in metallurgic, ceramic, and textile arts. In the numerous utensils fashioned from clay, instances are found of attempts at portraiture. Gold, silver, and copper ornaments of decorative and personal adornment are found, and indicate considerable progress and refinement in their manufacture and design. Cotton cloths, woven in complicated colors and graceful patterns, prove a high degree of skill in the fabrication of textiles. The painted vases and pottery are proofs of considerable talent, while the many articles of utility used in the household witness to the great ingenuity and invention of the people. Battles between the Peruvians and their enemies are depicted upon some of the larger specimens of pottery, with representations of the weapons in use, and are executed with much power and graphic delineation. A system of enumeration and accounting by means of variously colored threads was invented, and they were familiar with the curative properties of plants.

The dead were mummified by burial in a soil impregnated with chemicals or preserved by the intense dryness of a region where rain never falls. It is not believed that the preservation of the body after death was designed, but the custom of interring in the graves the most valued possessions of the dead seems to have been universal. It is to this custom that the archeologist is able to declare with some degree of certainty the standard of civilization attained at different periods, together with the probable time at which interments were made. In all the excavations of Dr. Uhle, the classification of the different cultures was observed. Several layers appear to have been superimposed, each with essential differences. In his opinion, formed after observation of numberless instances and at separate stations, the lowest and earliest of the layers exhibited a higher degree of artistic skill in the fabrication of the objects exposed than the one just above, and so on until the last, or fifth, which exhibited a great deterioration over all its predecessors. Five cultures were thus superimposed, and Dr. Uhle's conclusion is that each represented a definite period of five hundred years. Thus Schliemann at Troy and archeologists in many other instances were enabled to identify dynasties, and to trace periods and catastrophes in ancient localities; even in the absence of historical data.

The differences in the stratifications referred to have been noticed by other explorers in the same regions, who ascribed the changed conditions to the work of widely separated tribes, some exhibiting superiority over others.

This theory of Dr. Uhle, if well founded, proves that no account of the succession of time, as suggested in the stylistic strata, had been thought of. Dr. Uhle is the first, probably, to advance the proposition that each stratum, or culture, represents a definite period, which he conjectures to be five hundred years, the total being twenty-five hundred years for the five cultures. As no traces of former inhabitants have been found, and as it would appear impossible for the original race to have at once developed so high a stage of civilization without having left some indications of graduated progress, the conclusion is irresistible that the first culture represents an invasion of a powerful and well-developed people, somewhere about 1,500 years before the Christian era. In commenting upon this feature of Peruvian history, Dr. Uhle remarks: "It will now be easier to give the correct chronological position to each new Peruvian culture which may be discovered. Moreover, the results are of importance in investigating the connection between the cultures of Central and South America, for it is not improbable that if connection existed between the north and south, it took place during the earliest period. As the Peruvian cultures are now being classified according to age, it would be important to know by similar means the relative ages of Central America and other South American cultures; for connection can have existed only between contemporaneous cultures, and only such, therefore, should be compared if fruitful results are to be expected."

The explorations are now being conducted at Cuzco.

LODGEPOLE PINE.

THE lodgepole pine, which is known in the Sierras of California as tamarack pine, and in Colorado and Montana is sometimes called white pine, jack pine, pinyon, and scrub pine, bears the common name of "lodgepole" from the fact that the Indians used its long slender trunks as supports for their wigwams or lodges. Its geographical range is along the Rocky Mountains from Alaska to New Mexico and westward to the Pacific coast. In the United States it is found in merchantable quantity and dimensions on the spurs and eastern slopes of the Rocky Mountains throughout southern Montana, Wyoming, and Colorado, in the Bitter Root Mountains of Idaho, the Uintah Range in Utah, and in the Big Horn Mountains of Wyoming. The Bureau of Forestry is studying the species throughout this range of its best commercial distribution.

Lodgepole pine grows at all altitudes between 3,000 and 10,500 feet above sea level. In the Gallatin Mountains of Montana, and in the mountainous country south and east of Yellowstone Park it reaches its largest size at elevations between 4,500 and 8,000 feet. In Colorado, however, toward the southern limit of its range, the conditions which are necessary to its best growth are found between 9,000 and 10,500 feet elevation.

Lodgepole pine is valuable, for one reason, because it grows on high mountain slopes, and also on old "burns," where other trees find difficulty in obtaining

a foothold. It readily adapts itself to most diverse soil conditions, but thrives best where there is considerable moisture. Its roots accommodate themselves to the shallow soil common in the localities where it grows. At a very early age this tree produces cones in large quantities, and after it is ten years old the seed are generally fertile. The cones sometimes open and distribute the seeds as soon as they are ripe, though more commonly they remain on the trees for years with their seed carefully preserved beneath the scales. In many cases squirrels cut off the closed cones and hide them away in the ground. If a fire occurs before the seeds are eaten, it will cause the cones to open and set them free. As a rule, however, the cones of many seasons remain on the trees until a fire comes along, and, by heating them, liberates the seeds, when a dense growth of seedlings follows.

In many localities where lodgepole pine now grows, the ground was originally covered with Engelmann spruce in mixture with red fir and other species. Repeated fires laid waste these forests, and prevented their reproduction by destroying the seed and the thick forest floor of decaying leaves and litter, which is absolutely essential for the seed germination of these species. Lodgepole pine, however, thrives on an impoverished soil, and its great seeding capacity and the ability of the cones to withstand fire cause it to spread quickly over burned areas. In places where the pine has carpeted the ground again with a quantity of forest litter, and where lumbering has thinned the forest sufficiently for the light requirements of Engelmann spruce and red fir, these more valuable trees are found taking the place of lodgepole pine. Thus if fires can be kept out of the woods of this region, these more important trees can be produced in many places where they are now virtually extinct.

The wood of lodgepole pine is light yellow to nearly

other advantage to the forest in that it offers a means of utilizing the upper parts of trees cut for lumber, which in the ordinary way of logging are left on the ground to become dry and increase the danger of fire. It also makes possible the thinning of pole stands which contain few or no trees large enough for ties, but which are so dense that the trees have almost stopped growing.

By far the larger part of the merchantable lodgepole area is within existing or proposed Federal forest reserves, where the lumbering regulations which the government put into effect some time ago will protect and benefit the forests.

Other objects of the Bureau of Forestry in this study are to ascertain the rate of growth of the tree, and how it may be increased; to better existing lumbering regulations; to devise a system of fire protection; and to extend the commercial uses of the wood. A controlling consideration is the need of maintaining the forests on all the mountains they now cover, and of causing them to spread more widely, if possible, since the most important function they can perform is to safeguard the watersheds they include. This study will enable the Bureau to carry out more effectively the work of forest reserve management lately intrusted to it by Congress. The results of the study should also prove of large value to railroads and private owners, who hold a great many odd sections of land all through the lodgepole pine region.

RECEPTACLES OF QUARTZ AND THEIR USES IN CHEMISTRY.

By M. BERTHELOT.

FOR some time past we find in commerce a variety of recipients or tubes of a new material known as fused quartz, and these are distinguished by special qualities,

GREAT SOUTHWESTERN GATE OF FORTRESS EL CASTILLO, HUAMACHUCO.
RECENT EXPLORATION IN PERU.

white in color, with a coarse but straight grain. It is more resinous than the eastern white pine, but less so than the yellow pines of the South. It is soft and easily worked, and would make excellent finishing lumber were it not for the abundance of small though hard knots, and for its tendency to warp and check with seasoning. Without doubt the best use of lodgepole pine at present, and the one to which it is most largely put, is for railroad ties and mine props; but to be utilized with the greatest profit for these purposes the timber must first be subjected to preservative treatment. The Bureau of Forestry has for some time been conducting, in Montana and Wyoming, exhaustive tests in seasoning and in preservative treatment of this pine, and a comprehensive bulletin on the subject is now in preparation.

During the season of 1903-4 between 1,300,000 and 1,400,000 lodgepole ties were cut, most of which were treated with preservatives. The cut of this season will exceed this number, and without doubt the use of lodgepole pine for ties will increase yearly. Trees between 11 and 14½ inches in diameter breasthigh are hewed; those larger are logged and sawed, as the hewers refuse to work them. When a tree reaches 11 inches in diameter it is mature for ties; this makes it possible to remove a quantity of material from the dense natural forests as soon as a number of the trees have reached that size, and thereby to stimulate the smaller ones to a more active growth. At the same time a new generation may be started in the openings from the seed of the felled trees.

Great quantities of lodgepole pine are also used for props in the numerous mines of the region where this tree grows. The timber is cheap, and in its natural condition answers for temporary purposes in mine development; when well seasoned or treated with preservatives it may be used for permanent construction. Miners use poles as small as 5 inches in diameter at the top, and this demand for small timber works an-

such as their infusibility at temperatures as high as 1,400 degrees C., their resistance to acids, as well as sudden cooling, etc. I recently undertook some experiments with this material analogous to those which I made upon glass vessels and tubes sealed by the blowpipe. The latter were designed to be used for different researches, notably those relating to slow reactions carried out at constant temperatures and under pressures as high as 200 atmospheres. But the applications of this method are limited by the temperature of softening and fusion of the glass, and I could scarcely work higher than 550 degrees C.

By the use of vessels made of fused silica, it is possible to reach temperatures as high as 1,500 degrees. Some precautions must, however, be taken with the use of such vessels, and it seems useful to make some general observations in this case, before describing some of the new experiments made in my laboratory and the new problem I attempted to solve by their use.

The quartz tubes of small size may be worked by the oxyhydrogen blowpipe or more easily by the oxygen-acetylene blowpipe, which gives much higher temperatures. They can be drawn out or welded like glass tubes, but care must be taken against the cooling, which is quicker. The tubes which I generally employed are those of 10 millimeters (0.4 inch) diameter, some 100 millimeters (4 inches) long. Their capacity after sealing varies between 4 and 5 cubic centimeters. The thickness, which is about uniform, is some 0.7 millimeter. The resistance to internal pressure is near 3 atmospheres and this lasts up to the commencement of the softening point, between 1,300 and 1,400 deg. C. If need be, we introduce solid bodies in definite weight into the tube before drawing out the end. Then the latter is drawn, and can be fused to a capillary tube which is thicker and more convenient to join to a mercury pump. The mercury of the latter should never be allowed to come into the quartz tube. The pump serves to make the vacuum and then to introduce, by the

usual methods, different gases in a pure state, either at the ordinary temperature or under a reduced pressure at the required degree. We then seal up the capillary part by the blowpipe, in the region which belongs to the main cylinder, carefully avoiding the heating of the enlarged portions and of the gases therein contained.

As to the material introduced into the tube, the quantities of solid matter and gases are to be regulated with care, according to the limits of resistance stated above. In the case of gases which are isolated, or else used along with matter which is quite stable at 1,400 degrees C., we fill the tube when cold with the gases under a pressure of 36 or 38 centimeters of mercury at most, and often reduced to 15 centimeters. We measure this pressure exactly, along with the barometer pressure. As to solid matters which may take the gaseous state at 1,400 degrees, their weight should be established so that the united pressures of their vapor and the cold gas introduced into the tube shall not exceed 2.5 or 3 atmospheres at 1,400 degrees.

As to the method of heating, the quartz tubes are heated by the electric current according to the usual processes, by placing them in a large earthenware tube which should be unglazed. The latter is surrounded by a spiral of thin platinum foil which heats up by the current. The outer air freely penetrates into the inside of the large tube. The current is regulated by resistance. We can work as high as 25 amperes, in general, at a temperature which is determined by a Le Chatelier regulator or other exact instrument. The heat is kept constant for one or several hours. There is no advantage in continuing the heat too long, on account of the permeability of the quartz, which will be mentioned below. The quartz tube placed inside the earthenware tube is surrounded by a thin platinum foil (insulated electrically), so as to avoid sticking to the large tube. But if we exceed 1,400 degrees heat, the platinum foil is likely to adhere to the earthenware tube. Besides, the quartz tube commences to swell up

ments, such as the diamond, the carbon separated from hydrocarbon, etc., they are taken from the tube at the time of placing in the mercury or afterward, and examined. If need be we make an experiment by heating two similar quartz tubes at the same time in the same earthenware tube, one for observing the gases and the other for the solid bodies, without bringing them in contact with the mercury.

The use of quartz tubes shows a phenomenon which complicates their applications considerably; this is their permeability. In fact, the tubes are not impenetrable by gases and vapors, on the contrary to glass vessels. This observation has already been made in the case of hydrogen by M. Villard, and by Messrs. Jacquero and Perrot for helium, and this is the case even below a red heat. I found that it is the same, but in a less degree, for nitrogen and oxygen, and I observed the exchange which takes place between the gases formed inside the tube and the gases of the air, under certain conditions which are of interest. All the tubes mentioned below were heated in air, under the normal pressure. The gases had been introduced into the tubes by using a mercury pump, but without allowing any trace of mercury to enter the tube. The pressure of the gases is accurately known. Some of the phenomena which were observed are given as follows: 1. Amorphous carbon (wood charcoal purified by the action of chlorine at a red heat, etc.). A few milligrammes of the carbon were placed in a quartz tube having a capacity of 5.5 cubic centimeters. A vacuum was made by a mercury pump so as to remove the gases, taking the precaution to heat the tube over a flame before sealing it. The vacuum was as perfect as possible. The sealed tube is kept between 1,300 and 1,325 degrees C. for half an hour. At the end of this time it is brought slowly to the ordinary temperature and then opened over mercury. It was found to be no longer empty, but contained gases which exerted a certain pressure, although much below the atmospheric pressure. The latter fact shows that there is no direct communication with the

tube or by the action of oxygen, and 12 volumes of nitrogen penetrated into the tube. There remained in the tube only about one-half the initial amount of hydrogen.

The observations which were made upon hydrocarbon gases showed some very interesting results, and these will be given at length in a later communication. At present a few of them may be briefly stated, especially relating to the escape of hydrogen from the tube and the gradual penetration of the oxygen of the air. Naphthalene was chosen in these cases on account of its great stability, also formene, for the simplicity of its composition. In one experiment 0.051 gramme of naphthalene was placed in an empty tube having 5 cubic centimeters capacity. The tube was heated at 1,300 degrees C. In this case the tube exploded, and this is explained on account of the considerable volume occupied by the naphthalene vapor and by the hydrogen coming from its decomposition. In another experiment the tube contained 0.021 gramme of naphthalene. Its capacity was 4 cubic centimeters and it was heated at 1,300 degrees for 1 hour. The tube resisted the pressure. It was found to be full of carbon, partly brilliant and partly pulverulent. This carbon contained no more naphthalene. If all the hydrogen had been set free (0.0013 gramme, equivalent to 14 cubic centimeters when cold) the pressure at 1,300 degrees heat should have risen to nearly 17 atmospheres and the tube would have exploded. This was far from being the case. When it was opened over mercury it broke, owing to the shock of breaking off the point and also the sudden difference of pressure, and formed long fragments which are quite different from what an explosion would produce. The gases found in this case, reduced to atmospheric pressure, were but 0.18 cubic centimeter (instead of 14 cubic centimeters furnished by the carbon), and contained 0.15 cubic centimeter nitrogen and 0.03 hydrogen. This shows that the decomposition of the naphthalene into its elements, from the ordinary temperature up to 1,300 degrees and during the heat, does not take place rapidly, but gradually, and during a rather long time, in which the hydrogen escapes through the tube by degrees and burns at the outside. A little nitrogen penetrates into the tube, and its mixture with the small amount of hydrogen left in the tube only forms one-twentieth of the tube's capacity.

Pure formene gives rise to analogous phenomena which are even more strongly marked. The first experiment was as follows: Initial pressure, 37.3 centimeters mercury or one-half atmospheric pressure. Capacity of the tube, 4.5 cubic centimeters. Heat, 1,300 to 1,325 degrees for 1 hour. The tube is filled with leaf carbon and a powdery coating. Volume of gas found (reduced) 2.97 cubic centimeters, or superior to the initial volume, which is 2.25. The gas is practically free from oxide of carbon. It contains hydrogen 2.72, formene 0.05, nitrogen 0.20 cubic centimeter, or a total of 2.97 cubic centimeters. According to the original pressure of the formene, we should have had 4.50 cubic centimeters of hydrogen. Hence we see that about a third of the hydrogen escaped or was burned, since the formene is nearly all decomposed.

In the second experiment with pure formene, the original pressure was 36.0 centimeters mercury (atmosphere = 75.6). Capacity of the tube, 4.0 cubic centimeters. The tube was heated to 1,100 degrees during half an hour, then cooled without opening. It was filled with free carbon as above. The next day, it was reheated for one hour and brought to 1,300 degrees, then kept for one hour at that temperature. After cooling, the tube had become white and transparent, without keeping a trace of carbon. I thought at first that a crack in the tube had let in the oxygen, which had burned out the carbon, but this was not the case. In fact, upon opening it over mercury two hours afterward, it was found that the pressure in the tube was about one-half the atmospheric pressure (or near what it was at first), which excludes the idea of a perforation, as this would have established the equilibrium with the air. The tube contained 2.12 cubic centimeters of gas, mainly nitrogen, with a little oxygen and carbonic acid. These facts show that the air had entered the tube gradually by endosmose during the second period of the experiment. In this way two volumes of formene, or rather the corresponding oxygen and hydrogen, had been gradually burned, both outside the tube or in the interior, at the expense of the oxygen of the air. Thus we see that the quartz tubes should not be heated for a very long period.

These phenomena make it evident that silica when melted and then solidified acts in regard to gases like an animal membrane, capable of endosmose and exosmose. The character of these actions depends upon the thickness of the tube, the softening, the adherence of carbon and other matter to the inside, the proportion of alkali added to the silica, the successive temperatures of the heating and the duration of the latter. Also we must reckon the difference of pressure between the variable gases in the tube and the outer air.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Comptes Rendus.

Soldering Powder for Steel.—Melt in an earthen pot 3 parts of borax, 2 of colophony, 1 of potassium carbonate, as much powdered hard soap, to which must be added 3 parts of finely powdered glass and 2 parts of steel filings. The melted mass is run out upon a cold plate of sheet iron, and when it is completely chilled it is broken into small bits or finely powdered. To solder with it, it is necessary to sprinkle with it the surfaces to be joined, several minutes before bringing them together.

HUACA AT LA TORRE, NEAR LIMA.
RECENT EXPLORATION IN PERU.

under the pressure of the gas, at that temperature, and if the heat is too high the tube may burst, breaking the outer tube.

The next step is the cooling and removal of the matter in the quartz tube. When the experiment is finished, we can allow the whole apparatus to cool slowly. But it is often preferable to take out the quartz tube at once and the platinum foil surrounding it, by means of a platinum wire which has been fixed to it beforehand. The cooling can be made instantaneous by plunging the red-hot tube and the foil wrapping into a bath of distilled water. The quartz tube resists these conditions very well, and we can thus carry on some new experiments by its aid.

To collect the gases and other products we proceed as follows, first taking care to observe the tube and its contents carefully before opening it, and if need be, by the hand-glass or the microscope. The gases should be collected over mercury, then measured and analyzed. To this end we take the cold tube in the hand and hold it immersed in a large tank of mercury with the pointed end downward, and we break off the point carefully by means of cutting pliers. The mercury rises gradually in the tube, up to a certain height which depends on the original pressure and the volume of the newly-formed gases. We then turn up the tube under a small test-tube filled with mercury and by regular and prolonged shocks all the gas is made to pass into the test-tube. The quartz tube which has been filled with mercury is emptied, and we measure the mercury either as to weight or volume, so as to have the exact capacity of the tube. On the other hand, we measure the gas taken from the quartz tube, by means of small graduated tubes from 2 to 5 cubic centimeters, well divided into one-hundredths of a cubic centimeter, and giving a reading to the hundredths. Then we proceed to analyze the gases by the usual methods.

As to the solid bodies of the tube, either the original matter or bodies which are formed during the experi-

air. In fact, the volume of these gases, when reduced to the atmospheric pressure, represented only 0.015 of the interior capacity of the tube. The gas is formed of nitrogen 0.9 and carbon monoxide 0.6, or a total of 1.5. The nitrogen comes from the air, whose oxygen went to form the carbon monoxide gas. Thus the elements of the air penetrated into the tube by endosmose during the experiment.

2. Amorphous carbon, as above. Weight 9 milligrammes. Capacity of the tube 29 cubic centimeters. The tube was filled with pure nitrogen and was heated for some minutes over a flame. Then the gas was rarefied, so as to lower its pressure to 16 centimeters mercury, or one-fifth the atmospheric pressure. The tube was sealed and then heated to 1,300 degrees for one hour. The internal pressure must have risen under these conditions to about 1.3 atmosphere. It had swelled out the softened tube. After cooling, the tube was opened over mercury. The volume of gas taken from the tube, when reduced to atmospheric pressure, was 7.3 cubic centimeters, that is, much superior to one-fifth of the initial volume. This gas was formed of nitrogen 0.82, and carbon monoxide 0.18. The formation of the carbon monoxide, as well as the increase in the volume of the gas, showed that the oxygen had penetrated into the tube by endosmose.

3. Hydrogen. Several experiments were made with tubes containing hydrogen, and these confirmed the former results. The following may be cited as an example. Pure hydrogen, at an initial pressure of 15.2 centimeters mercury, the atmospheric pressure being 75.1 centimeters. Capacity of the tube 5 cubic centimeters. Heat, 1,300 degrees C. Volume of gas finally extracted, 0.68 cubic centimeter at atmospheric pressure (instead of 1.0 cubic centimeter, which was the initial volume reduced to atmospheric pressure). The final gas contained 0.12 cubic centimeter nitrogen. These figures show that upon 100 volumes of hydrogen, 44 volumes disappeared, either by passage through the