While listening to the debates this evening my attention has been called by Mr. Webster to the fact that one of the subjects to be discussed by the International Committee on Testing Technical Materials, is that which we have here advocated; a paper having been announced in the program to be read by Mr. Albert Sauveur, of Boston, editor of the *Metallographist*.

CHEMICAL SECTION.

Stated Meeting, November 15, 1898.

[ABSTRACT.]

AGRICULTURE IN THE HAWAIIAN ISLANDS.

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DESCRIPTION OF THE HAWAIIAN ISLANDS.*

The island of Hawaii, which gives the name to the group, is the largest of the series, embracing about 4,210 square miles of surface.

The island of Hawaii is more than five times as large as the largest of the other members of the group. The three most important islands after Hawaii, together with their areas, are as follows: Maui, 760 square miles; Oahu, 600 square miles; and Kauai, 590 square miles. The total area of the four large islands of the group is 3,110,000 acres. The other islands of any agricultural importance are as follows: Molokai, 270 square miles; Lanai, 150 square miles; Niihau, 97 square miles; and Kahoolawe, 63 square miles. The total area of the islands where agriculture is possible is 6,740 square miles. There are hundreds of other islands connected with the group, but they are mostly barren rocks, and at present have no agricultural significance, with the possible exception of those where birds collect in great numbers, and where the carcasses of birds, as well as the eggs which they deposit, are valuable for fertilizing purposes.

*The lecture was illustrated with stereoptic photographs of the landscapes and crops of the Islands.

The whole territory embraced by the Hawaiian Islands is included between longitude $154^{\circ} 40'$ and $160^{\circ} 30'$ west, and latitude $22^{\circ} 16'$ and $18^{\circ} 55'$ north. The extreme northern limit of the islands is therefore a little south of Key West, but, owing to the prevalence of the northeast trade-winds, the climate of Hawaii is probably the most grateful of any tropical climate in the world. The temperature at Honolulu rarely rises above 90° , nor does it fall below 54° . A case of sunstroke has never been known on the islands. White men can work in the open air and upon the farm in all parts of the islands, and this is not possible in other tropical countries.

The prevailing winds are the northeast trades. These blow for about nine months of the year. The islands possess a healthy climate. There are no virulent fevers such as are encountered on the western coast of Africa and in the West India islands. The island of Hawaii has been formed as the result of the action of four great volcanoes which are now extinct. The present active crater of Kilauea is evidently of too recent formation to have played any important part in the formation of the island. By the successive eruptions of the old volcanoes, and the cooling of the lava thrown out, mountains of lava have been formed by the four chief craters of the following respective heights: 13,805, 13,675, 8,275 and 5,505 feet. These peaks lie at an average distance of about thirty miles each from the other. It is evident that at first the spaces between the volcanoes were covered by the sea, but by the gradual degradation and overflow of the lavas these valleys have been filled up, and now in some places lie as high as 3,000 feet above the sea level.

From a geological study of the volcanoes it is evident that as they grew higher they opened lateral craters, due to the pressure upon the top of the crater. It is due to these lateral craters, largely, as well as to disintegration of the lava thrown out from the central one, that the intermediate spaces between the volcanic centers were filled. One of these lateral craters was developed from Maunaloa in 1868, when a stream of lava poured down

to the sea, making the water very hot to a distance of more than a mile from the shore, and killing all living things in contact with it. Dr. Maxwell observes that "in the space of a day's ride he noticed no less than eighty-nine of these lateral cones, and observed mounds covered by forests on the mountain slopes which suggested many more. Each one of those in its day and measure was a center of eruptive force. Lava in some form came from their throats, and fumes of acidulated steam escaped from fissures in the lavas in their localities, leaving marks of their action of disintegration which are not difficult to distinguish. This distribution of centers of eruptive action gives to the valleys dividing the great cones the true character of vast volcanic plains."

CHARACTER OF HAWAIIAN SOILS.

The typical soils of the Hawaiian Islands have been carefully studied by Dr. Walter Maxwell, formerly one of my assistants in the Chemical Division of the Department of Agriculture, and for some years past the director of the agricultural experiment station which has been founded by the planters of the islands.

From a study of the geology of the Hawaiian group it is evident that these islands are entirely of volcanic origin. Professor Dana says in regard to them, "The Hawaiian Island group is a sample of a line of great volcanic mountains. Fifteen volcanoes of the first class have existed at different times and been in action along the line." The group of islands therefore represents that portion of the great mass of matter due to volcanic action which is projected above the water level. Doubtless these islands are connected by ridges of volcanic matter which perhaps have never been above the surface.

The character of the original rocks composing the islands is therefore evidently that of lava in general. The rock formations are not sedimentary, but have resulted from the cooling of the lavas which have been projected from the volcanoes. This at least is true as far as the surface of the mountains is concerned. The great up-

lift forming the ridge probably was due in part to the ordinary causes producing mountain ranges, namely, the cooling and shrinking of the earth's crust. For agricultural purposes, however, the lavas are the only rocks which are to be considered, since it is from the decomposition of these lavas that the soils of the islands have been formed. The lavas have resulted chiefly from the fusion of rocks of basaltic nature, and hence the composition of the original lavas is such as would be produced by the fusion of basalt. The differences between the lavas and basalt would simply be those due to igneous action on fused basalt exposed to the air. The Hawaiian lavas resemble in their chemical constitution the basalts existing in the United States. A comparison of the analyses of a great number of lavas with a great number of American basalts is given in the following table :

Materials.	Analyses.	SiO ₂ .	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Na ₂ O	K ₂ O
		Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Hawaiian Lavas	18	47.90	18.23	13.36	8.99	6.05	2.20	1.50
American Basalts	20	49.15	15.66	9.50	8.29	7.90	2.84	1.90

In the above table the analyses of lavas were made by Dr. Maxwell and his assistants, and of basalts by Prof. F. W. Clarke, of the United States Geological Survey, and his assistants.

FORMATION OF SOILS FROM LAVAS.

The formation of soils from lavas takes place under practically the same conditions which attend the weathering of ordinary rocks in the formation of common soils. All rocks, when exposed to the chemical and physical action of the forces which are found on the surface of the earth, suffer disintegration. Some kinds of rocks, of course, disintegrate much more rapidly than others, but all are affected. Soil, from an agricultural point of view, is the *débris* of rocks mixed with decayed organic matter. The forces which act upon rocks and lavas are many. Some of the more important ones only are mentioned here.

First of all may be considered the merely physical attrition. The beating of the rain, the eroding action of running water, the friction of the wind, and the grinding of particles of dust projected against the rocks, all tend to the same end, viz., the reduction of the rocks to fine particles.

The action of bacteria is also helpful to the disintegration of rocks. Even in localities in high mountains, where it would be supposed that bacteria did not exist, it has been found that fragments of rock are permeated to a greater or less depth with these organisms. In the exercise of their vital functions the particles of rock in contact with them become eroded, and are gradually rendered easy of degradation by other forces. Especially are the nitrifying bacteria active in erosion of this kind, since whenever they exercise their true vital function nitric acid results, and this acid acts rapidly upon most rocks in effecting decomposition. Even on rocks which seem almost bare, certain mosses and lichens are found to grow, and the vital activity of these vegetable growths rapidly affect the texture of the rock. It has been repeatedly shown that rocks, especially carbonates, when in contact with the rootlets of plants, suffer solution in all parts of contact. The growth of mosses and lichens in like manner disintegrates the rock and renders the processes of comminution easy. In the decay of organic matter, especially under the action of organisms, large quantities of acids are formed, which are carried into the rocks by the rains and help to dissolve them. The action of nitric acid has already been referred to. The action of carbonic acid which results from the oxidation of organic matter, is also powerful in effecting the disintegration of rocks. When the processes of soil formation have once started and small quantities of rock *débris* are formed, the growth of larger plants and the existence of terrestrial worms and insects help a still more rapid disintegration. In colder countries and on mountain peaks, where the temperature at times falls below freezing, the expansive force of water passing into the form of ice often helps to split up the rocks into smaller fragments. Inasmuch as many of the rocks are formed in conditions where metallic compounds tend to be

reduced to a metallic state or to a lower degree of oxidation, it is found that the oxygen of the air itself is a powerful disintegrating agent. It is carried into the exposed rocks either in the air itself or by water, and in oxidizing the lower to a higher oxid, or metals to the condition of oxids, powerful disintegrating influences are exerted. It is under these and similar influences that the lavas which have flowed out over the surface of the Hawaiian group have gradually been converted into soil.

In the regions of active volcanoes water has acted in a more powerful way, because it is forced into all the crevices by the steam rising from the volcanic action. The heavy rains, which often occur in those vicinities, fall into the craters of the volcanoes, and reappear as steam. It is probable, also, that subterranean passages admit water to the regions of great heat whence the lavas come, and the water thus admitted is converted at once into steam, and finds egress through the crater of the volcano and through all the crevices communicating therewith. In many parts of the islands this action of steam on the exuded lavas may still be seen.

The general nature of the various craters in their original form may be surmised by a study of one of more recent origin. The crater of Kilauea is 3,972 feet above the sea level. The area enclosed within this crater is 2,650 acres. This was doubtless in the not very far remote past a lake of liquid fire. The actual area, however, which is covered by melted lava at the present time is not more than 50 acres. Throughout the whole area of the crater, however, volcanic evidences may be seen. It is stated by Dr. Maxwell, who has made a careful study of this locality, that in the morning before sunrise, when the temperature is low, a large part of the floor of the crater is concealed by condensing steam which issues from fissures and fractures in the lava which have been produced by partial cooling. In some instances the condensing steam shows an acid reaction to litmus paper, and in a few instances the steam was found to be extremely acid. Over the areas covered with steam it was noticed that there were deposits of materials which

would be brought up through the fissures, and wherever this acid steam came into contact with the surface, evidences of rapid solution were seen. In one case, where a quantity of the steam was condensed and preserved for analysis, it was found to contain 4.92 per cent. of sulfuric acid. This steam contained no chlorine, showing that the sea water does not have ingress to the sources of volcanic activity. In the opinion of Dr. Maxwell, the action of this acidulated steam is one of the most important of the factors concerned in the disintegration of the lavas in the islands. In order to determine the effect of this action alone, as separate from that of surface forces, Dr. Maxwell removed the overlying slabs of lava and secured blocks from below which had never been exposed to surface forces, but only to the action of the acidulated steam mentioned above. At the time of taking the specimens the blocks were so hot that the hand could not touch them. Two of the larger specimens were found partially studded with crystals of sulfur. Where the steam has eaten out cavities in the blocks they were found partly filled with crystals of gypsum and alum. Over the surface and within the blocks iron was found oxidized and collected in pockets of red ochre, while the silica was separated into distinct masses of so-called yellow ochre. The process of decomposition was found to continue after the blocks were removed to the laboratory, so that the processes could be studied as they were taking place.

TYPICAL SOILS DERIVED FROM THE DECAY OF LAVA.

Two general types of soils are recognized as the resultant of the decomposition of the lavas in the Hawaiian Islands. These are distinguished at once by their color, and the two types are known as the "dark red soils" and the "yellow soils." This distinction in color, however, does not always serve to define the types of soils themselves, as both the chemical analysis and the character of the crops produced show that the soils of the yellow color sometimes belong to the red type and the soils of red color to the yellow type. It must not be understood from the names given to the typical soils that all the soils of the islands can be readily

grouped by their appearance into two classes. Between these definite types may be found all gradations of color, and a gradual merging of one type into another. In general in the islands the red soils are considered the more fertile, but, as intimated above, this is not always the case.

The dark red soils appear to have come, as a rule, from the lavas which were more or less free-flowing at the time of their ejection, and which have undergone slow disintegration, and where the rainfall has not been abundant. These soils usually are rather deep, in some places extending to a depth of three or four feet without any marked change of texture or color. The red color is so deep as to be appropriately designated "blood red." In many places where these soils have been formed large blocks of lava remain undecomposed, and are scattered over the surface of the soil in much the same way that the rounded boulders are found as the result of glacial action. Great expense is often necessary to remove these boulders in order to prepare the surface for cultivation. It is evident that this coloration of the soil is due chiefly to the oxidation of the iron contained in the original basaltic lavas from which the soils were formed. In the oxidation of the iron the first step is doubtless its conversion into ferric oxid. If this disintegration takes place at high temperatures, and in the presence of a minimum amount of water, the ferric oxid is practically free from hydrate and the color is a deep red. If, however, the oxidation takes place in the presence of an abundant supply of water, ferric hydrate may be formed, varying in color from red to yellow. It is evident that the temperature at which ferric oxid alone would be formed in the presence of steam must be rather high. It has been demonstrated by experiment that at a temperature of 200° F. in the atmosphere, ferric oxid is formed directly and no ferric hydrate is produced. It is evident, therefore, that the yellow soils, the other typical variety, have been formed in conditions of oxidation favoring a production of ferric hydrate. This is rendered the more certain from the fact that when these yellow soils are heated, and the combined water which they contain is driven off, they assume at once a red color.

Nearly allied to the dark red soils which have just been described may be mentioned the light red or crimson soils. These are essentially of the same typical character as the dark red soils, but contain a larger proportion of organic matter and a smaller quantity of lime.

YELLOW AND LIGHT RED SOILS.

The yellow and light red soils have evidently been derived chiefly, not from normal lavas, as was the case with the dark red soils, but from lavas which at the time of their ejection have been subjected to some sudden change which altered to some extent their nature. Lateral or tufa cones, as has already been remarked, are found in all parts of the islands, and the soils which have been derived from these—that is, the tufa soils—are consequently found over large areas. The tufa lavas are evidently the result of the expiring activities of large craters where the ejective force is not sufficient to drive the lavas entirely to the top of the cone, but only through the lateral fissures. The yellow soils therefore evidently have arisen chiefly from the decay of the masses of tufa lava. These originally were composed of mixed colors with very distinct shades, but by the action of water and wind and cultivation, the colors have been gradually mixed until the soils have assumed the yellow tint which gives them their characteristic name.

SEDIMENTARY SOILS.

In addition to the typical soils formed *in situ* which have been mentioned above, it is evident that sedimentary soils must be found in the valleys and other places in the islands where the original soils have been subjected to any considerable degree of translation. The sedimentary soils are usually found at low levels, and have resulted chiefly from the heavy rains in the mountains carrying the soil particles down and depositing them in the valleys. Some of the most fertile plantations of the islands are located on sedimentary soils. In some cases evidences are seen that these soils were at one time subjected to the action of the sea, showing that there have been considerable changes in level since the soil formation commenced on the islands.

DISTRIBUTION OF RAINFALL.

The rainfall in the Hawaiian Islands is extremely uneven and unevenly distributed. At Sprecklesville and Lahaina, on the island of Maui, the mean annual rainfall is only about 20 inches. Around the district of Pepeekeo the annual rainfall amounts to about 150 inches. At Olaa, on the island of Hawaii, on the windward side and at an elevation of about 2,000 feet, the rainfall for the years 1894-5 was 177 inches, while at Kailua, on the leeward side and nearer to the sea, it was only 51 inches during the same period.

RELATIVE FERTILITY OF THE SOILS.

As has already been mentioned, the dark red or blood-red soils, as a rule, are more fertile than the light red or yellow type. The sedimentary soils are almost equal in fertility to the dark red variety. The average period of cultivation of the chief agricultural regions of the islands, so far as sugar making is concerned, is twenty years. It is only about sixty years since any sugar at all was grown in the Hawaiian Islands for sale, although sugar-cane had been grown in a small way for domestic consumption for a much longer period. It was not until 1880 that any great advance was made in extending the sugar crop of the islands. In 1880 the total amount of sugar produced was only 30,000 tons. At the present time the annual production is about 250,000 tons. The productivity of the soils of the different types is clearly set forth in the following table, showing an accurate measurement of the average crop per year produced on more than 80,000 acres of land for a period of three years. The estimates were made only upon those areas upon which the typical soils were well marked.

TYPES OF SOILS.	Approximate Number of Acres.	Yield of Sugar Per Acre.
		Pounds.
Dark red soi's	30,000	10,411
Yellow and light red soils	32,000	6,291
Sedimentary soils	20,000	10,301

The average number of crops of cane secured is one in two years. Although the actual time of the growing of a single crop may not be much over eighteen months, the other six months must be allowed for the time of preparing the land, planting, etc. From the above it is seen that there is very little difference in the yield of sugar obtained from the dark red and the sedimentary soils, while the yield from the yellow and light red soils is only a little over half of the other two. The character of the cane grown on the yellow or light red soils, however, is higher, the canes being richer and the juices expressed therefrom being purer. It requires, therefore, a less number of tons of cane grown on the yellow or light red soils to produce a ton of sugar than from the others. This is shown in the following table :

SOILS.	Tons of Cane Per Acre.	Purity of the Cane Juice	Tons of Sugar Per Acre.	Tons of Cane to 1 Ton of Sugar.
		Per Cent.		
Sedimentary	47.80	84.2	5.11	9.1
Yellow or light red	23.60	92.5	3.08	8.1

COMPARISON OF HAWAIIAN AND AMERICAN (CONTINENTAL) SOILS.

It is interesting to compare the soils of the islands with those of the United States. In the very first place we notice the great difference in the origin of the soils. As has already been stated, the soils of the islands are essentially the products of the disintegration of basaltic lavas. The soils of the continent, on the contrary, are the product of the disintegration of limestones and granites. In addition to this, a large portion of the continent of North America occupied by the United States is covered by drift; that is, soil which has been deposited during the Glacial Age. This drift soil has in many cases been brought from remote localities, and in other cases has resulted from the grinding of the rocks in the leveling of the hills and filling up of the valleys due to glacial action. On the American continent, therefore, we find a great variety of soils, while on the

Hawaiian Islands, the soil is essentially of a single origin. A large number of analyses of typical American continental soils has been combined in the following table to get the average figures. In comparison with these are two columns of average data obtained from the analysis of a large number of Hawaiian soils of two types, viz., lowland and upland. The relative proportions of the different ingredients in the soils are shown in the table.

Ingredients.	American (continental).	American Lowlands.	Hawaiian Uplands.
Organic and combined water	5'18	16'80	23 30
Silica (insoluble)	69'02	10'29	10 67
" (soluble)	7'39	13'39	9'90
Titanic oxid	—	5'07	5 19
Phosphoric acid	0'34	0'72	0'87
Sulfuric acid	0'07	0'18	0'13
Carbonic acid	0'04	0'20	0'03
Iron peroxid	12'56	25'15	26'17
Alumina		23'54	20'06
Lime	0'79	0'85	0'64
Magnesia	0'73	1 35	0'95
Manganese peroxid	0'27	0'12	0 15
Potash	1'53	0'65	0'71
Soda	2'11	1'34	1'28

The most striking difference in the comparison above noted is shown in the quantity of insoluble silica. American soils are made up chiefly of sand in some form of combination or as pure silica. The table shows that altogether more than 76 per cent. of our continental soils consist of silica, of which nearly 70 per cent. is insoluble and a little over 7 per cent. soluble. In striking contrast with this are the data for the Hawaiian soils, showing for the lowland type a little over 23 per cent. of silica, and for the upland nearly 20 per cent. of silica. In striking contrast, too, are the relative proportions of soluble and insoluble silica in the two soils. In the American continental soil the insoluble is almost ten times the soluble, while in the Hawaiian soils the soluble and insoluble silica exist in almost equal quantities. The silica of the

American continental soils is largely replaced by iron and alumina in the Hawaiian soils. In the latter almost 50 per cent. of the total weight of the soil consists of iron and alumina existing in about equal proportions, while in the American continental soils only about eight per cent. of the total weight is composed of iron and alumina. Hawaiian soils may therefore be regarded as iron and alumina soils, and American continental soils as silicious in their composition. As is justly observed by Dr. Maxwell, the two kinds of soil are wholly different in their nature, and therefore the conclusions from an agricultural point of view which are derived from the study of one set of these soils cannot be applied with any degree of confidence to the other. The acidic elements in American soils are largely in excess, while in Hawaiian soils the basic elements preponderate.

One important consideration is derived from a comparative study of the two soils, viz., that plants are capable of adapting themselves to types of soils radically different, provided the plant food which these soils contain is accessible. In regard to the actual plant food which is present, it may be noticed that the phosphoric acid in the Hawaiian soils is about double that in the American continental soils. Potash, on the other hand, in Hawaiian soils is less than half that in the American continental type. In organic matter, on the other hand, the Hawaiian soils have the advantage, containing from three to four times as much organic matter and combined water as are found in typical American soils.

The Hawaiian soils are essentially new; in fact, the processes of soil formation are still rapidly going on. The American continental soils, on the other hand, are old, geologically considered—as old as those of the continent of Europe or of Asia.

ZONES OF AGRICULTURAL ACTIVITY.

For the purposes of agricultural consideration the Hawaiian Islands may be divided into four zones.

The first zone comprises that portion of the land beginning at the sea level and rising to an altitude of about 1,500

feet. All of this soil which is sufficiently decomposed and of proper contour and accessible to water is suited to the growth of sugar-cane, and the sugar-cane area comprises practically the lands situated between the limits of the altitude mentioned. In some rare cases sugar-cane is grown very successfully at a higher altitude, even up to 1,900 feet, but these cases are very exceptional. About one-half of the total area under cultivation in sugar-cane is artificially irrigated; the other half of the area depends upon the natural rainfall for its moisture. The character of the sugar cane grown in the Hawaiian group is probably better than that grown in any other quarter of the earth. The tonnage per acre is very high, and the juices of the cane very rich in sugar and very pure. Yields of 8 tons of sugar per acre have been secured, and an average of 4 to 5 tons per acre is counted upon in favorable years. The limit of cultivation of sugar-cane, aside from altitude, is determined by the degree of decomposition of the soil, the contour of its surface and the supply of water, the latter being the most important factor. The practical absence of running streams on the islands renders it necessary to collect the water artificially, either by ditches on the mountain sides to collect the surface drainage during times of storm, or by wells from which water is pumped to a sufficient altitude to secure the irrigation. It is evident, therefore, that the process of irrigation is expensive, and the quantity of water available is limited.

The second zone of agricultural activity comprises those areas suitable to cultivation lying at an altitude of from 1,500 to 3,000 feet. This zone is peculiarly suited to the culture of coffee, which has lately been undertaken in a systematic way on the islands. The coffee produced on the islands is now chiefly grown on Hawaii, and from the name of the district where the coffee is cultivated it is known as Kona coffee. The coffee produced is remarkably valuable, being esteemed of a finer quality than the best Mocha or Java. While the quantity of coffee produced is not yet very great, in fact, not enough to become a commercial factor, yet where it has been exposed for sale in San Francisco it has brought a higher price by about three cents per

pound than the finest coffees on the market. Many advantages to coffee culture are presented in the Hawaiian group. In the first place, at the altitude mentioned, viz., 1,500 to 3,000 feet, it is found that artificial shading of the trees is not usually necessary. This, as is well known in tropical countries, especially in Nicaragua and Guatemala, is a very important factor in coffee growth. In the first attempt at growing coffee in the Hawaiian group it was thought to be necessary to secure artificial shade by planting trees of rapid growth and exuberant foliage. The coffee grown under these conditions has not been of as good quality as that grown without any shading other than that afforded by the trees themselves. In the second place, owing to the higher altitude, the precipitation in the coffee zone is sufficient to secure the growth of the trees without irrigation. Were it necessary to practice irrigation for the growth of the trees, it would be impossible to expect any large extension of coffee growing in the islands, since all the available water is now employed, practically, for the growth of sugar-cane, which is more profitable than that of coffee.

In the coffee zone are grown with considerable success the vegetables and small fruits, and even grains, necessary to the sustenance of the farmers. There are many places, also, in which cinchona, camphor and rubber trees grow with exuberance.

The zone in which vegetables, small fruits and grains grow may be called the third agricultural zone, although it overlaps in almost every place the zone suited to the growth of coffee. So these two zones, viz., that in which the coffee grows and that suited to the growth of vegetables, fruits and grains, may be considered together. The importance of the proximity of the vegetable zone to the coffee growers is at once apparent without further illustration. It requires several years to bring a coffee grove into bearing. Meanwhile the owners and workers of the grove must live. If they were compelled to purchase all their fruits, vegetables and other foods, the cost of bringing a coffee grove into bearing would be greatly increased. Therefore, it is seen that the proximity of the

zone where ordinary human foods can be produced in sufficient abundance is of the highest significance in considering the development of the coffee groves of the islands.

The fourth zone, from an agricultural point of view, occupies altitudes of from 3,000 to 5,000 feet. At these altitudes, wherever the contour of the surface is sufficiently smooth and the lava rocks sufficiently decayed, is found fine pasturage, where beef cattle and other domestic grazing animals flourish. It is not generally known that on these plateaus practically all the meat which is consumed in the Hawaiian Islands is produced. It is evident that these grazing lands can be made more generally effective by introducing modern methods of stock raising, so that the supply of domestic meat can be greatly increased. From an agricultural point of view that country is destined to the greatest prosperity which has the most fertile soil, the most favorable climate, the greatest variety of productions and the best markets. In all of these respects the Hawaiian Islands are most favorably situated, and it is evident that under the beneficent influence of American control, or as a part of the great American nation, they are destined to reach a state of evolution which is only limited by the areas which can possibly be brought into cultivation.

PRINCIPAL CROPS.

The chief agricultural product of the Hawaiian Islands is sugar. From what has been said it is seen that the sugarcane grows in the greatest exuberance in the dark red soils and in the sedimentary soils near the coast. There is, perhaps, no other quarter of the globe where so large a quantity of sugar can be produced per acre as in the Hawaiian Islands. The possible crop of sugar, however, is limited by two conditions: (1) the small area of land which is suitable for sugar culture; and (2) the supply of water. In those portions of the islands where the annual rainfall is less than 35 inches, it is necessary to practice irrigation. Unfortunately the excess of water which falls on one side of the islands, where the rainfall is sometimes as high as 170 inches, cannot be utilized on the parts of the islands where

the rainfall is deficient. The greatest economy, therefore, must be practiced in the use of the water, and the greatest technical skill displayed in constructing reservoirs for holding the excess which is precipitated until such time as it may be needed by the crop. It is evident that all of the land suited to agriculture cannot be devoted to sugar growing, since there is a certain limit of appropriation which must not be passed. Vegetables and fruits must be grown on the islands, since it is cheaper to produce them than it would be to import them. In addition to these, the rice and taro plants must also find a place. From a careful study of the areas which can still be brought under culture, and the quantity of water which may be made available for irrigation, it seems to me that the maximum production of sugar in the islands may be conservatively placed at 500,000 tons, a little over double the annual amount now produced. In the agricultural possibilities of the islands, therefore, it is not wise to count upon a future maximum product of more than the amount just mentioned.

It is further evident that the production of sugar is not an agricultural industry in which a poor man could profitably engage, except as a renter. The cost of bringing the lands under irrigation, and the great cost of sugar factories would prevent the poor farmer from engaging in the industry on his own account. Large capital controlling large interests is necessary to produce sugar at a minimum cost.

The planting and cultivation of sugar-cane in the islands are conducted in general as in other cane-producing countries. There are, however, some peculiar conditions connected with the industry in the islands which deserve mention. In localities where the supply of water is not abundant, as, for instance, at Sprecklesville, it has been found that it is more profitable to plant the cane freshly for each crop than to depend upon the ratoons. If the water be placed upon the ratoons after the harvesting of the crop in order to preserve their vitality the growing cane must be neglected, and if the water be used for the growing cane the ratoons must be left to die. For this reason, in the localities mentioned it is customary in nearly all cases to plant anew for each crop.

In other localities, where the supply of water is abundant, either under irrigation or by natural rainfall, the crops are left from ten to twenty years without replanting, the ratoon canes producing abundantly, and having a rich and pure juice.

As in other countries, the ratoon canes contain more fiber and woody matter than the canes grown directly from the first planting. Usually, in planting, the small canes which are left in the field and the tops of the good canes are planted. Sometimes young ratoons are cut and planted. As little as possible of the rich and mature cane is used for seed purposes.

In the older fields artificial fertilizing is carried on extensively. All kinds of fertilizers are used, some of them blindly and others with due regard for the needs of the crop. At Sprecklesville, especially, the soil is deficient in nitrogen, and nitrogenous fertilizers are about the only ones employed. For this purpose fish scrap from Alaska is used. The principal point in Alaska where this fish scrap is prepared is Killisnoo.

The manufacturing season begins at various times. In fact there is no period of the year when it is not possible to make sugar. Generally, however, the season lasts from the 1st of January to the 1st of June.

RICE AND TARO.

Rice and taro are two crops which are grown under water. The white citizens of the islands who are not native born do not well endure the work in rice and taro fields. In the islands the labor of the production of rice is left almost exclusively to the Chinese and Japanese, while the production of taro is conducted by the natives.

Rice culture is so familiar that it is not necessary to describe it in detail. It can only be practiced on level areas where large quantities of water can be secured for flooding. There is, however, an upland variety of rice which is grown with considerable success in the islands. This rice does not require submersion, but grows after the manner of an ordinary cereal. Its yield per acre, however, and its quality,

are not considered equal to the rice of the lowlands grown under water. Nevertheless the rice industry is one which is capable of a considerable degree of expansion, and the product of the rice fields finds a large market at home.

The taro is a plant which is known botanically as the "*Colocasia antiquorum*." It is also a plant which is grown under water. The taro gardens are very small in extent, but the quantity of food which they produce is something enormous. It has been estimated that a taro patch 40 feet square, containing 1,600 square feet, will produce enough food to sustain one person for a year. The taro is a plant which resembles, in many of its properties, the sweet cassava, which grows in such abundance in this country, in Florida. The starch and other nutritive properties, however, are stored in a bulbous root, and not in roots which extend from a central stem in every direction, as is the case with the cassava plant. The taro, like the cassava, contains an acrid principle, probably, as is the case with cassava, hydrocyanic acid, which renders it unsuitable for eating in the raw or fresh state. On baking or boiling, this acrid principle, being volatile, is expelled and the baked mass is entirely free of the objectionable taste and styptic qualities of the fresh material.

In the preparation of taro the bulbous roots are cleaned and baked, usually in ovens built in the earth, the heat being furnished by hot stones, previously heated by burning wood. The baked or boiled root is beaten to a paste in a wooden trough with a pestle made of a rounded piece of lava. It is then mixed with water and allowed to stand for two or three days until fermentation has taken place. Water is added until the paste is of a given degree of consistency, and the material, after thus fermented and mixed with water, is the great national diet of the natives, and is known as "poy." Poy is made either of the one-, two- or three-finger variety, the thickest paste being eaten with one finger, the next thinner variety being eaten with two, and the thinnest paste of all being eaten with three fingers. Poy is eaten by the family out of a common bowl, into which the fingers are stuck, when with a skillful whirling

movement the poy is made to adhere to the finger and is then carried to the mouth and sucked off. Poy, being a starchy material, is very fattening, and on account of the ease with which it is produced and prepared, it is the food which is preferred by the native population. The whites also, after a time, learn to like it. In the valleys where the taro is grown, the patches planted are so constructed as to receive the water from a running stream. The bottom of the pond is made of fertile clay or soil, and the native islander, by working only an hour or two a day, can keep his-taro patch free of weeds. The growth of taro will probably continue, indefinitely, to be one of the great agricultural industries of the islands, supplying the natives with their chief quantity of food.

COFFEE CULTURE.

The coffee industry in the islands has, in the last few years, grown very rapidly, hundreds of thousands of young trees having been planted, and many of them are just coming into bearing. Coffee trees are first sprouted in a nursery, and after attaining a growth of one or two years are transplanted to the coffee groves. As has already been intimated, it has not been found necessary, in the Hawaiian Islands, to protect the coffee plants in the groves by planting other trees. The moderate temperatures at which the coffee groves are found do not prove injurious to the plants. This is a great advantage which the Hawaiian groves have over those in the hot tropical countries, where the planting of shade trees is an absolute necessity.

Coffee trees, when properly grown, begin to bear in the fifth or sixth year, and by the seventh year, in favorable conditions, they ought to produce enough coffee to pay for their care and the interest and other fixed charges on the plantation. After the seventh year the coffee trees should yield a profit. Unfortunately for the coffee growers, the rapid decline in price which coffee has undergone in the last few years has prevented many of the owners of orchards from making the profit which they expected.

FRUITS AND VEGETABLES.

In the uplands fruits and vegetables grow with good success in parts of all the islands. It is evident that as the population of the islands increases the production of fruits and vegetables will acquire a greater agricultural significance. Strawberries, raspberries and other small fruits are grown with excellent results, and in some localities even apples and other fruits of that class can be produced. Bananas and cocoanuts are easily grown, and afford a considerable degree of encouragement for the agriculture of the future. Already large quantities of bananas have been exported from the islands, chiefly to the San Francisco markets. Pineapples grow in great abundance, and are sources of profit to the small grower. Cattle and pigs flourish in many parts of the islands, and pigs especially are found in almost every portion, as their flesh is much prized, not only by the natives, but also by the white settlers of foreign birth. There are many cattle in the hill countries where there is good grazing and yet where the land is too rough for cultivation. At these high altitudes the grazing of cattle for the meat market will probably prove profitable.

HARDSHIPS FOR THE POOR IMMIGRANT.

I have set forth above, briefly, and yet I hope clearly, the conditions which attend the practice of agriculture in the Hawaiian Islands. It is well that the intending immigrant of small means consider carefully all the hardships which he may expect before he finally decides to migrate to our far-off Pacific possessions. If he go as a mere laborer, he will have to begin in a climate to which he is not accustomed, although it is an agreeable one, and to come in competition with the cheap labor which has already been established in that locality by the importations from China and Japan. The Hawaiian Islands are, therefore, a place which, it seems to me, the American laborer should avoid, unless he can go under contract with some of the large agricultural interests, like the large sugar factories of the islands.

For the small farmer there is more encouragement, as the

growth of pigs and small fruits in the uplands, coffee on the middle hills or uplands and cattle in the grazing lands still higher, form some of the inducements for profitable labor. Nevertheless, the small farmer must act with great caution and not cast his fortunes hastily in a land so far away.

For the capitalist there are yet large opportunities of successful investment in the islands. There is still a large amount of sugar land which can be brought under cultivation, but this requires a heavy outlay of capital. There are few areas now unoccupied in sugar production in the Hawaiian Islands where the land could be properly cleared, smoothed and irrigated for less than \$100 an acre. Add to this the original cost and the fixed charges of the investment, and it is seen that large capital is necessary to push forward the sugar industry in the islands. Still, I think that of the three classes of probable immigrants mentioned, viz., the laborer, the small farmer and the capitalist, the advantage certainly lies with the latter.

We have seen how crops, which for countless centuries have grown on other soils, adapt themselves without harm to the new environment to which they are subjected in the islands. Here the future years will see the garden spot of the great American people, led by fate to extend their liberties and their institutions to the islands of the Pacific. The climate will attract alike the invalid, the eager traveler, the weary seeker after rest and the immigrant. Nowhere else will the sun's rays be found so grateful, the flowers so eternal, the breezes so balmy. Men and plants thrive equally well in these dreamy regions, children of the sun and sea, where neither the heats of summer wither nor the snows of winter chill. May we not hope that the flag, emblem of our progress and our power, shall also take root in this new soil, and the blessings of liberty and progress be ever secure beneath its folds.