Elegante collapsed into that void of its own weight.

So ended the volcano Elegante, but not its usefulness to science. The caldera, for instance, has yielded climatological information on a bygone age. One bit of knowledge derived is that the prevailing winds probably blew from the southwest during the growth of the volcano,

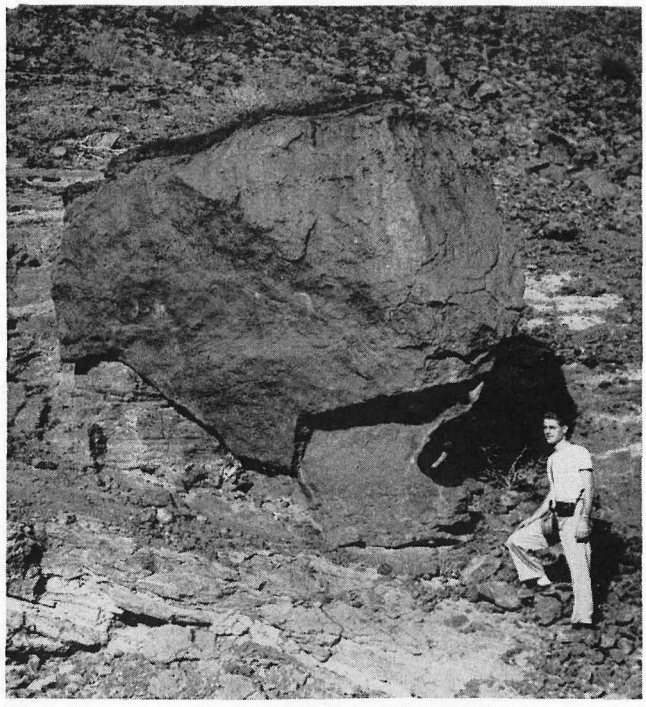


Outer rim of another caldera known as Cerro Colorado (Red Hill) was preserved because the collapse was asymmetric. This gives us the best clue we have as to the probable appearance of Elegante volcano, prior to its collapse.

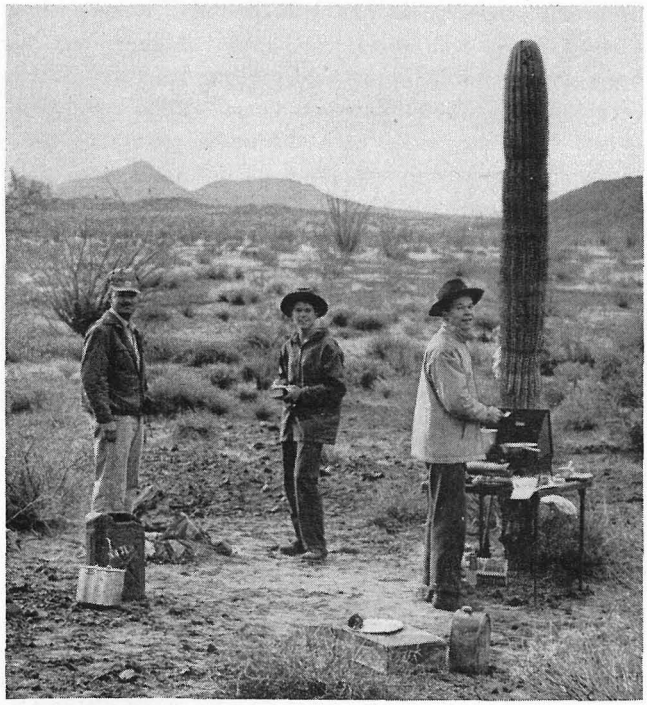
just as they do today. The investigators found this evidence in the fact that most of the cinders accumulated on the northeast sides of the small subsidiary cones. Another such contribution was the moisture pattern revealed by the old lake bed.

Materials from the caldera are being studied also in search of a better fundamental understanding of rock formation, particularly in a gas-rich environment. Samples of the glassy froth and heavily-honeycombed lavas are being subjected to further physico-chemical examination in the Institute laboratories for this purpose.

The scientists hope ultimately to shed more light on the effect of gases on the development not only of crystalline lava but of large crystals in general. They are seeking answers to such questions as how fast crystals grow, what governs the size they reach and what makes some of them perfect while others are full of imperfections. Such knowledge may prove valuable in the light of increased mineral synthesis and the laboratory growth of crystals for electronic equipment.



This large boulder of basalt tumbled off the wall of Crater Elegante shortly after the collapse of the volcano. It was incorporated into the fine-grained delta deposits being built into the lake that once occupied the bottom of the depression. Helmut Abt, graduate student in astrophysics at Caltech is looking it over.



The field party enjoys a leisurely breakfast in the rain. Dr. Jahns is assuming a nonchalant air at the left; Peter Kamb, graduate student in botany at the University of California, is feeling the cold in the center, and his twin brother Barclay, senior physics student at Caltech, is doing the cooking on the right.