SEVENTEENTH ANNUAL MEETING OF THE
GEOLOGICAL SOCIETY OF AMERICA.

By EDMUND OTIS HOVEY.

THE seventeenth annual meeting of the Geological Society of America was held at the University of Pennsylvania, Philadelphia, December 29 to 31, 1904, under the presidency of Prof. John C. Branner, of Stanford University. Sixty-one papers, divided among eight branches of the science, were presented for reading, and about one hundred members of the Society were in attendance, making the convention one of the largest in its history. The report of the Council for the year 1904 shows that in all respects the affairs of the Society are in a highly satisfactory condition. The net active membership of the Society was reported as being 259, and 15 new members were elected at the Philadelphia meeting. During the past year, five members have been removed by death: Prof. C. E. Beecher, J. B. Hatcher, Henry McCalley, W. H. Petree, and Charles Schäffer. Memorials of these members were read at the first session of the Philadelphia meeting.

Prof. Branner chose as the subject of his presidential address "Geological and Geographical Studies on the Northeast Coast of Brazil," and illustrated his paper by means of numerous photographs and charts. The most peculiar feature of this coast is the series of hardened sandspits, occurring at the mouths of most of the rivers. These spits consist of quartzose sand, which has been cemented together into a hard solid rock by means of calcium carbonate brought down in solution by the rivers and precipitated by contact with the waters of the ocean, which here possess a high degree of salinity. This hardening extends to a depth of several feet and, in many instances, has been of great economic importance through the formation thereby of natural breakwaters, forming safe harbors, as at Pernambuco. The spits contain many fossils, all of which are of living species. A second coast feature of importance is the series of coral reefs, which alternate or which are associated with the sandspits in certain localities. These reefs seem to be comparatively thin, but many of them are wide. That the coast has remained stationary for a considerable time, is indicated by the fact that these reefs reach to the upper limit of coral growth, where they show broad areas of dead coral within the fringe of living animals.

In the restricted space of a summary report like the present, it will not be possible to do more than briefly outline the contents of the more important of the 43 papers which were actually read, leaving out of account those which were read only by title.

Dr. Robert Bell, director of the Geological Survey of Canada, read a somewhat detailed paper on the geology of the region in the vicinity of the Great Slave Lake, and illustrated his remarks by maps and sections made for the Canadian Survey. Prof. E. R. Cumings, of the Indiana State University, discussed the development and morphology of Fenestella, and showed that this Devonian Bryozoa is related genetically to the Cyclostomata.

In a paper containing new evidences of the geographical differences of fossil faunas of the same age, Prof. H. S. Williams, of Cornell University, stated that extended study of the Devonian rocks of the eastern United States pointed to the conclusion that geological faunas once thoroughly established probably possessed a geological range far greater than is indicated by the actual range in any particular section.

The petrographic and economic papers were introduced by Prof. James F. Kemp, of Columbia University, in a paper detailing observations made along the garnet contact zones and associated copper ores at San José, Tamaulipas, Mexico. These contact zones are the result of the action of an intruded bed of andesite upon the surrounding Cretaceous limestone. Geologically, the formation of garnets has been the most important feature, and has resulted from the rearrangement and recrystallization of the materials present in the limestone. The chalcopyrite, which is the important ore, is a later phase of the contact phenomena. In another communication, Prof. Kemp described his method of "Geological Bookkeeping," which is a system of taking notes in the field, and of locating the observations upon the field map, based upon a series of definite and invariably subdividing squares. This leads to a compilation book, in which the observations of scattered seasons are entered upon pages which correspond in their enumeration to the series of squares on the field map. It is believed that the system possesses advantages in affording permanency and intelligibility of records, even though the latter be made at widely diverse times and by different individuals.

In a paper on the occurrence and distribution of celestite-bearing rocks, Dr. E. H. Kraus, of Michigan State University, stated that the mineral occurs widely throughout central New York and southern California. The percolating waters have leached out the crystals to a considerable extent, forming the so-called "vermicular" limestones of New York and the "gashed" and "acicular" dolomites of Michigan. Precipitation of the material from these waters is the source of the large deposits of celestite which occur at Put-in-Bay, the Maybee Quarry, Monroe County, Michigan, and elsewhere.

Prof. T. C. Hopkins, of Syracuse University, described the closely crystalline, fine, fossiliferous, metamorphic limestones of central and southern California, which contain the wonderful deposits of tourmaline and other gems which have been obtained within the past few years from Eldorado County southward to the national boundary.

According to Dr. G. P. Merrill, of the National Museum, the so-called asbestos (fibrous serpentine) of the Thetford mines, Canada, and elsewhere, fills cavities which were made by the shrinkage of the massive serpentine, in which the fibrous material occurs, and he advanced arguments to prove that the filling process is due to crystallization from the walls of the cavities inward.

Messrs. Ralph Arnold and A. M. Strong, of the California State University, described at length the crystalline rocks of the San Gabriel Mountains near Pasadena, California. The last of the petrographical papers was by Dr. G. M. Murgoci, of Bucharest, Roumania, and concerned the origin of the peculiar kind of rock known as riebeckite granite, suggesting that the change from normal granite was due to heavy pressure combined with motion.

Five papers on physiographical geology were presented, three of which were read in full. Prof. N. M. Fenneman, of the University of Wisconsin, in a paper on the control of the form of contact surfaces by marine denudation, laid down the principles that the nature of a surface of unconformable contact between strata is determined by two factors: (1) the topography of the early land surface, and (2) cliff erosion during submergence. The first element would preserve the former land surfaces in the subsequent beds, while the dominance of the second element would make the contact surface in every case a plane.

Prof. R. S. Tarr, of Cornell University, described some drainage features of southern central New York, showing the relation of the pre-glacial valleys to the present surface. In many instances along the divide between the Susquehanna and St. Lawrence drainage system there is a condition of lowered divides, across some of which, as in the Tioughnioga valley, east of Cortland, and the Cayuta Creek valley, west and south of Van Etten, the present drainage passes. There are three theories to account for these phenomena: glacial erosion, erosion by ice-fed stream, and head-water erosion during rejuvenation. Evidence from valley form, glacial deposits, and hanging tributary valleys shows that these drainage features are in many cases, if not in all, due to changes of earlier date than the advance of the last great ice sheet. While the influence of possible earlier ice advances, of which no evidence has been found in this region, is not eliminated, the facts so far discovered favor the hypothesis of rejuvenation rather than of glacial action during earlier ice advance.

The next paper pertained to hanging valleys, and was by Prof. Israel C. Russell, of the University of Michigan. He recognizes four classes of such valleys, each of which contains several varieties. The author considers that too much stress has been laid upon the existence of lateral glaciated hanging valleys on the sides of glaciated troughs, and he advances evidence to show that in certain instances at least such valleys are not due in a conspicuous manner to differentiation of glacial erosion. The study of glaciated hanging valleys is intimately connected with a still greater problem, namely, the origin of the leading features in the relief of such mountains as the Sierra Nevada range and the Cascades. There is good reason for thinking that these two ranges were deeply stream-sculptured prior to the glacial epoch.

Under the head of physical and structural geology twelve papers were read. Prof. C. K. Leith, of the University of Wisconsin, discussed in masterly fashion the present state of knowledge of the subject of rock cleavage, with special reference to recent publications by Dr. Becker and himself. The author has devised a piece of apparatus which mechanically illustrates his theories in a remarkable manner. Dr. E. H. Kraus, in a paper on the origin of the caves of the island of Put-in Bay, Lake Erie, stated that in all probability the folding of the Lower Helderberg limestone of the region was due to hydration of anhydrite, since large deposits of gypsum have been encountered in sinking wells in the immediate vicinity. The increase in volume caused by such hydration may be as high as 60 per cent, and the energy developed in the process would be sufficient to account for the results observed. Subsequent leaching out of the gypsum by percolating waters would account for the existence of the caves, and the collapse of the roofs of the cavities would account for the steplike form of the ceiling.

Mountain growth and mountain structure was the subject of a communication from Mr. Bailey Willis, of the United States Geological Survey. The study of peneplains at various altitudes with reference to sea level, in North America and Eur-Asia, demonstrates that elevations of the earth's surface have resulted from deformation, which produced warping of previously leveled-off surfaces. In general this process has been a recent one, post-Mesozoic in time, and it may be held that mountains are youthful features of the earth. The structures which have been discovered in mountain masses are such as are developed under a considerable load, and consequently at notable depths in the earth's mass. Study of the relation between structure and form leads to the conclusion that modern mountains are not the effects of the forces which produce the structure, a conclusion which cuts at the foundation of older systems of classification.

Prof. Florence Bascom, of Bryn Mawr, brought out by means of detailed maps the nature of the formation and the structure of the Piedmont region of Pennsylvania, giving the results of extended field work carried on for the United States Geological Survey. Her paper was followed with one on the Piedmont of Maryland in correlation with that of Pennsylvania, by Prof. E. B.

Mathews, of Johns Hopkins University. The latter author afterward read a paper on the Cockeysville marble, in which he gave the results of much very close field study by himself and W. J. Miller, of Baltimore, into a concrete problem in Piedmont structure, the area concerned occupying approximately 300 square miles, and lying north of the city of Baltimore.

Mr. N. H. Darton, of the United States Geological Survey, in discussing overlap relations along the Rocky Mountain front range, described features which have been traced by him through Wyoming and Colorado into New Mexico, mainly for the purpose of correlating the different forms. He finds that the Palaeozoic and Mesozoic rocks of the region present frequent variations in character, occurrence, and varieties. In the course of his field work, Mr. Darton visited the Zuñi salt lake, forty miles south of the Indian pueblo of Zuñi. At this locality there is in the plain a circular depression about a mile in diameter, containing a salt lake and two cinder cones. The depth of the depression is about 200 feet, and its walls are of Cretaceous sandstone, capped on one side by a lava flow. All around the rim there is a wide low ridge of volcanic ejecta, which has been laid down in water. The history of this remarkable feature is not clear.

Prof. Frank D. Adams, of McGill University, presented the results of an investigation made by himself and Mr. E. J. Coker into the cubic compressibility of rocks and certain phases of rock flow. The apparatus employed was an improvement of that which had been used by Prof. Adams in some remarkable experiments, the results of which were published five years ago. In the present experiments, nickel-steel tubes have been used, and the compressibility of fourteen typical rocks determined. The deformation of the rock-making minerals concerned was carefully studied by means of the microscope.

Mr. E. O. Hovey, of the American Museum of Natural History, presented three papers upon the Caribbean volcanic islands. He described the Soufrière of St. Lucia as being the result of waning volcanic activity manifested along ancient fissures, but not within any recognizable crater. The Boiling Lake of Dominica is considered to be within an ancient broken-down crater, from the southern portion of which there was a superficial eruption of dust and fine lapilli in 1880. The third of these papers pertained to the present condition of Mont Pelé, which was stated to be in a condition of intermittent mild activity; the dome, which has formed as a feature of the eruptions which began in 1902, is still undergoing modifications, elevation and subsequent destruction by explosion being nearly balanced. The great spine was destroyed more than a year ago.

The six papers upon glacial geology which were read gave rise to much discussion. The first of the series was by Prof. R. S. Tarr, upon the moraines of the Seneca and Cayuga Lake valleys. During the recession of the Wisconsin ice sheet, a stand was made near the heads of the two lake valleys—Cayuga and Seneca. This major ice stand consisted of a series of minor halts in the receding ice, which projected lobes up the two lake valleys, and minor lobes into the side valleys. By reason of the irregularity of topography and the several minor halts, a complex series of moraines was accumulated, both as lateral and terminal deposits, the latter being developed with especial intensity in the two major valleys south of the heads of the lakes.

The drumlins in the Grand Traverse region of the northwestern part of the Southern Peninsula of Michigan have been studied recently by Mr. Frank Leverett, of Ann Arbor, Mich., who contributed a paper on them which, in the absence of the author, was read by Prof. Russell. Particular attention was devoted to modes of development, since more than one mode appears to have been operative; some drumlins have been sculptured from earlier deposits at the last ice advance, and some built up during that advance from material contained in the ice. Attention was called incidentally to heavy deposits of nearly pebbleless laminated clay, apparently laid down in interglacial lakes, for this clay has been molded to some extent into drumlin forms by a subsequent ice invasion. Large valleys excavated in this interglacial clay were briefly discussed, and shown to antedate the production of the drumlins, the latter being in some cases built upon the valley bottom.

A second paper upon the drumlin areas of Michigan was delivered by Prof. Russell. It described with some detail two regions in the Northern Peninsula of Michigan, in which drumlins form the most conspicuous features of the topography. One of these areas includes Les Cheneaux Islands and a part of the adjacent mainland, on the north shore of Lake Huron; and the other area is situated principally in Menominee County, to the west of Green Bay. The drumlins are for the most part smooth-surfaced, half cigar-shaped hills of the normal type, but in a few instances instructive irregularities are present. Among these irregularities are: a flattening of a portion of the normally elliptical ground-plan, as if a marginal portion of a well-shaped drumlin had been removed by erosion, leaving an abnormally steep slope; deep transverse trenches at right angles to their longer axes; straight or curved trenches extending from their summits down their sides; irregular pits in their normally smooth surfaces; and, in one instance, a terrace-like shelf with a convex longitudinal profile, parallel with the crest-line of the drumlin on the side of which it occurs. In the valleys between the drumlins, there are several eskers. From the evidence, the conclusion is

drawn that the drumlins of the Menominee area were produced by ice erosion from a previously deposited till sheet.

The drumlins of central New York State were the subject of a brief paper by Prof. H. L. Fairchild, of the University of Rochester, who also summarized the more important glacial problems in the State. A third paper by Prof. Fairchild took up the thesis that the theory of erosion by ice is a fallacy, in amplification of a paper presented by him at the preceding annual meeting of the Society. The author gave arguments for arriving at the conclusion that deep ice erosion of living rock has never been proven, and that it is practically impossible of accomplishment. In New York State there seems to be positive proof that there has been no effective excavation by ice in the valleys of the Finger Lakes, the field study thus sustaining the theoretical consideration of the question.

The stratigraphical section of the programme showed the largest number of titles of papers offered and read. Prof. W. G. Miller, of Toronto University, discussed the pre-Cambrian rocks in the vicinity of Lake Temiskaming, Ontario, not only from a stratigraphical but also from an economic point of view. The region in question shows at the base a complex assemblage of igneous rocks including granite. Erosion of this complex has given rise to conglomerate and finer-grained slate-like rocks. Afterward ensued a second period of erosion, during which arkose and quartzite were deposited on the surface of the older two series. Finally each of these three series is intersected by dikes of pre-Palaeozoic age. The second group or series, the conglomerate and slate, is of economic interest on account of the occurrence therein of fissure veins carrying important amounts of silver and of cobalt and nickel ores and smaller quantities of other ores.

In a paper on the palaeogeography of St. Peter time, Dr. C. P. Berkey, of Columbia University, showed by means of charts and sections the probable varying distribution of land and water during the formation of the St. Peter sandstone of Minnesota. The rock was interpreted as of marine origin where early deposited. The region then became a land area, with the production of sand-dune phenomena, after which there occurred another period of submergence. In the discussion which followed the reading of the paper, the fact was brought out by Prof. Gilbert van Ingen that rounded sand grains are not necessarily an indication of arid conditions of deposition, since they are found in coastal sand-dunes to-day. Dr. Berkey's second paper was upon the stratigraphy of the Uinta Mountains, and announced the discovery of an erosion interval in the section, which favored referring the great basal Weber quartzite to Cambrian age, rather than to Carbonic, as held by King, or to Devonian, as contended by Powell.

Prof. A. W. Grabau, of Columbia University, in a paper on the relative areas of the Oneida and Shawangunk conglomerates, advanced the theory that these beds represent different portions of a basal conglomerate in the transgressing Silurian sea. In another paper, Prof. Grabau discussed Helderberg seas and the interrelationships of lower Devonian strata in the eastern United States. Charts were used in showing the long narrow Cumberland sea, as this body of water is called. Mr. C. A. Hartnagel then, in some notes on the Ontario (Silurian) section of eastern New York, traced the comparative sections to the west and to the east of the Helderberg Mountains, and showed the continuous character of the Cobleskill beds. On the east the formation immediately beneath this is, probably, Salina in age, down to and through the Shawangunk conglomerate as the basal member of the Salina group.

The age of the Morrison formation of the Rocky Mountain region was the theme discussed by Mr. N. H. Darton, who has carried on extensive field work along the outcrops. It has been found that the Morrison formation is of wide extent in the Rocky Mountain region, from Montana to New Mexico, but evidence as to its age is meager. Abundant mammalian remains occur, but the palaeontologists do not agree as to the horizon, some investigators regarding them as Jurassic and others as late Cretaceous. The meager fresh-water molluscan fauna is not definitive. Some time ago, Mr. Willis T. Lee found evidence that Morrison shales give place to Comanche deposits in western Oklahoma, and the author has found similar relations in the Two Butte uplift in southeastern Colorado, and concludes that the Morrison strata are of Comanche (Lower Cretaceous) and that sandstones occur representing both the Lakota and the Dakota sandstones of the Black Hills region.

In a paper on the classification of the Upper Cretaceous formations of New Jersey, Prof. Stuart Weller, of Chicago University, reviewed the schemes proposed by the State survey at various times, and, by means of fossils, substantiated the subdivision which had been made by Knapp and Kummel on lithologic grounds alone. Prof. Weller then went on to discuss in detail in a second paper the fauna of the Cliffwood, N. J., clays, which form the most notable example of marine sedimentation in New Jersey during Raritan time.

The fossils of Cook's Inlet and the Alaska Peninsula have been made the subject of careful study by Messrs. T. W. Stanton and G. C. Martin, of the United States Geological Survey. The section shows a great thickness of beds, which are well provided with fossils. The beds seem to be closely related to the Jurassic strata of Russia. The scientific programme was closed by Prof. G. H. Perkins, of Vermont University, with a paper on the Tertiary lignite of Brandon,

Vermont, and its fossil fruits. These historic beds were worked for fuel during the anthracite coal strike, and as a result many specimens of fossil fruits were found, most of which are described now for the first time.

The officers of the Society for the ensuing year are: President, Raphael Pumpelly, of Dublin, N. H.; first vice-president, Samuel Calvin, of Iowa City, Ia.; second vice-president, W. M. Davis, of Cambridge, Mass.; secretary, H. L. Fairchild, of Rochester, N. Y.; treasurer, I. C. White, of Morgantown, W. Va.; editor, J. Stanley-Brown, of New York city; and librarian, H. P. Cushing, of Cleveland, O.

IRRIGATION IN THE UNITED STATES.

The Bureau of the Census has just published a bulletin showing the condition of irrigation in the United States in 1902. This report was authorized by a joint resolution passed by the House at the first session of the Fifty-seventh Congress, and was prepared under the supervision of Mr. LeGrand Powers, chief statistician for agriculture, by Mr. Clarence J. Blanchard, now of the Geological Survey.

The statistics presented were obtained by correspondence, supplemented by fieldwork in a few States and by information given by State engineers and their assistants.

The report is introduced by a short history showing the growth and development of irrigation in this country, and the statistics are presented and discussed by regions, by States, and by drainage basins.

During the last twenty years there has been an awakening to the opportunity that lies in the arid West for the farmer and the homemaker, and a remarkable transformation has taken place in many parts of this region. Thousands of miles of canals, representing a vast expenditure of money and labor, distribute water upon more than 8,000,000 acres of land, which once was a barren desert but now is annually producing crops worth \$100,000,000.

The remotest parts of our great desert are being reached by railroads, and the introduction of facilities for transportation has been followed by a corresponding increase in irrigation. The irrigators, too, are becoming more experienced; their labors are less severe and their achievements are greater than those of their predecessors, because they have learned how to subdue and apply the forces of nature through innumerable inventions. Problems of water storage and diversion have been worked out to a practical solution. Every available stream is now a potent force for good. The dams that hold back and store the floods also furnish abundant electric power for all purposes, and even the flow of the canals turns wheels that lift large quantities of water to fields above the level of gravity supply.

With the development of irrigation the range supports larger herds and flocks, while in more than one valley the irrigation ditches have made possible the development of great mines. Populous and prosperous cities have risen in the desert and have attained commercial and mercantile greatness.

The statistics for 1902 show that 33,415 systems with 59,311 miles of main canals and ditches irrigated 9,487,077 acres on 134,036 farms. The amount expended in constructing these systems was \$93,320,452.

The increase from 1899 to 1902 was more than 20 per cent for the number of irrigated farms, the number of irrigated acres, and the construction cost of the systems.

The statistics are classified according to the three sources of water supply—streams, springs, and wells. The streams are by far the most important, since they supplied more than three-fourths of all the systems and more than nine-tenths of the irrigated farms and acreage.

While irrigation in all portions of the United States is for the same general purpose, the degree of requirement, the extent of exploitation, and the methods of application differ widely in certain more or less well-defined regions.

In this report the United States is divided into the following regions: The arid region, comprising those States and Territories between the western boundary of the Mississippi valley and the Pacific Coast, where agriculture is dependent almost entirely upon the artificial application of water to the land; the semiarid region, comprising parts of those States lying midway between the Rocky Mountains and the Mississippi River, wherein the rainfall is so uncertain that irrigation is necessary except during years of unusual precipitation; the rice producing States, comprising parts of Texas and Louisiana and certain counties in the Carolinas and Georgia; and the humid States, represented by several of the New England, Middle Atlantic, and Gulf States, in which irrigation is practised to a limited extent.

The report shows that in 1902 there were in the arid region 91.1 per cent of the total number of irrigated farms, 89.3 per cent of the irrigated acreage, and 83 per cent of the construction cost of the systems. Although irrigation was carried on most extensively in the arid region, the rate of increase from 1899 to 1902 was less for that region than for any other. In irrigated acreage the increase was 16.6 per cent for the arid region, 52.6 per cent for the semi-arid States and Territories, 76.2 per cent for the humid States, and 141.3 per cent for the rice States.

Of the nine States and two Territories in the arid region, California ranked first in both the number of irrigated farms and in the total construction cost of systems; Utah ranked second in the number of farms,

and third in the construction cost; and Colorado ranked third in the number of farms and second in the construction cost. In total irrigated area, Colorado ranked first; California, second; and Montana, third.

For the arid region the average construction cost per acre was \$9.14, and the average per irrigation system was \$2,710.

For the semi-arid region as a whole, it may be said that ordinary crops can not be grown more than three years out of five without the artificial application of water. The soil, however, is, with few exceptions, as fertile as any in the United States, and with sufficient moisture produces large yields of any crop suited to the temperate zone. In this region the number of irrigated farms increased from 4,897 in 1899 to 7,021 in 1902, or 43.4 per cent, while there was a gain of \$2,212,947, or 76.5 per cent, in the construction cost of systems. The largest relative increase was shown for North Dakota. In this region Nebraska ranked first and Texas second in the extent of irrigation.

Although rice is grown in nearly all of the Southern States, the practice of irrigation in its culture is confined principally to the coast counties of the Carolinas and Georgia, to the Mississippi delta, and to the coastal prairies of Texas and Louisiana. These coastal prairies were considered to be fit only for grazing until experiments in 1897 proved the peculiar adaptability of the soil for rice culture. Then many farmers from the States of the Middle West went to this country and engaged in the cultivation of rice. They introduced improved methods and modern machinery, and there was a wonderful development in this industry. Now thousands of acres are being irrigated annually for the production of rice.

In Louisiana the year 1902 was a year of great extremes. The growing season was marked by excessive drought, while the season of harvest was one of great rainfall. The increased number of pumping plants drew so heavily upon the rivers and bayous in the prairie region that their levels were lowered and salt water came up from the Gulf and caused considerable damage. In order to prevent a similar occurrence, dams costing many thousands of dollars have been built or are being planned, and additional levees have been thrown up.

Irrigation in the humid States is practised largely as an insurance against the droughts that occur early in the growing season. In 1902 irrigation was reported from Maine, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Florida, Alabama, and Mississippi. In the New England States and in Pennsylvania it was confined principally to hay meadows bordering on small streams. A few farmers reported the irrigation of vegetables and small fruits, and exceptionally large yields were obtained.

In the winter of 1894-95 nearly all of the large orange groves in Florida were destroyed by frost, and many of the fruit growers were compelled by circumstances to engage in truck farming. They used their irrigation plants in the new work and the yields were improved and the profits became greater. Since the value of irrigation in truck farming was demonstrated in this way many farmers have installed plants that may be used for irrigation purposes when needed. In this State the progress of irrigation has been remarkable; a great variety of crops are irrigated, and the irrigation systems are among the most modern in the country.

The future development of the arid and semi-arid country depends largely upon the volume of its streams and the utilization of as large a proportion thereof as possible, and, in order that a better knowledge may be had of the extent to which these waters are being used, the statistics are also presented by drainage basins.

The Mississippi River drainage basin ranks first in importance for irrigation. The Mississippi valley proper is a region of ample rainfall, but the great western tributaries of the river flow through land where irrigation is of the utmost importance, and almost one-third of the total irrigated area of the arid and semi-arid regions is supplied by these streams. The waters of this drainage basin supplied 2,906,665 acres on 27,999 farms. Its 8,090 systems, with 20,135 miles of canals and ditches, cost \$20,494,070.

The Great Interior basin includes the most desert-like part of the arid regions, and, except in isolated localities, agriculture without irrigation is impossible. Throughout this basin the demands of irrigation have exhausted the normal flow of all the streams, and in years of light snowfall in the mountains, crops suffer severely. Conservation of the floods on nearly all of the streams will have to be resorted to in order to allow more land to be irrigated.

The reports for this basin show 22,805 irrigated farms with 1,575,757 acres. The systems numbered 3,324 and cost \$10,505,530. In this basin there were 8,027 miles of canals and ditches.

The Columbia River basin was third in importance in 1902, with its 5,470 systems irrigating 1,288,935 acres on 19,163 farms. These systems with 10,373 miles of canals and ditches cost \$10,767,664.

The Colorado River, both in length—2,000 miles—and extent of drainage area—approximately 225,000 square miles—is one of the greatest rivers of the arid West. However, the discharge of the Colorado River, direct, is less than that of many of the small eastern rivers because of the extreme aridity of the country. As a result of the canyon-like character of the Colorado Valley, there were only twenty systems supplied from the main stream. Practically all of the irrigation is from systems heading near Yuma, Ariz.