NATURAL GAS INSPECTION FORCE

THEODORE KINGSBURY, Supervisor.

DEPUTIES

C. N. Brown ..... Geneva
John Ersinger ..... Sullivan
J. P. Horton ..... Montpelier
J. E. McIntyre ..... Marion
Herschell Ringo ..... Muncie
Geo. H. Smith ..... Owensville
John Watson ..... Petersburg
Howard Legge ..... Bloomington
O. H. Hughes ..... Sharpsville
E. E. Wherry ..... Shoals

PUBLICATIONS

Reports and articles were prepared and published during the year as follows:

"Report of the Division of Geology," Indiana Year Book, 1921. This report contains an account of the work and finances of the division and technical papers as follows: "The Building Stones of Indiana" and "Cement Materials and Industries."

A map showing the distribution of oil and gas in Indiana was prepared and published in "The Petroleum Register," New York.

An article entitled "In Case of a Petroleum Shortage" was published by the Oil News. "The Division of Geology" was published in Indiana Academy of Science. Many extracts of reports were published in the newspapers of Indiana. Reviews and notices of the Kaolin and the Petroleum reports were published in Science, Economic Geology, Journal of Geology, University Quarterly, Oil News, Petroleum, Magazine of the New York Petroleum Exchange and other periodicals. "The Oatsville Oil Field," Oil News. "Oil Shales of Indiana," Engineering and Mining Journal, Oil Shale Review, and Street. Chapters on geology were prepared for "A Survey of Indiana's Natural Resources" published by the Department of Conservation. Articles prepared, or partly prepared, for publication include: Handbook of Indiana Geology, The Geology of the Clay City Quadrangle, the Oil Fields of Pike, Gibson and Sullivan counties, the Gas Structures of Tipton and Howard counties, the Coal Field of Indiana.

ARCHAEOLOGICAL INVESTIGATIONS

Field investigations in archaeology were undertaken during the year in connection with the geologic investigations. A number of new archaic deposits were located. Besides the work done by the regular field party the following were engaged for brief periods in such investigations: W. N. Logan, J. R. Reeves, Dick Guernsey and T. C. Heistand.

due to the formation of scales on the tubes by the large amount of calcium sulphate in solution. Various softeners were used to reduce this with some results. Frequent scalings were also necessary. By the method described above a potash matter was extracted averaging about 20 per cent potassium oxide.

At the time the plant was closed down (about two years ago) potash was being produced at a cost of approximately $2 per unit or ten cents per pound pure potassium oxide. Mr. Baylor believes the cost of production can be reduced materially by increasing the output of the plant and improving the method gradually.

AN INTRAFORMATIONAL BRECCIA OF THE ST. LOUIS LIMESTONE OF INDIANA

JOHN R. REEVES

According to Graubau (1) an intraformational breccia is one formed from the sequential divisions of a single rock series, and according to C. D. Walcott's (2) definition, which is somewhat more explicit, an intraformational conglomerate is one formed within a geologic formation of material derived from and deposited within that formation. It must be stated here before going further with the discussion, that the terms "intraformational breccia" and "intraformational conglomerate" have been used in describing similar formations. The difference between the two is that the embedded material of a breccia is more angular and less water worn that that of a conglomerate, the matrix or cementing material being nearer the composition of the fragments of the breccia and the time that elapsed between the fragmentation and embedding less. However, these are only general distinctions and cannot be said to hold true in all cases.

In speaking of the origin of intraformational conglomerates Walcott (2) says, "The presence of the conglomerate above the limestone beds, from some portions of which they were derived, leads me to believe that the sea bed was raised in ridges and domes above the sea level and thus subjected to the action of shore ice if present, and the aerial agents of erosion. From the fact that the limestone upon which the conglomerate rests rarely if ever show traces of erosion where the conglomerate comes in contact with it, the inference is that the debris worn from the ridges was deposited in the intervening depressions beneath the sea." It does not seem probable that a single layer a few feet thick lying in a shallow sea near a shore could be raised in ridges and domes above the sea level without a folding of the rocks below also, and this is not usually the case since the breccia is intraformational and the rocks above and below are parallel. But if there were special forces sufficient to cause the folding of such a layer, it is difficult to conceive of a thin rock of sufficient strength to withstand folding and subsequent erosion.

F. W. Sardeson (3) thinks that "giant sea weeds anchored to the bottom, if entangled by rafts of other sea weeds driven by storms or

One of the most valuable discoveries was that of the skeleton of a human being exhumed by Mr. Dick Guernsey, assisted by T. C. Heistand. The skeleton was taken from a prehistoric mound near the east fork of White River, in Guthrie Township, Lawrence county. The mound had been laid out in the form of a square and a vault system, constructed of slabs of limestone brought from the river bluffs some distance away, occupied the lower part. The upper part consisted of loose sand in which bodies had been buried promiscuously. The skeleton was obtained from the lower level and was lying as buried with all parts intact and in position with the exception of some of the more fragile parts. The skeleton is that of a man about six feet high and somewhat past middle age at the time of his death. As far as could be ascertained from the remains, death occurred from natural causes. The fragment of an arrow point was found between the cervical vertebrae and a small bone, that of a bird, apparently, in the roof of the mouth. Another arrow point and a bone awl made from the antler of a deer were found near the body.

The teeth of the lower jaw are in good condition with the exception of the right anterior pre-molar which shows evidence of decay. There had been some absorption of the tissue of the lower jaw at the base of the teeth, due evidently to pyorrhea. The upper jaw on the right side has three good molars, the pre-molars are badly worn and one bicuspid is lacking. On the left side of the upper jaw the canine, bicuspids, the anterior pre-molar and the posterior molar are gone.

The skull measurements are as follows: The anterior-posterior circumference of the skull is 24¾ inches; the lateral cheek circumference is 21¼ inches; the distance from coronoid process to coronoid process is 4 5/16 inches; the distance from the exterior of right condyle to the exterior of left condyle is 5½ inches; the submaxillary circumference is 8½ inches; the distance from the point of the submaxillary to the base of the frontal bone (anterior) is 5 inches; the lateral circumference is 7¼ inches; the distance from the nasal spine to the posterior side of the foramen magnum is 3 inches; the distance from mastoid to mastoid across the foramen magnum is 4¼ inches; the diameter through the zygomatic processes of the temporal bones is 5½ inches; the anterior-posterior diameter of the foramen magnum is 1 7/16 inches and the lateral diameter is 1 3/16 inches.

The skeleton was brought to Indianapolis and now rests in a case in the museum. Other explorations led to the discovery of several artifacts.

OIL SHALE INVESTIGATIONS

Investigations of the oil bearing shales of Indiana were carried on throughout the year in the field and in the laboratory. The investigations embraced:

1. The determination of the number of gallons of oil per ton of the various oil bearing shales.
2. The testing of different methods of extraction.
3. Possible methods of utilizing the spent shale.
4. The discovery of possible valuable by-products.

with just enough water to thoroughly mix it and form a comparatively dry briquette. These briquettes as they came from the machine were discharged through a gravity pipe into the upper end of a seven by 100 feet rotary cement kiln.

At first the material was not briquetted but fed to the kiln in a dry form as in the dry cement practice, but the results obtained were not satisfactory, due to the material slipping on the bottom of the kiln instead of turning over, the result being that the top part of the mix was overburned and the bottom part underburned. The mixture was then introduced in a slurry form. This necessitated the use of large slurry tanks, pug mills and pumps. Using the slurry mixture in the kiln gave a very intimate mixture and the desired turnover, but another difficulty became apparent. When the material in the kiln began to dry enough to be gummy it began to build rings on the walls of the kiln, thus shutting off the kiln draft. It was found impossible to operate the kiln for more than forty-eight hours without making a shut down to clean out the rings. Different methods were used to prevent the formation of rings, but none gave the desired results. After operating under these conditions for several months it was decided to make use of the good points of both dry and wet methods and eliminate their weak points. The briquetting machine was then installed, the product from it being a semi-wet material that was too dry to ring the kiln and at the same time coarse enough to give the necessary turn over in the kiln.

The heat in the kiln was produced by means of pulverized coal, the same as used in cement practice. Care was taken not to let the temperature go beyond 1,600 degrees F. Temperatures above 1,600 degrees cause the potash to volatilize and allow it to escape with the flue gases. The changes brought about in the kiln by this heat treatment consisted essentially of converting the insoluble potassium silicate to the soluble potassium chloride. In this heat treatment an average of 80 per cent conversion was effected.

After the heat treated bricks were discharged from the kiln they were carried into storage and allowed to cool. From this storage they were carried to the grinding machinery where the material was ground to the fineness of corn meal. After the grinding it was carried to the mixing pug mill where enough water was added to make a slurry thin enough to pump with the ordinary type of slurry pump. After being thoroughly mixed and agitated with water (usually about twenty minutes was enough to get all the potash in solution) it was pumped to continuous filter wheels where the original mixing water was extracted and the remaining dry cake on the wheel washed two or three times to extract the final traces of potash. By this method 98 per cent of the soluble potash was recovered. After going through the filter wheel process the solid residue was conveyed back to the cement mill where it was incorporated with the regular cement mix. The potash brine extracted in the filter wheel process was pumped to an evaporating plant where the potash and excess salt were separated. For the purpose of evaporation three Swenson single effect evaporators with the necessary auxiliaries were used. Difficulties were encountered here,

Three methods of extraction were employed, the dry process, the wet process and the heavy oil digestion process. The apparatus and machinery necessary for testing the last named process was furnished through the kindness of Mr. Louis Clarke of Ardmore, Pa., at an expense to him of about one thousand dollars.

Experiments conducted in our laboratory in extraction by using the heavy oil digestion process were unsatisfactory in the results obtained and led to the abandonment of the process. The unsatisfactory results obtained also led to the temporary abandonment of the commercial plant, ground for which had been broken in southern Indiana. As a result of these preliminary investigations in the laboratory many thousands of dollars were saved the investors.

Our efforts for the present are being concentrated on the dry distillation process. The method used will be the same as that used by the United States Bureau of Mines. In fact the future work on the oil shales of Indiana will be done in co-operation and under the advisory supervision of the Bureau of Mines. By the use of this method comparison can easily be made between the results obtained in Indiana and those obtained from oil shales in other states.

The following is a brief summary of the results obtained by our investigations thus far:

DATA ON THE NEW ALBANY OIL SHALE

Name—The New Albany Shale.

Age—Devonian and Mississippian.

Distribution—Southeastern Indiana in Jennings, Jackson, Clark, Jefferson, Scott, and Floyd Counties. Also White and Carroll.

Thickness- From 20 to 100 feet in the area of the outcrop. Total thickness about 140 feet.

Areal outcrop—500 square miles.

Transportation—Three main railways thru the district.

Price of the land—From $30 to $100. (Normal.)

Yield of oil—From 15 to 20 gallons per ton.

Specific gravity of the oil—Averages. .8900.

Fractionation of the oil—

150 degrees	17.75%
200 degrees	11.75%
250 degrees	17.75%
300 degrees	16.00%
Above 300 degrees	8.50%
Coke and tar	28.25%

Temperature of distillation—Best at 850 to 900 degrees, F.

Ammonium sulphate—From 5 to 20 pounds per ton.

Total nitrogen—From .25% to 1.00%.

Gas—From 500 to 2,500 cubic feet per ton.

Remarks—Shale can be quarried for from 20c to 50c per ton. Can be crushed in an ordinary limestone crusher. Overburden where found from 10 to 15 feet of glacial drift. Unlimited quantity of shale. Formation homogeneous thruout.

A little work has been done on the oil bearing shales of the Coal Measures. These, as a rule, contain a higher per cent of oil which in some samples investigated run as high as fifty gallons per ton. Mining conditions are different and more difficult in these shales. In some places these shales may be mined with the coal.

Company for bricks. No. 2 is the same as the first except that it is from the lower part of the formation. Blue shale, No. 3, was taken one mile west of New Albany and the shale was used for bricks.

DESCRIPTION OF THE NEW PROVIDENCE

The formation is the lower member of the Knobstone group of Indiana and is correlated with the Osage of the Mississippi Valley. The formation is underlain by the Rockford limestone and is capped with the Kenwood sandstone.

The formation is composed of soft green and blue shale easily disintegrated by weathering, particularly running water. The body of the shale is composed of very fine grains, over 85 per cent of which pass through a 200 mesh screen after being washed. These fine grains seem to be bound together by a greenish argillaceous material even finer in texture. The shale is plastic and can be easily molded. Locally there occur thin lenses of limestone and ellipsoidal nodules of siderite.

In Indiana the formation is at least 120 feet thick at New Albany. Across the river in Jefferson County, Kentucky, the formation, according to Chas. Butts, is from 150 to 160 feet thick as near as can be determined. The shale is at least 100 feet thick in Bartholomew County about five miles west of Columbus. A shale is being used at Brooklyn, Indiana, for bricks which is thought to be the New Providence. The shale is found elsewhere in Indiana in Scott, Jackson and Morgan Counties and probably others.

POTASH DEVELOPMENTS

In 1917 the Louisville Cement Company began to perfect a method by which to utilize the potash of the New Providence shale. As they were already using it in their cement mix, the matter of quarrying and a supply did not need to be considered. After long experimentation the following method, which has kindly been described by Mr. H. D. Baylor, superintendent of that company, was used at a profit. The method is essentially the same as other processes which convert the insoluble silicate to a soluble salt by replacement, the potash coming out in the form of a chloride or sulphate.

The shale was quarried by means of a steam shovel, loaded into dump cars, and hauled to the mill. Here it was first put through a dry pan mill for initial reduction, then passed through a rotary dryer to drive off all the excess moisture. After being dried it was mixed with the proper proportion of limestone and salt to bring about the transformation of potash. When treated the mix consisted of:

65 per cent New Providence shale (average 4½% K_2O).
25 per cent limestone.
10 per cent salt.

This mixture of material was conveyed to the raw grinding department where it was reduced to a fineness of 95 per cent passing a standard 100 mesh sieve. From here it was conveyed to a hopper directly over a briquetting machine. From this hopper a constant feed was drawn to the briquetting machine and at the same time it was sprinkled

FIELD WORK

During the past summer season systematic field work was conducted in the northern part of the Coal Measure area of the state. The territory included in the survey embraced parts of, or the whole of, Clay, Vigo, Parke, Vermillion, Fountain, Benton and Warren counties.

The field work consisted of a study of the topographic, stratigraphic, structural and economic conditions of the area.

The field party included the following members: W. N. Logan, John R. Reeves, Ralph E. Esarey, Glen G. Bartle, Marshall A. Harrell, Horace L. Barnett, Thos. C. Heistand, John I. Moore, Kenneth W. Ray, Elmer L. Lucas and William P. Rawles.

A number of problems connected with the distribution and identification of the coal beds were solved. Samples of coal, oil shales, fire clays and other materials were collected for study in the laboratory. These studies will be carried on by the laboratory force as time from other duties permits.

Dr. E. R. Cumings, assisted by Mr. P. B. Moore, made a study of the older rocks of the state and of Kentucky and Ohio with a view of correlating the rocks of the older divisions in the three states named.

Dr. C. A. Malott with Mr. Chas. Butts of the United States Geological Survey made a study of the Chester Division of the Mississippian period in Indiana and Kentucky. They succeeded in establishing a correct correlation of the subdivisions of the Chester in these two states.

After the close of the regular field season Mr. H. L. Barnett and Mr. W. P. Rawles collected data in the southwestern oil fields. They secured the elevations of the mouths of the wells above sea level, located the wells, secured logs and data on production.

The Chief of the Division, Mr. J. R. Reeves, Mr. Dick Guernsey and T. C. Heistand made some investigations of an archaic nature.

STATE FAIR

On account of the small amount of space furnished the Department of Conservation for exhibit purposes, it was impossible for the Division of Geology to make a creditable exhibit at the State Fair. Such an exhibit will be made whenever the space is available. During the week of the Fair and of the G. A. R. Encampment the number of visitors to the museum taxed its capacity.

LABORATORY DETERMINATIONS

A large number of minerals such as quartz, feldspar, mica, pyrite, also coals, clays, shales and other rocks and mineral substances were received from citizens of the state during the year with requests for information as to the value or possible usefulness of these substances. All qualitative tests were made without expense to the applicant, but for quantitative analyses, requiring the services of a chemist, the expense was borne by the applicant for the service. Both qualitative and quantitative tests were made at a minimum of expense to the citizen.

shallow sea water, probably on a coast as sand, small quantities of the soluble salts carried in solution by sea water may also be deposited, such as magnesia, lithia and salt. However, the presence of these materials most probably came from waters subsequent to deposition. Unless metamorphism of such a deposit takes place or unless it is subjected to the heat of a nearby basic intrusion, its composition after solidification is not liable to change.

A formation deposited under the above conditions is the New Providence shale. Although it is not certain, the main body of this shale probably came from Appalachia in a disintegrated form as sediment. These sedimentary silicates not being subject to chemical change under the prevailing conditions existent during their transportation were deposited in a sea of considerable depth. During this period of deposition which must have been long as the formation is 160 feet thick in places, it is possible that conditions prevailed under which the thin limestones of the formation as found in Jefferson County, Kentucky, were laid down.* Granite contains about 5 per cent potash, syenite 3 per cent, diorite nearly 2 per cent and gabbro less than 1 per cent. The New Providence shale contains from 3 to 6 per cent potash in the same form as found in the igneous rocks, about 60 per cent silica and 20 per cent alumina.

It has been suggested by Dr. W. N. Logan that the potash of this formation is glauconite or of glauconitic origin. The pale green and blue-green color of the formation suggests this as well as the amount of potash in the formation, although slightly lower than most glauconites. Microscopic examination of the shale has failed to reveal the grains of glauconite. Glauconite sand when exposed to weathering darkens, the glauconite grains becoming black or almost black. This is not characteristic of the New Providence. It may be noted that the consumption of glauconite and the New Providence shale differs. Though that fact may or may not have little bearing on the origin of the potash. Analyses of the glauconite show its silica content to average 50 per cent, the total iron 23 per cent, and the alumina 7.5 per cent. Analyses of the New Providence show its silica content to average 50 per cent, the total iron to be 5 per cent, and the alumina 18 per cent. The origin of glauconite has often been connected with the presence of marine fauna, but there is no evidence of marine life of any form in the New Providence shale with the exception of the very few thin lenses of limestone found in its upper part in Kentucky.

The first two of the following analyses were taken from Chas. Butts' Geology of Jefferson County. The third is taken from the 28th Rep., Ind. Geol. Sur., p. 513.

	K_2O	SiO_2	TiO_2	Al_2O_3	H_2O	Fe_2O_3	CaO	MgO	Na_2O
No. 1	3.98	63.38	.91	17.85	4.99	5.38	.38	1.47	1.29
No. 2	4.85	60.44	.80	19.92		6.48	.28	2.01	1.00
No. 3	4.87	60.40	.83	19.73		4.72	.78	2.10	.96

No. 1 was taken from the lower part of the formation, Coral Ridge, Jefferson County, Kentucky. Used by the Coral Ridge Clay Products

* Chas. Butts, Geology of Jefferson County, Ky., Geol. Sur.

The following is a summary of the determinations made by the division force during the year:

Alunogen	3	Pyrite	60
Calcite	5	Peat	7
Chert	8	Soils	3
Clay	57	Sands	19
Coal	40	Quartz	54
Conglomerate	1	Galena	3
Chalcedony	1	Hyalite	2
Diamonds	4	Iron ores	14
Feldspar	2	Jasper	6
Garnets	3	Limestones	23
Gas	7	Zinc Ores	9
Selenite	2	Water containing oil	30
Mica	21	Waters	20
Molding sands	7	Miscellaneous	37
Oil shales	29		
Oil sands	81	Total	589
Oils	31		

COMPENDIUM OF INDIANA GEOLOGY

For two years the members of the Division of Geology have been working on a compendium of the geology of Indiana. The preparation of this work required an exhaustive study of the literature of the subjects treated, in addition to investigations carried on in the field and laboratory. No work of this character has previously been undertaken in Indiana, though the desirability of such a publication has been recognized for many years.

The work is divided into a number of parts. The first part, dealing with the geography of Indiana, was written by Dr. S. S. Visher. It includes a discussion of the location of the state and the climatic and other effects which have been produced because of its location. The area of the state is compared with other states and the effects of size discussed. The quality of the land, the climate, agriculture, transportation, population, principal cities and industries are some of the topics treated.

The topographic features and the glaciology are discussed by Dr. C. A. Malott in the second part of the work. This part contains a discussion of the general topographic features of the state, the physiographic provinces, regional units based chiefly on topographic conditions, the principal features of the Wisconsin and the Illinois glacial stages, their boundaries, the driftless area of the state and other physiographic features.

The third part contains a discussion of the stratigraphic, paleogeographic and paleontologic conditions of the state and was written by Dr. E. R. Cumings. The history of the development of our knowledge of the stratigraphy of Indiana is carefully and systematically set forth. Problems of nomenclature are solved, the stratigraphy presented by the use of detailed cross sections, and paleogeographic maps. A very complete bibliography accompanies this part of the work.

seldom pure as they often contain other common salts as sodium chloride, sodium sulphate and calcium sulphate which are expensive to remove. Potash is sold, for example, as 75 per cent potassium sulphate which contains a 54 per cent equivalent of potassium oxide. In this case, of the material bought, 75 per cent is potassium sulphate and the potassium sulphate contains an equivalent of 54 per cent potassium oxide or pure potash, thus the buyer pays for the amount of potassium oxide only.

USES OF POTASH

Most of the potash used in the United States is for agricultural purposes as a fertilizer. As one of the essentials to plant growth, it is most likely to become exhausted. Caustic potash is used in the manufacture of fine soaps and is the base of all soft soaps. Hydrated potassium carbonate is used in the manufacture of high grade glass, such as is used in electric light bulbs, cut glass and optical instruments. Potash is also used in the manufacture of explosives and matches. Certain compounds of potassium are used in tanning leather, particularly chrome leather, in photography, electroplating, metallurgy, dyeing, medicine and in chemical laboratories.

PRODUCTION OF POTASH

Until 1917 most of the potash used in this country was imported from the Strassfurt deposits of Germany. This supply was shut off on account of the war until 1920, when a considerable amount was again imported. After the German supply became shut off in 1916 exploitation of known sources in the United States was begun and efforts were made to locate new deposits. Potash is produced from Searle's Lake of California, probably the richest source, from the Salt Lakes of western Nebraska and from the Great Salt Lake of Utah. Potash has also been produced from the sea water and from kelp or sea weeds. An organization has recently been effected to handle 10,000 tons of alunite daily from a deposit near Marysvale, Utah; however, some production has been going on here since 1916. Alunite is a hydrous sulphate of aluminum and potassium whose symbol is ($K_2O.\ 3Al_2O_3.\ 4SO_4.\ 6\ H_2O$) and is a much more common mineral than at first thought. The mineral is also found in several other states. Glauconite or greensand has long been used for fertilizing purposes and as a source of potash and lime. It is found mostly in the Atlantic coastal states.

THE NEW PROVIDENCE SHALE

When potassium bearing igneous rocks as granite, syenite, diorite and gabbro, are disintegrated by erosion, the sediments formed are redeposited usually as shales or clays. The chemical composition of these sediments is such that they are not readily subject to any chemical influences such as oxidation or weak acids, that may prevail during their transportation from the place of origin to the place of deposition. After the deposition of such sediments has taken place or during deposition, cementation usually occurs in the form of calcium carbonate, iron sulphide, or in certain cases some silicates. Having been deposited in

Some of the principal features of the hydrology of Indiana are set forth by Dr. W. M. Tucker in part four. This part contains a drainage map of the state, a map showing drainage basins, rainfall recording stations and gaging stations, data covering the flow and discharge of streams, maps of lake basins and other hydrographic information.

The fifth part, written by the Division Head, contains a discussion of the economic geology of the state. Building stones, cement materials, coal, clays, kaolin, iron ores, lime, marl, natural abrasives, mineral waters, oil and gas, peat, pyrite, road materials, sands, fertilizers, gypsum, gold, hydraulic limestone, lithographic limestone, manganese, diatomaceous earth, mineral paints, precious stones, salt and sulphur are the topics discussed.

The sixth part contains a discussion of the oil bearing shales of Indiana and was prepared by Mr. J. R. Reeves. The report discusses the distribution of the New Albany shale, its thickness, mineability, oil content, structure, accessibility, methods of extraction best suited to it, and the quantity of oil recoverable.

OTHER LINES OF INVESTIGATION

During the year data was collected in the field and laboratory on a large number of the mineral resources of the state. Samples of clay and shales were collected. The physical and chemical properties of these will be determined in the laboratory. Samples of building stones, abrasives, molding, foundry and glass sands, cement materials and road materials were collected. The investigation of all these materials will be made the subjects of future reports.

NATURAL GAS SUPERVISION

The supervision of natural gas conservation and the plugging of abandoned oil and gas wells is in charge of Theodore Kingsbury and his deputies: C. N. Brown, Geneva; J. P. Horton, Montpelier; John Ersinger, Sullivan; O. H. Hughes, Sharpsville; Howard Legge, Bloomington; Geo. Smith, Owensville; Herschell Ringo, Muncie; John Watson, Petersburg, and E. E. Wherry, Shoals.

Indiana law requires that wells drilled into gas or oil bearing rock that are to be abandoned shall be plugged in a specific manner described in the law, the object being to prevent any leakage of salt water, etc., from the lower strata to mix with fresh water strata nearer the surface or into nearby oil or gas domes. The plugging of such, the law stipulates, shall be done under the supervision of the Supervisor of Natural Gas or a deputy, for which there is a fee of $10 for each well plugged.

During the year the Supervisor of Natural Gas and deputies inspected the plugging of 424 wells. The previous year 406 wells were plugged. The wells plugged during the year were distributed in twenty-eight counties as follows:

WARREN COUNTY

"This county lies on the western border of Indiana, wholly within both drift areas. Virgin copper and gold are found in small quantities. These metals, with small nuggets of galena, were imported from the north. At Gold Branch of Pine Creek, on a gravel bar, a quantity of gold reported at $70 was collected. An energetic Californian can 'pan out' from $1.00 to $1.25 per day. An equal amount of labor expended at any ordinary avocation will bring better returns.

"Besides the above mentioned counties, gold has been found in minute quantities in Gibson and Pike, both along the border of the drift area, and in Sullivan County."

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POTASH IN THE NEW PROVIDENCE SHALE OF INDIANA

JOHN R. REEVES

The word "potash" is a trade name at first applied to some of the salts of potassium and later applied to other specific salts of this element. Potassium is an element belonging to a group known as the alkali metals and is similar in properties to sodium and lithium. Potassium does not occur free in nature, but in compounds, among which are the different forms of potash. The element is widely distributed, being found in sea and mineral waters, soils, saline beds, sea weeds, and in many rocks, shales, and clays, also in minerals such as orthoclase feldspar, glauconite, sericite and leucite. Although the element is widely distributed throughout the earth's crust, soluble compounds that can be put to immediate use are not so plentiful. Pure potash is potassium oxide (K_2O), this having been adopted as the unit of measurement for all potash salts. Some of the most abundant salts of potassium are sulphate (K_2SO_4), potassium nitrate (KNO_3), and potassium carbonate (K_2CO_3). The potash value of any one of these salts is determined by the per cent of K_2O equivalent it contains. The marketed salts are

Jay	74	Hancock	7
Pike	41	Shelby	7
Wells	38	Marion	6
Sullivan	31	Daviess	5
Gibson	29	Clay	4
Delaware	28	Hamilton	4
Tipton	25	Madison	3
Randolph	19	Greene	2
Adams	18	Wabash	2
Grant	17	Dubois	1
Huntington	15	Lake	1
Blackford	10	Martin	1
Miami	10	Vigo	1
Henry	9		
Howard	8	Total	424
Rush	8		

For the inspection of these wells $4,240 was collected, of which $3,392 was paid to deputies ($8 for each well plugged) and $848 turned into the general fund of the Department of Conservation as a partial offset to the office expense incurred as a result of conducting the work.

A general complaint has been expressed by oil men against the law passed by the last legislature requiring one well to be drilled on each lease every year, in order that the lease might be held. If this is not done the lease, with the exception of small tracts surrounding any producing wells, reverts to the owner.

OFFICE WORK

The Assistant Geologist and the stenographer handle the routine office work of the division. This work consists in answering letters requesting information on a multitude of phases of our natural resources, of mailing reports in response to requests or in cases where information asked for is contained in available reports, and in conferences with individuals who come to the office for information. Considerable time is taken in working on reports, collecting information, proof reading publications issued by the division, cataloging well records and publications received, attending to bookkeeping and other clerical work of the division. The Assistant Geologist also supervises the plugging of wells which cannot be reached by the deputy inspectors.

Following is a summarized report of the office work for the year ending September 20, 1921:

	Office	Laboratory	Total
Letters received	2699	350	3049
Letters mailed	2457	400	2857
Reports distributed—			
Geological	262	000	262
Petroleum and natural gas in Indiana	385	15	400
Kaolin	126	10	136
Personal conferences	1201	360	1561

MUSEUM

The museum received more visitors during the year than any preceding year. Registered attendance for the fiscal year was 43,968, as compared to 11,378 the year before, an increase of 32,590. A con-

to handle, the tests showed seventy-seven cents per cubic yard for the matter composing the lowlands. There is probably an aggregate of ten to twelve square miles of the gold bearing lowlands in Brown, Morgan, Johnson and Jackson Counties.

"The most serious problem to be solved in the working of these placer deposits on a large scale is that of a permanent water supply, as most streams are dry several months in summer. By constructing permanent dams in several valleys, enough water could probably be conserved to tide over the dry season. There is no doubt but that large quantities of gold exist in the area mentioned. Only a person experienced in hydraulic and placer mining, who is conversant with the latest improved machinery for that purpose, will be able to state whether the process of its separation can be made a profitable one. One company with a large amount of capital at its disposal could, with a plentiful supply of water and machinery which would care for 98 per cent of the gold, perhaps make money in the thorough washing of these placer deposits, but one is warned against investing money in small stock companies, several of which have been promoted for that purpose in the last few years.

"Adam Linn, a miner in California and Oregon since 1854, made a careful investigation of the lowland deposits and he stated that the gold was much more abundant than he expected. His opinion was that these deposits would yield from twenty-five to forty cents per cubic yard, and thought it well to pipe in water twenty or thirty miles providing a company could control a thousand or more acres of the lowlands. Otherwise the expense would be greater than the output.

"In the southern part of Morgan County gold also occurs along all the streams and equals in richness to these of the northern part of the county.

"In western Morgan County, in 'Burkhart Settlement,' gold is equally abundant. John Merriman, the veteran Brown County gold seeker mentioned above, here once secured 264 colors, by actual count, in one pan.

"Doubtless these lowlands of Morgan County are richer in gold than those of similar tracts in Brown County. Gold is undoubtedly present in both counties and perchance some day a mining engineer with experience and up-to-date machinery will prove that it is present in paying quantities."

PUTNAM COUNTY

"This county is forty miles due west of Indianapolis and lies wholly within the 'Illinoian drift' area and the border of the Wisconsin drift passes across its center. Gold has been found in a stream flowing into Big Walnut Creek, two miles east of Bainbridge, in a thick bed of black magnetic sand. However, it does not exist in paying quantities."

VANDERBURG COUNTY

"This county lies in the southwestern corner of the state on the Ohio River, wholly outside the drift area. However, minute quantities of gold and nuggets of copper ore sometimes are found."

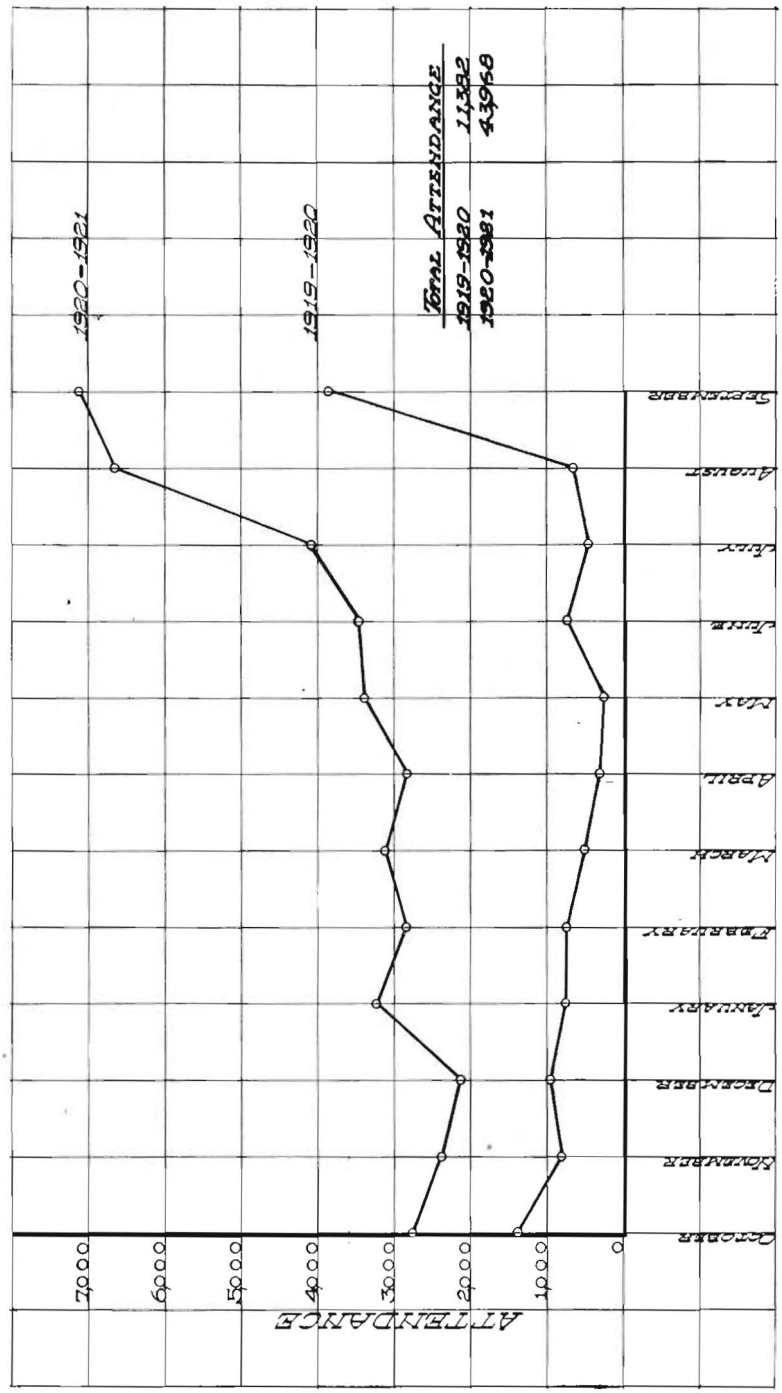

Chart showing attendance at State Museum for years 1919–20 and 1920–21

an actual 'placer mine' in Indiana brought together so many fortune hunters that every ravine was directly occupied and the sands were soon washed out and the 'gold fever' subsided. Within the last few years the excitement has been revived and gold washing, to a limited extent, has been resumed, paying from fifty cents to $1 per day. The gold is in very thin scales, almost invisible grains, and is remarkably free from alloy of any kind.

"The origin of this gold is a geological problem. The only rational solution seems to be that which refers the gold to the blue clay, which is the lowest member of the drift. Where the clay forms the summits or sides of the hills, it is washed into gulches by the rains. The lighter and finer particles are borne onward with the current, while the heavy black sands and gold lodge among the rocks in the bottom. Fortunes, however, will never be made by gold mining in Morgan County.

"Along the west branch of Highland Creek, gold in forty-one colors has been panned. On Sycamore and Gold Creeks, the best known Morgan County gold seeker, 'Wild Bill' Stafford, has washed gold for thirty years. He says that where he could get an average of twenty colors to the pan, it always paid to run a sluice box or rocker. Like most other gold hunters of Brown and Morgan Counties, Stafford washes only the bars of the streams, paying no attention to the gravel deposits underlying the lowlands, mainly because the soil is cultivated and owners forbid its disturbance. He says it pays much better to work out and pan a whole bar sweeping the bed rock, cleaning out the cracks where the coarse gold has lodged, than to pan a little here and there. The old experienced washer can pan $1.50 to $1.75 per day. One piece of gold valued at $4.70 was the largest he had ever taken.

"Special attention is given to the lowlands bordering Highland, Sycamore and Gold Creeks and their tributaries. In most places, these lowlands are composed of two or three feet of gravel resting upon the blue shale or bed rock. Above the gravel is a foot or two of clay and above this a sandy or alluvial soil from six to twelve inches deep. The streams, whenever full and swift, erode a portion of the gravel with its accompanying gold, carrying it forward and building up bars farther down their courses. In this manner the annual supply of gold particles in and along the immediate stream beds is replenished.

"About forty-five square miles are overlain with the gold bearing drifts. Practical tests have been made of the lowland material in a number of places in northern Morgan County. These have proved that it runs from thirty to eighty cents per cubic yard. The most thorough test was made on the land of Dr. Clark Cook, just north of the post-office of Brey. Here twenty-five holes were dug through a strip of lowland to bed rock, the average depth being three feet nine inches. From each of these holes, seventy-five pounds of gravel were carefully panned, one-third being taken from the top, one-third from the middle and one-third from the bottom of the gravel stratum. In addition, miscellaneous gravel from the holes was added to bring the total up to two thousand pounds. From this, gold to value of $1.54 was secured. Allowing three thousand pounds as the weight of a cubic yard of gravel, and deducting two-thirds for soil and clay, barren of gold, but necessary

servative estimate of the visitors not registering, or refusing to do so, would be 20 per cent. Taking this into consideration, the estimated attendance during the year was 52,761, an average greater than three visitors for every minute the museum was opened.

The attendance, with few exceptions, showed a steady increase each month. In October, 1920, the first month of the fiscal year, there were 2,769 visitors, and in September, 1921, the last month of the fiscal year, there were 7,105.

The marked increase in attendance emphasizes the need of and justification for larger quarters for the museum. Visitors frequently complain of the crowded condition which makes it impossible to display the specimens advantageously or permit proper lighting, particularly in the lower parts of show cases. There is no doubt that many private collections of merit and value would revert to the state if better provisions were made for their care.

Following is the list of donations received during the year:

Peculiar Growth—This knot grew twenty-two inches underground on the root of a red oak tree on the farm of B. C. Whitlow, three miles southeast of Lebanon, Boone County, Indiana. While blowing stumps with dynamite this knot was blown out of the ground.

Residue taken from the Basin of Outside Drinking Fountain, Indiana Soldiers' and Sailors' Monument, Indianapolis, Ind.—Analysis (qualitative) showed the sample to be mainly chlorides and carbonates, probably those of calcium and magnesium. From Board of Health office.

Petrified Wood—Polished. From the Governor's office.

Bullets—"Yank and Johnny," from the Battle of Atlanta. Gathered after the battle by W. H. Cobb, 10th Indiana Volunteers.

Plow Paper Weight—Presented to state of Indiana by Wm. Jennings Bryan. Sent from the Governor's office.

Skeleton—From mound in Guthrie Township, Lawrence County.

Sea Shells—An assortment of ocean shells—sixty-five in number. Donated by Harold Brown, Herron Art Institute, Indianapolis.

Regalia—I. O. O. F. Presented to Jos. Kendall, Shelbyville, Ind., in 1852. Donated by his daughter, Mrs. Lyda Eves, Indianapolis.

Watch—Taken from body of a German soldier at Chateau Thierry, France, July 4, 1918. Found and donated by Chas. P. Darrough, Battery A, 102nd Field Artillery, 26 Division Street, Indianapolis.

Knife—Found on battlefield of Chattanooga by S. G. Conlee, Indianapolis. Donated by him.

Moth (Luna)—Donated by A. L. Barthel, Indianapolis.

Octopus—Caught by Burge Schooney, Bay Harbor, Florida. Donated by Albert W. Sullivan, Indianapolis.

Pioneer Farm Implements—Wooden Flail, Scoop, Hay Forks, etc.

Model of Box Feed Cutter—Made by Dr. J. A. McGee, Big Springs. Donated by Clarence Biddle, Indianapolis.

Chinese Battle Flags—Captured in the "Boxer" War August 12, 1900, at "The Forbidden City," Pekin, China. Donated by Homer Ingle.

Sword Hanger—Supposed to have been worn by General Israel Putnam.

JEFFERSON COUNTY

"In this county, which is in the southeastern part of the state, wholly within the boundary of the Illinoian drift, gold has been panned only on a stream about six miles north of Madison. No attempt to pan the gold from the gravel of the stream has been made."

JENNINGS COUNTY

"Some particles of gold have been panned from the bed of the south fork of the Muscatatuck. This gold was found in combination with the black sand washed down from the glacial drift of the uplands. The excitement occasioned by this discovery was very great at the time, and some useless labor was spent in sinking a shaft, as the drift and accompanying gold dust was foreign to the state. It was useless to penetrate limestone strata below in search of it."

MONTGOMERY COUNTY

"This county in the western central part of the state lies wholly within the drift of the second glacial invasion. The boulder drift deeply covers the eastern, northern and northwestern parts of the county, bearing internal evidence of its origin as imported from the Laurention beds north of Lake Superior. When long concentrated by currents of water, some notable deposits of gold dust and magnetite occur, associated on account of their approximate specific gravity on the bars and riffles of the water courses. More than $50 worth of gold dust and magnetite have been panned out by collectors on the ford bar just above Iron Bridge across Sugar Creek. Near the junction of Lye and Sugar Creeks several dollars worth of gold occurs in flat scales."

MORGAN COUNTY

"Morgan County lies just southwest of Marion County near the center of the state and comprises 409 square miles. The west fork of White River flows diagonally through the county from northeast to southwest. The principal tributaries of White River from the north, along whose beds and lowlands most of the gold of the county occurs, are White Lick, Sycamore Creek and its tributary, Gold Creek, Highland Creek, Lamb's Creek, Burkhart's Creek, Fall Creek and Butler's Creek.

"The northern third of Morgan County in which most of the gold occurs, is covered by the drift of the second glacier and the gold is a part of that drift. In the southern part of the county, the drift is that of the first Illinoian glacier which embraced all of the territory included in the county. From each of these glaciers whose crests doubtless towered far above the hills preventing their further movement southward, rapid streams flowed and bore down the gravel, clay and sand with their accompanying gold, now found in beds beneath the lowlands of the present existing streams.

"Gold has been found in the tributaries of Sycamore and Lamb's Creeks and some of the more skillful miners were able to wash out $2 or $3 worth of gold per day for several weeks. But the excitement of

Portion of Wood—From Ship "Alliance," the first vessel to fly the "Stars and Stripes" after their adoption.

Photograph (Framed)—Delegates to the State Convention, G. A. R., Evansville, Indiana, May, 1916. Donated by C. W. Chappell, Co. F, 25th Indiana Infantry, Indianapolis.

G. A. R. Emblem Flag—Donated by Miss Hattie Vaughn, Indianapolis.

Arrow Heads—Louis Hild, Indianapolis.

British Bayonet—Harold Stewart, Indianapolis.

U. S. Navy Gas Mask—Donated by George E. Edenharter, Indianapolis.

Limestone—Donated by Zenia Egnew, Carmel, Indiana.

Japanese Sash, Sword and Scabbard—Ross Boggs, Indianapolis.

Infant's Shoe—Made in 1812. Donated by Cornelius Bowen, Knightstown, Indiana.

Chert Cemented by Gallicate—Donated by W. F. Thompson, Greenwood, Indiana.

British Soldier's Button—From battlefield of Vimy Ridge, France. Donated by J. McCormick.

Bible—Printed in 1812. Presented by E. J. Chandler, Bicknell, Indiana.

Gun Barrel—Used at the battle of Tippecanoe.

Johnny Cake Baker—Donated by E. J. Chandler, Bicknell, Indiana.

Jack Knife Work—Two pieces. Donated by D. Onear, Indianapolis.

Fragment of Marl—Baked, not burnt, from Saratoga Mt., Florida. Donated by Mrs. Ella Mussellman.

Laurel Wood Ring—Carved by S. D. Anderson, 17th Regiment, Indiana Volunteers, during Civil War. Presented by Mrs. R. Riley.

Collection Sea Bird Eggs—Sixty-five in number. Donated by Glenn Houston Craynor.

Wild Passenger Pigeon—Mounted. Presented by W. S. Ratcliffe, Richmond.

Newspaper—Printed on wall paper during the siege of Vicksburg, Miss., 1863. Presented by Andrew Kunkel, 7th Indiana Volunteers.

Book—Carved from a laurel growing on side of Lookout Mountain, taken while Confederates yet held possession of the summit of mountain range. Book was made while lying in trenches at foot of mountain during the siege October, 1863, by W. F. Cobb, 10th Indiana Volunteers. Donated by Dr. Geo. Edenharter, Central Insane Asylum, Indianapolis.

Petrified Moss—From Fountain County, Indiana. Donated by B. M. Yates, Kingman, Indiana.

Beaver Cutting—From Algonquin Park, Ontario. Donated by — Comstock.

Souvenir Cards—Found in upper lefthand pocket of blouse of Oral Dean, private, first class, 150th Field Artillery, Rainbow Division. Killed by a piece of shrapnel at Chateau Thierry, France, July 19, 1918. Presented by his father and mother, Mr. and Mrs. J. A. Dean.

Paxton Collection from Bluffton, Indiana, added this year, remains unpacked.

CLARK COUNTY

"This county, lying in the southern part of the state, was partially covered by the first glacial invasion. Rudolph Bastian states that in the black sand stratum, he can find numerous particles of gold in every panful which he washes. The black sand and garnets are finer than those found farther north and it may be that the deposit is but the diluvium from the streams flowing from the melting glacier of the Brown County region."

DEARBORN AND OHIO COUNTIES

"The most remarkable prolongation of glacial drift southward is seen in Dearborn and Ohio Counties, Indiana, and Boone County, Kentucky. In the first two named counties the drift is found in its greatest force. A low bed of sand and gravel resting upon the Silurian bluish clay shale contains a portion of gold dust and gold washing has been carried on here in a small way for years. If hydraulic washing could be resorted to, it is possible that considerable gold might be washed out. Some portions of this Laughery drift are so rich in gold that it is seen with the unaided eye. The gold is found in the form of dust, flattened scales and small nuggets."

FRANKLIN COUNTY

"This county is wholly within the bounds of the first glacial invasion. In the northwest part of the county in Laurel and Posey townships, upon Sim Creek and its branches, gold is generally disseminated in very small particles. A common panful of gravel and sand when washed out shows from two to three particles of gold in thin scales. None have ever been found larger than a grain of wheat. It is doubtful whether the quantity is sufficient to pay the expenses of washing it out. Gold has been found upon Little Duck Creek, and here, as elsewhere, is associated with black sand."

GREENE COUNTY

"This county lies west and south of the center of the state. The border of the first glacier passed in a northeast southwest direction through its eastern half. Gold occurs with black sand, which is all the record shows us concerning gold within the county."

JACKSON COUNTY

"This county lies south of the central portion of the state comprising 520 square miles. The border of the Illinoian Glacier passed through the eastern half of the county and its alluvium covers much of it. Gold has been found in a number of localities, chief among which is the bed of a stream near Freetown. Scales and particles to the value of about $5 were panned from the gravel and sandbars. The gold is not present in sufficient quantity in any part of the county to pay for working it."

GOLD IN INDIANA

W. N. LOGAN, State Geologist.

A large number of specimens of so-called gold reach the office of the Division of Geology and its laboratory each year. These specimens are sent in by citizens of the state who think they have discovered something of value. In most instances the minerals are either pyrite or mica of cupric or brassy hue. Occasionally a copper or zinc mineral is sent in and very rarely a specimen containing native gold. The pyrite is a compound of iron and sulphur and the presence of the sulphur may be easily detected by the odor when the mineral is heated. In some instances vein pyrite carries gold, but little, if any, vein pyrite occurs in Indiana. The pyrite of the state is associated with sedimentary rocks under conditions not favorable to the formation of vein gold.

The mica is a silicate mineral which splits in thin plates and under weathering frequently turns a golden hue. These minute flakes may be distinguished from flakes of native gold by the fact that in water they will remain partly suspended for a short time, as they are of a much lighter specific gravity than native gold. The copper and zinc minerals which are mistaken for gold are usually sulphur bearing but sometimes the native copper is found.

OCCURRENCE OF GOLD

Gold is found in veins usually associated with igneous rocks or in placer deposits. The gold in the veins may occur as free gold (native) in quartz, as tellurides or other compounds, or associated with other metalliferous compounds such as silver, lead, zinc and copper. These gold bearing veins are associated with regions where there have been profound movements of the rocks of the crust of the earth and near enough to regions of vulcanism so that mineralizing thermal waters have penetrated the surficial rocks. It is probable that no where in Indiana have the essential conditions for auriferous veins been met. It is possible that if the domes, such as the Kentland Dome, of northern Indiana, have been the result of vulcanism, some deep seated mineralization may have taken place, but, if so, there seems to be no indication of such action in the exposed rocks.

PLACER GOLD

The weathering of gold bearing rocks and veins produces a concentration of native or free gold in surface deposits of sand and gravel which are called "placers." Placer deposits occur in the beds of streams, in the alluvium of valleys, and in the benches or terraces of valleys. The gold in the placer is in nuggets, flakes and grains. Nuggets vary in size from a small fraction of an ounce up to as high as 2,280 ounces. Of the smaller grains it may require 2,000 of them to make one cent's worth of gold, yet they may form a "color" which can be recognized in the prospector's pan.

The gold of the placer settles to the bottom of the loose sand and

$10,000 value, and the best nugget weighed at $1.10. At least seventy square miles of northern Brown County lies within the drift covered gold bearing region of the first glacial invasion.

The quality of the gold found is of the best, as it will average twenty-two or more carats, as against sixteen to eighteen for California gold and fourteen to sixteen for Klondike gold.

Along each side of the streams in the county mentioned is a strip of bottom land of varying width composed of gravel, clay and soil, the gravel resting upon the bed rock, which is the blue Knobstone shale. It is this gravel next to the bed rock that is richest in gold. Most of the surfaces of these strips are cultivated and the owners will not allow the "gold hunters" to pan except in the beds of the streams. These beds have most of them been washed many times in succession, a new supply of gold being eroded during each freshet from the gravel beds along the banks. These beds which form the base of the lowlands were formed during the melting of glaciers when streams flowing through the valleys were much wider and stronger than now. The gravel and sand composing them was then deposited and the soil for the most part has been formed since then by decaying vegetation and annual overflow.

"After every freshet, the children of the vicinity seek gold along the rocky bottom of each rill and stream and often find pieces worth twenty-five to forty cents. Much of this is found lodged in minute crevices at the bottoms of small waterfalls. A few of the natives do little else than pan gold for a livelihood." One of them, Uncle John Merriman, of Brown County, now deceased, panned more or less every year for nearly seventy years. "The largest nugget he ever found was taken on Bean Creek. It weighed 132 grains and was valued at $5.50. He found a number of pieces which ran as high as $1.00 to $1.25 in value, but most of what he secured was in the form of minute flattish particles. He estimated that the gravel beneath the soil of the lowlands would average twenty-five cents per cubic yard in gold. On two occasions Mr. Merriman kept a careful account of results of a month's work. Sundays excluded, one month yielded him $34, another $40. He claimed that he could average $1.25 a day during the panning season, which runs from March to November except in the summer drought."

CASS COUNTY

"This county lies about eighty-five miles a little west of north of Indianapolis, containing 420 square miles which is wholly within the drift covered area. In the vicinity of Logansport, numerous beds of gravel ranging in thickness from one to thirty-two feet lie immediately above bed rock of Devonian and Niagara limestones. A number of small flakes of gold have been incidentally picked up without panning, which proves that gold is widely distributed in the drift gravel deposits of the state. Most of these deposits are so deeply buried beneath clay, sand and soil of different materials that there is no way of determining the presence of gold and no way of securing it. It is only along the edges of the moraines or where gravel deposits rest on outcrops of bed rock that the gold bearing gravel is accessible."

gravel, because of its higher specific gravity, and is found near the contact of the sand and gravel with solid bed rock. Gold-bearing gravels may also contain magnetite sands derived from the disintegration of magnetic iron ores. These grains are also of high specific gravity and settle toward the bottom of the gravel deposit. Thus it happens that the grains of gold are often found in black sands.

The gold of the placer is separated from the sand and gravel by some process of washing away the lighter particles by processes called "panning," "cradling" and "sluicing."

GOLD IN INDIANA

Small quantities of native gold have been found in many of the counties of Indiana which are near or border on the driftless areas. The gold is the placer type, i. e., it occurs in sands and gravels lying in depressions in the bed rock. The gold particles vary in size from microscopic to as large as one-fourth of an ounce. The particles are usually found associated with magnetite sands.

SOURCE OF THE GOLD

The presence of small pieces of vein quartz carrying particles of metallic gold in the glacial drift of Indiana has led to the conclusion that the gold of the state has been brought from some auriferous area of the great crystalline belt of rocks lying beyond the boundaries of the state to the northward. These gold bearing rocks were picked up by glaciers, transported by them and finally deposited within our boundaries. Not only was auriferous vein stone carried but also gold bearing igneous and metamorphic rocks. With the disintegration of these rocks by weathering agents came the concentration of the gold in the placers.

ECONOMIC VALUE

The gold placers of Indiana have little economic value. The cost of securing a water supply large enough to handle a large amount of sand and gravel in a short period of time prevents economic mining. Small winnings may be made by the "pan" prospector, but fair wages are not to be expected.

SUMMARY OF THE DISTRIBUTION OF GOLD IN INDIANA

The following pages give a summary of the distribution of gold in some of the counties of Indiana. The facts recorded have been obtained from the publications named in the bibliography at the end of the article and to these writers the credit is due.

The earliest printed record of the finding of gold in Indiana was found in the Journal of the Franklin Institute for June, 1850, as follows: "Professor Frazer read to the meeting (of the Franklin Institute) a letter from Professor T. A. Wylie, of Indiana University, announcing the discovery of gold in the vicinity of that place and exhibited specimens of the gold and of the black sands in which it is found. The gold has been found in the beds of the rivulets in Morgan County about twenty miles

northeast, in Jackson County about twenty miles east, and in Greene County about fourteen miles west of Bloomington, as well as at certain intermediate points but not in the immediate vicinity. Where it has been found, it is always in connection with a black sand called 'emery.' This sand is found at the bottom of the streams usually at upper end of sandbars, or on margins of the streams where there is a sudden turn, and in such places as it would be naturally deposited on account of its density. The coarse gravel is sifted and washed in the usual way until nothing remains but the dense black sand. Through use of the microscope and magnet, the gold in flat scales is separated."

BROWN COUNTY

The northern boundary of this county is about thirty miles nearly due south of Indianapolis. It contains 320 square miles. High ridges surround Brown County on all sides, while from east to west and southwest, three similar ridges traverse the county, all connected on the divide near Trafalgar in Johnson County. The first and most northern constitutes the southern bluff of Indian Creek and is called "Indian Creek Ridge;" the second, south of Bean Blossom, is known as "Bean Blossom Ridge," and the third is Central Ridge. Only the northern third of Brown is within the glaciated region. The northwestern part of Hamblin Township and the greater portion of Jackson Township are covered with drift accumulations as far south as Bean Blossom Ridge, the drift being found on the slope of this ridge nearly 200 feet above the water in the stream. Boulders of granite, gneiss and jasper, three to five feet in diameter, occur frequently in this region. In Salt Creek Valley, northeast of Nashville, but little drift was seen. Bean Blossom Ridge, then, marks the southern limit of the first and only glacial invasion of Brown County and it is only north of this ridge that gold in anything like paying quantities is found in the county.

The long continued melting of ice, loaded with greenstone, quartzite gold and magnetite deposited quantities of these imported materials in Bean Blossom Valley. Gold is found in the bed or on the bars of all the brooks that flow into Bean Blossom from Indian Creek Ridge and on the streams which flow from the foot of the "drift backbone" in the northeast corner of the county. Fine dust and minute scales may be found further within the county wherever black sand and small pebbles indicate former currents of ice water as far south as Elkinsville. During the excitement a few years ago, several companies took leases, made sluiceways and prepared long rockers. But the returns were not satisfactory. It is probable that the best "pay dirt" lies at the deepest part of the rocky trough in which the creeks have their course. By bores, the line of greatest depth may be ascertained and by shafting, the richest dirt, possibly in paying quantities, may be brought to the surface. Reasoning from the facts observed, this would be true of Bean Blossom, and especially from its greater width and probable depth, also of Indian Creek Valley. This is mentioned as a reasonable deduction, warranted by the facts and not for the purpose of exciting a mining fever. It was estimated that the amount of gold found in the county to 1874 equalled

by sea current—a sort of sargasso—would appear to be a sufficient agent to tear up the bed of a shallow sea, at least under favorable conditions, over a very wide area. Earthquakes might be the cause of loosened stone on the bottom of the sea, or, again, of currents such as to cause dragging up of the bottom by sea weeds." These causes seem quite probable in some cases, but the hypothesis rather resorts to the unusual. Such informations as are under discussion are widespread throughout geologic time, and it seems there should be some more common cause for their origin.

E. Wilson (4) supposes that the fragments "must have been simultaneously deposited over several square miles and in water of variable depth and distance from the land. Though no striæ have been found, the angularity and confused arrangements of the fragments, the fact that some of the largest have travelled a long distance, and the general absence of any attempt at stratification, the sudden transition in thickness and texture of the breccia, point possibly to glacial origin, as droppings, say, from the melting of icebergs or floes." This may be necessary to account for some formations in which the embedded material is of composition entirely foreign to the matrix or adjacent rocks, but such a formation, according to definition, is a conglomerate or normal breccia.

In speaking of the distribution of pebbles due to organic growth in a conglomerate, after they had been formed, T. C. Brown (5) says, "At periodic intervals these beds of calcareous mud and intermingled pebbles slumped or slid along the sea bottom under the influence of gravity. At the time of the slump or slide the matrix around the pebbles consisted of incoherent lime-mud or paste. As it moved it developed unsymmetrical waves or ripples in its mass—and there remained until the lime-mud became transformed into limestone."

Stose thinks that they were formed by thin layers breaking into small flat pebbles or shingle. When the tide came in, these flat fragments were washed together in all positions and held by a soft paste which surrounded them. This does not explain what caused the breaking up of the fragments, but it is quite probable that tidal lime-muds such as we now find on shores could become the limestone matrix of these breccias.

In his paper on the Shawangunk formation Schuchert (6) remarks that these fragments were formed by "local disruption of a thin bed of shale by storm generated waves in this shallow water deposit."

W. N. Logan has suggested that the origin of these fragments may have been due to mud bumps such as are now found along the Gulf Coast, rising above the sea level, drying to hardness, and then becoming broken up by storms.

"Such rocks," writes Grabau (1) in speaking of intraformational breccias, "are composed largely of the finest lime-mud, accumulated in shallow water or in part even above the normal level of the sea. In form they probably constitute a sort of mud flat delta. On exposure, partial hardening permits the formation of a superficial crust, which may subsequently break or become deformed by the sliding of the entire mass seaward. If the surface layers alone slide, a fracturing will re-

sult which produces a mass of angular or subrounded flat mud cakes, which will be held together, as a result of this sliding, in a compound mass, the fragments most frequently standing on end, but also inclined in all directions. They will be surrounded by the fine still fluid mud which wells up around them and in which these fragments become embedded. Thus is formed an *edgewise conglomerate*." Such is Grabau's theory as to the origin and it seems that it can account best for the numerous intraformational breccias found in all geologic ages.

It is generally admitted that these breccias were formed in a shallow sea near a shore. It is probable that wave action played an important part in either breaking up the fragments or in eroding them, or both. It is more probable that the material from which the fragments were derived came from the dried lime-mud on shore or thin hardened limestone layers capable of being shattered by wave action. The wave-like forms in which the embedded materials have been found, as described by Brown (5) show this and also show that they have been tumbled and washed by water. It is also possible that special causes may have produced certain breccias but these may not be applied as a general theory for most of them.

DESCRIPTION OF THE ST. LOUIS LIMESTONE BRECCIA

This intraformational breccia is found near the middle of the St. Louis limestone (Mitchell) of Indiana, in McCormick's Creek Gorge, near Spencer. It may be traced along the north wall of the gorge for a distance of three hundred yards, and is from five to fifteen feet in thickness.

The embedded fragments vary in size from one-half to four inches in diameter. In shape they vary from roundness to angularity, the greater part of them being subangular. The fragments are of soft sandy limestone and the matrix partly of blue argillaceous clay and partly of blue-gray hard limestone. There are no bedding planes, and the fragments are heaped together in a confused mass. There is no evidence of folding or faulting within the formation, but in a few cases the fragments show evidence of slickensided surfaces. No fossils were found. At fairly regular intervals there appear what might be crude wave forms, the depressions or troughs being filled with the hard blue-gray limestone which rests immediately on top of the breccia. In one place the breccia has been eroded through to the layer of limestone below and exhibits appearances which might lead to the belief that the erosion was due to a current of water. The overlying layer, as has been stated, is a blue-gray hard limestone, and the underlying one is gray-white and brittle, that is, characteristically St. Louis in this region. These layers are parallel to each other. The general dip of the strata in this region is to the southwest at the rate of thirty-five feet per mile.

CONCLUSIONS

In the formation of this breccia it seems probable that the shore of a shallow sea was covered with lime-mud, the upper exposed part being cracked and hardened by exposure to the sun, the lower depths being