Boyer Copper Deposits, Nevada

By Arthur Howe Carpenter

The Boyer property was located by Alva Boyer, a pioneer ranchman and prospector of Nevada. He has disposed of interests to others, but still retains the control. This deposit occurs near the contact of a flow of andesitic porphyry over an earlier mass of green andesite. The earlier mass is provisionally classified as 'melaphyre,' more in the sense of meaning black or dark porphyry, a use of the term proposed by Chamberlain and Salisbury. It is a dark greenish andesite with rather abundant white crystals of feldspar. Magnetite, augite, and olivine occur. The overlying eruptive was called an 'obscure trachyte' by Clarence King, whose Fortieth Parallel Survey passed over the property. Following the proposed scheme of classification, this might properly be called 'leucophyre.' It is not trachyte. It has a rough fracture, the ground-mass is even and uniform to the eye, and the only crystals certainly visible are clear tabular sanadine.

The contact lies flat, dipping about 20° to the northwest. The white porphyry is the base upon which the thick series of basalt flows make a long high table-land called Table mountain. These flows of basalt have the same dip as the contact, suggesting that the white andesite was intruded after the basalt flows, but the dip of these old lava beds is more probably due to faulting and folding. The mass of white porphyry outcrops for about four or five miles in an easterly direction, and the dark melaphyre outcrops below it for the same distance. There are a number of copper prospects along this contact and near it in addition to the Boyer group, which is near the west end, and some of these deposits near the eastern end might repay prospecting. Chalcopyrite and chalcocite intermingled occur, almost at the surface. However, on the Boyer, the deposits seem to be the strongest and most abundant. Near the eastern end of this white andesite belt the nickel and cobalt mines of Cottonwood canyon occur, which are described by F. L. Ransome on pp. 55 to 58 of Bulletin 414, U. S. Geological Survey. These mines attracted a great deal of attention thirty years ago by producing rich cobalt ores, which were shipped to Swansea. At the prices then paid, some of the ore brought over $1000 per ton. At either end these andesitic flows disappear against massive rhyolite hills and mountains, while several miles farther south a similar outcrop occurs with copper veins capped with pure hematite.

The main workings at present on the Boyer property are on Treasury Box hill, about 200 ft. below the contact and in the altered zone in the melaphyre. The copper was evidently deposited at the time of the eruption of the white andesite. The heat and steam accompanying this flow altered the upper two hundred feet of the underlying melaphyre, forming at the base of the altered zone a hard and impervious layer with a peculiar banded structure. This forms the foot-wall of the copper deposits, which lie in the 200 ft. of altered material above, and below the contact with the overlying andesite. In many places throughout the altered zone, small dikes of the white porphyry occur, shooting off from the main body. In places just above the contact, small iron-capped veins are seen coming up through the leucophyre. When followed these veins lead to massive chalcocite disseminated in a gangue of breccia, pieces of the pure black sulphides half as large as a man's hand having been occasionally found. Massive bornite, tenorite, and cuprite occur also, mixed with the two carbonates, melachite and azurite, making small rich deposits of ore. If followed, it is thought that these oreshoots will lead to the larger deposits that may lie at the contact and in the altered zone below it. At one place, from a deposit occurring at the surface (almost exactly at the contact), several large wagon-trains were loaded with rich copper sulphides and oxides, in 1861, and taken to Sacramento overland. The old shallow pits are still to be seen, surrounded with the piles of refuse, where was cobbed out the richer ore. Samples of these piles assay 29% copper. These rich ores carry 5 oz. of silver and traces of gold. Every other occurrence of copper ore on the property, when carefully assayed, seems to carry about 20c. gold per ton for every per cent of copper present.

The main work on Treasury Box hill was done in a bed of copper-bearing andesite about 100 ft. or more in thickness. The ore is chalcopyrite disseminated through the melaphyre, and the lower 30 ft. of the bed averages from samples obtained, wherever it has been opened, nearly 5% in copper and $1 in gold and traces of silver. Owing to lack of funds, it has been impossible to continue the development work as far as the contact, which dips in the direction the prospecting adits have been driven, but when this development work is done, interesting results may be obtained.

About a mile of the contact is included within the limits of the property, and throughout this distance it is possible to find ore in the altered zone in the melaphyre below the contact. At three other places besides on Treasury Box hill the surface indications are promising, and, in fact, at few of the well known copper properties of the West are the outcrops of copper-bearing rock more extensive. Large masses of carbonate ore exist assaying about 1.5% copper, and in places it is much richer.

The ground explored by the adit is badly faulted, so that it has not been possible to develop a continuous bed of ore, but it is thought that a bed of copper ore once existed over 100 ft. thick, 200 ft. wide, and, measured along the line of the dip, 500 ft. or more in length. Owing to the many faults, however, there are only blocks of ore lying at different levels, and not all of them have been opened. The dimensions given are simply the limits of the present exploratory work, and there is not so much ore actually developed. It is only possible ore. But there is reason to believe that the lower 30 to 50 ft. of each of these broken blocks will average over 4% copper. There is also reason to hope that the beds will continue down along the plane of the contact in the altered zone. The richer beds may be wider than this, but this is a matter of speculation. Naturally it is not thought that all of the altered zone beneath the contact is as rich in copper as this bed. The whole of it, however, seems to be copper-bearing, but most of it will be too low grade for profitable mining. Other beds will likely be found as rich and extensive as the one opened on Treasury Box hill, and the ore-bearing zone should continue as far down as the contact between the two porphyries and the beds of valley ore prove strong and permanent. This ore zone lies that several thousand feet of it, perhaps, underneath white porphyry and back from the outcrop, could be prospected with churn-drills, though many of the holes farther back would have to go quite deep.

The ores are primary, and there is little or no secondary enrichment, nor has there been much chance for it. Large areas of the copper-bearing rock have been leached barren near the surface. The ground-water line does not seem to lie very deep now, however, and springs come to the surface in the contact and near it, and in places above. In his general description of these properties Mr. Ransome refers to the occurrence of pyrite, but, so far as known to me, after a residence of nearly a year at the property no pyrite occurs, all the sulphide ore consisting of chalcopyrite. This carries almost the theoretical content of copper, several pure specimens having been carefully analyzed. The general trend of the belt described by Ransome is the same as that described here, but it is not more than over 200 ft. wide.

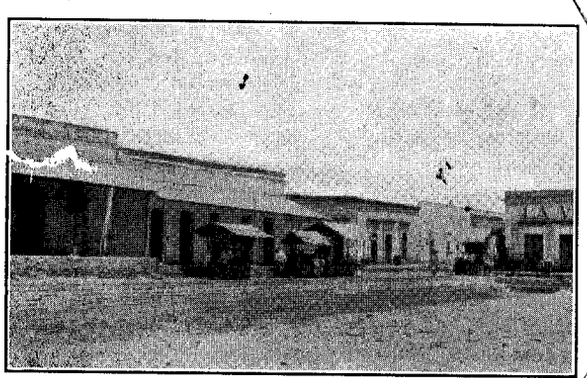
Chalcopyrite is hard to concentrate, as it slimes badly in crushing. Several concentration tests made with Wilfley tables, however, gave a recovery of 70 to 80% of concentrate assaying over 20% copper, which is high grade for an ore. It is therefore apparent that no difficulties will be like those encountered at Yerington. The ore is peculiarly one for oil flotation processes, and a test made in the laboratory machine gave the wonderful result of 95% recovery in concentrate assaying 30% copper.

The Sinaloa Mining District

By G. L. SHELDON

The Sinaloa mining district is due south of the Fuerte and north of the Mocorito district, in the State of Sinaloa, Mexico. The county seat, Sinaloa, on the river of the same name, is an old town with a population of about 2000. Bamoa, a station on the Southern Pacific railroad Mexican system, about 14 miles south, and across the river, is the nearest railroad point. The western half of the district extends to the Gulf coast and is an agricultural area. The eastern half is in the foothills and Coast range section, extending to the Chihuahua State line, north and south from San Jose de Gracia.

At Bacubirito, 20 miles east of Sinaloa, the river makes a large bend, 6 to 8 miles long, and at the narrow neck, only about 300 yd. wide, the river bed, it is claimed, carries a good deal of placer gold. About twelve years ago considerable gold was taken from it, including numerous nuggets of good size, one of 4½ lb. At the neck of a tunnel could be driven that would carry the water of the river during the low-water stage, and the bed below could be cleaned to bedrock. The tunnel would give a 70-ft. fall on the downstream side and generate a large amount of electric energy. A few years ago Messrs. Yard and Hughes

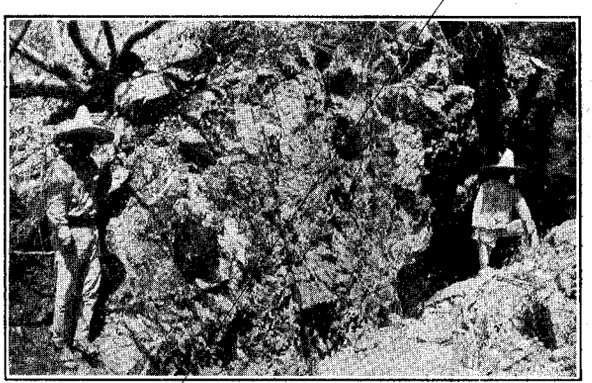


STREET BOOTHS, SAN JOSE DE GRACIA.

did some work on the placer benches above the river, near ... putting in a small pumping plant. Five years ... some Philadelphia people put up a small mill on a property near the river, between Bacubirito and Sina... The San Jose de Gracia section is the principal one ...he district that has received attention, because of the ...gh gold content of its veins; this has been recently de...ribed in the *Mining and Scientific Press*.

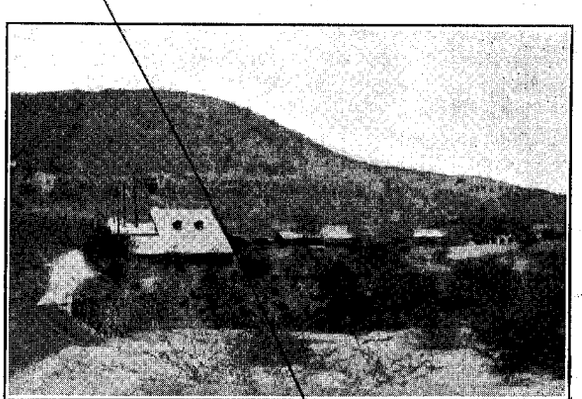
Twelve to fifteen miles west and north of San Jose is ... old silver district where several mines in past years have ...oduced and shipped considerable high-grade silver ore. ...n years ago the San Jose mine was worked by an Amer...n, and some shipments of good ore were made, but the ...ner lacked capital to properly develop it. It is in a ...ntainous country. North and east of this, at Alisos, ...San Jose creek, near its head, are several prospects ...ing gold and silver. Thirty miles east of San Jose, ... San Vicente on the river, during the past two years, ... discovery has been made. The vein is 30 to 40 ft. ...nd shows a gold content of $10 to $50, with some ... the vein can be traced several miles, and shows ...zation. Many locations have been made upon it, ...r it is but little developed. About ten miles above ...ate, on the river near Torrogueno, Don Zarapo ...ns the Torrogueno gold property. This is 2000 ... the river in the andesite—a good 9-ft. quartz ... years ago some Americans did some work upon ...t for want of funds, it is said. South from ..., near the divide between the districts of Sina...adirahuato, is the La Colorada mine, worked ...s ago to a considerable extent. This is a 10 ...ein carrying silver. Two years ago a water...dly covered the old works with débris, as it is in a small gulch. West of this and south down the river, on the east side, is a large limestone area which has many known prospects, mostly silver, with not sufficient development to demonstrate their value. In the vicinity of Bacubirito the veins contain mostly gold.

Northwest of Sinaloa, 12 or 15 miles, is Ocoroni, on the river of the same name, known above the Yecorato river. Four miles above this place is a lead-silver district which, while known for many years, has only received attention since the advent of the Southern Pacific railroad. Many claims have been located and considerable



TORROGUENO VEIN, SINOLOA DISTRICT.

work done during the past year or two; for a distance of several miles there is a very good showing on a vein or veins, from 10 to 40 ft. wide, carrying 10 to 70% lead, good silver content, a little gold, and in some places zinc and copper. It was examined two years ago by an engineer who had several years' experience in the Coeur d'Alene in its early days, who thought the showing here was as good as that on the surface. It is only 20 miles by wagon-road from the station of Naranjos, on the Southern Pacific railroad, where it crosses the Ocoroni river. On account of its good transportation facilities and the urgent



SAN JOSE DE GRACIA MILL BEFORE ERECTION OF CYANIDE PLANT.

need of lead ores on the west coast for fluxing purposes, it is a promising lead district. Above it a few miles is an old silver-mining camp with ruins of old *haciendas*, where the ores were treated years ago. While the Sinaloa district is not as large as the Fuerte there is no doubt of its containing much good ore, and in time more than one producing mine will be opened.

The San Jose de Gracia is probably the best small gold district in the State. The lower agricultural country is fully equal to the valley of the Fuerte, and with its rich silt soil probably surpasses it. There is abundance of water in the Sinaloa and Ocoroni rivers for irrigation purposes.

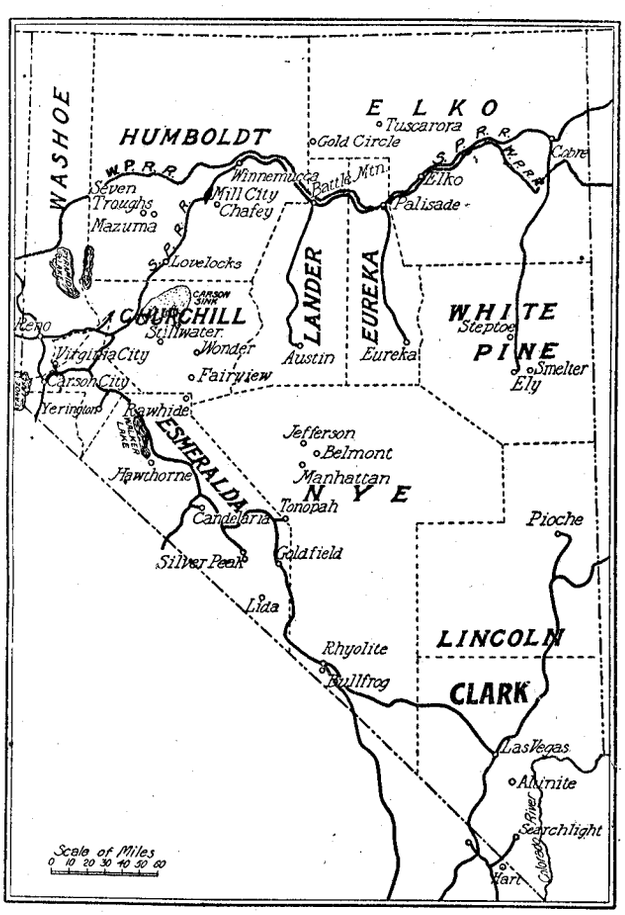
THE world's production of zinc during 1910 was 883,419 short tons, and the consumption 882,573 short tons. In the United States the production was 269,184 short tons, and consumption 245,884 short tons.

There are over 1000 acres in the group of claims, and in Dixie valley, two or three miles from the property, mill-sites are held. Plenty of water can be had in this flat or valley, and it is probable that artesian water could be developed. In the centre of the flat a number of springs come to the surface. In the next valley to the east, flowing artesian wells thirty years old exist. That valley is said to be 500 ft. higher than Dixie valley, which is the lowest in Nevada, and, according to King, the point in front of the property is the lowest in the interior basin, so that water cannot get away. Everywhere in the centre of the flat water seems to stand permanently about 6 ft. below the surface. At the old borax plant, formerly operated there, they were not able to lower it below this point in a well, using a 4-in. triplex pump operated with a gasoline engine. The lower portion of this flat is occupied by the great Ossobb salt marsh, fully described by King. The whole valley is really a rock-bound lake, full of rock, silt, and clay of Quaternary times, and covered with the débris from the old lake floor. Water stands on the salt beds most of the year. The springs are fresh water. It is about 75 or 80 miles to either Battle Mountain or Winnemucca, both on the Southern Pacific railway. In going to either place there are no mountains or other barriers to cross. Winnemucca would probably make the better point for shipping and serving this section.

On Treasury Box hill about 500 ft. of work has been done, adits, drifts, raises, and winzes. Other parts of the group have received less attention. At one point about one-half mile north of the Treasury Box workings a shaft was put down into the melaphyre at the contact. They intended to drive from the bottom of this shaft back into the contact. This shaft cannot be explored now. It is supposed to be 170 ft. deep and passed through a bed of copper ore said to be 17 ft. thick, of oxides and carbonates. A sample taken from the ore piled on the dump assayed 15% copper with a little silver. The story among the local miners is that they actually drove toward the contact from the bottom of the shaft, but when they approached it. the ground got soft and, owing to the use of too few timbers, forty feet or more of the drift suddenly caved, becoming filled with decomposed rock, mud, and water. It is said that this water coming from the breast of the adit was greenish from copper salts, and that picks and shovels left standing in it became coated with metallic copper. An adit was then started farther down the hill to cut under the shaft and meet the contact lower. It was never finished, though about 800 ft. was driven. This could be cleaned out and driven through, but it was not laid out with any idea of future work and is on the wrong side of the hill, so that any ore developed would be inaccessible and costly to move. A shorter adit from the opposite side would cut the contact more quickly and develop more promising territory.

The property is a promising prospect. There is no large tonnage of ore blocked out at present. Probably 70,000 tons is all that can be counted as probable ore so far developed in the sulphide zone on Treasury Box hill, and much of this is low-grade concentrating ore. The adit through this zone averages 1.70% copper. This was driven at the time the porphyry copper mines were so fashionable, and this is a 'porphyry copper mine' in the sense that the gangue of the ore is an eruptive rock and the sulphides are disseminated through the rock. But it is chalcopyrite, not chalcocite, and while the grade compares well with the copper content of the ores at Ely and Bingham canyon, in America at least, no one has so far attempted to exploit primary ore deposits of this character. At present it is remote from railroads. However, local conditions are favorable for cheap mining operations, once a railroad reaches the district. There is reason to expect that the Southern Pacific company will build a line or 'cut-off' from Battle Mountain to Hazen through this valley. This will shorten the distance across Nevada by the present route 49.3 miles, but necessitates the construction of a long tunnel, about six miles. There would be no other mountain ranges to cross and an almost level grade can be had. The estimated cost of this construction is much less than the cost of the Lucin 'cut-off' across Salt Lake, and the distance saved would be much greater.

The copper belt of the Piute range of mountains is about ten miles long and a number of other prospects occur farther south. On one group a vein or deposit outcrops about 100 ft. wide. An adit has been driven to cut this, but, so far, has only entered the foot-wall. The breast of the adit is in decomposed rock, badly stained with iron oxide. It will cut the vein about 200 ft. below its outcrop, and, I believe, will open a valuable deposit. There are a number of veins or zones extending the whole length of the ten miles, easily noticeable from a distance out on the flat, on cloudy days, as dark bands along the mountains. These are silicious irony outcrops, 50 to 100 ft. wide, and the zone in which they occur is 2000 or 3000 ft. wide. Whenever closely examined, copper sulphide, oxide, and carbonates are found, and it is likely that important deposits of copper will be discovered below. However, the ore of this region is chalcopyrite, and, until the secondary ores of Bingham, Ely, and the great Arizona 'porphyry' copper mines become scarcer, it is not likely that attention will be turned to these primary ores. But, sooner or later, the disseminated chalcopyrite ores that occur in large masses will attract attention, and it is from these deposits that future copper supplies of the world will be drawn. When that time comes, with the advent of a railroad, this region will become a copper producer of no mean importance.



MAP OF WESTERN NEVADA.

THE Straits Settlements Land Office returns show that during 1910 the area alienated for mining in Perak amounted to 10,464 acres. These figures show a considerable advance on those of the preceding year. There was some activity in mining in the Kinta district. In face, however, of the increased area alienated for mining in the year, the total area held under mining titles is said to have been reduced by about 3000 acres; the labor conditions have been enforced with some stringency, and there have been fairly numerous applications for the conversion of mining titles into agricultural.

Deterioration and Spontaneous Heating of Coal in Storage

By Horace C. Porter and F. K. Ovitz

*Not many years ago, coal was commonly regarded as an extremely unstable material, subject to very serious alteration and losses on exposure to the elements. The 1889 edition of Groves & Thorp's 'Chemical Technology of Fuels' says: "In some places coal is known to lose 50% of its heating value in six months." Other statements like this are to be found in recent literature, but probably the great majority of chemists and engineers today hold no such exaggerated ideas on the subject. There is, on the other hand, a well defined suspicion, in the minds of many, that sufficient loss of volatile matter and sufficient deterioration by oxidation does occur in coal to be of industrial importance; and for that reason the investigations described in this paper were undertaken, by the Bureau of Mines, to determine accurately the extent of the deterioration in different types of coal. First, a study was made in the laboratory of the loss of volatile matter from crushed coal during storage. The results of these experiments have been published in Technical Paper No. 2, Bureau of Mines, entitled 'The Escape of Gas from Coal,' and will therefore not be given here in detail. Suffice it to say that while several coals evolve methane in large volume, especially in the early period after mining, the coal suffered in one year a loss in calorific value from this cause of but 0.16% as a maximum. It seems, therefore, that the loss due to escape of volatile matter from coal has been greatly overestimated.

At the instance of the Navy Department, however, which is a purchaser of coal to the extent of two or three million dollars annually, and stores large lots in warm climates for long periods of time, more elaborate tests were undertaken to determine the total loss possible in high-grade coal by weathering. The extent of the saving to be accomplished by water submergence as compared to open-air storage was a point to be settled, and there had also arisen the question as to whether salt water possessed any peculiar advantage over fresh water for this purpose. Coal-storage problems have assumed importance during the past few years on account of the uncertainties of supply due to strikes and transportation difficulties. The naval coaling-stations, the Panama Railroad Co., the commercial coal-distributing companies of the Great Lakes, large coke and gas or power plants at a distance from the coalfields, and the railroads themselves, particularly those in the West, keep 50,000 to 500,000 tons in storage a large part of the time.

In brief outline, the tests by the Bureau were carried out as follows: Four kinds of coal were chosen: New River, on account of its large use by the Navy; Pocahontas, as a widely used steaming and coking coal in the Eastern section and as being also the principal fuel used in the Panama Canal work; Pittsburg coal, as a type of rich coking and gas coal; and Sheridan, Wyoming, sub-bituminous, or 'black lignite', a type much used in the West. Every test portion was sampled each time in duplicate. Moisture, ash, sulphur, and calorific value determinations were made on each sample, the last by means of the Mahler bomb calorimeter and a carefully calibrated Beckman thermometer. All the calorific values in the tables have been calculated to a comparable unit basis.

The results show in the case of the New River coal less than 1% loss of calorific value in one year by weathering in the open. There was found practically no loss in the submerged samples, and fresh water seemed to 'preserve the virtues' of the coal as well as salt water. There was almost no slacking of lump in the run-of-mine samples, and the crushed coal, in all cases, deteriorated more rapidly than run-of-mine. The Pocahontas run-of-mine, in a 120-ton pile on the Isthmus of Panama, lost during one year's outdoor weathering 0.4% in heating value, and suffered little or no physical deterioration of lumps. The Pittsburg gas coal, during six months outdoor exposure, suffered no loss whatever of calorific value, measurable by the calorimetric method used—not even in the upper surface layer of the bins.

The Wyoming coal lost as much as 5.3% in one of the bins during 2¾ years, and 3.5% even in the first three months. There was bad slacking and crumbling of the lumps on the surface of the piles, but where the surface was fully exposed to the weather this slacking did not penetrate more than 12 to 18 inches in the 2¾-year period.

No outdoor weathering tests have been made by the Bureau on coal of the Illinois type. Thorough tests, however, on this type have been reported by S. W. Parr, of the University of Illinois, and by A. Bement of Chicago, both of whom find from 1 to 3% calorific loss in a year by weathering. Mr. Bement reports a slacking of lumps (in tests on small supplies) of over 80% in one case and about 12% in another. It is probable that in this type, as in the Wyoming, the slacking in a large pile would not penetrate far from the surface.

Storage under water unquestionably preserves the heating value and the physical strength of coal. But it practically necessitates firing wet coal, and therefore means the evaporating in the furnace of an amount of moisture varying from 1 to 15%, according to the kind of coal. This factor is an important drawback to under-water storage with coals like the Illinois and Wyoming types, which mechanically retain 5 to 15% of water after draining, but in case of the high-grade Eastern coals, if firemen are permitted, as is ordinarily the case, to wet down their coal before firing, "so as to make," as they say, "a hotter fire," then the addition during storage of the 2 or 3% moisture which these coals retain would be of little consequence. Submergence storage is an absolute preventive of spontaneous combustion, and on that account alone its use may be justified with some coals, but merely for the sake of the saving to be secured by avoidance of weathering, there does not seem to be good ground for its use.

Losses in coal due to spontaneous heating are a much more serious matter. Oxidation, probably in the main an absorption of oxygen by the unsaturated chemical compounds in the coal substance, begins at ordinary temperature in any coal, attacking the surfaces of the particles, thus slowly developing heat. In a small mass of coal this slowly developed heat can readily dissipate itself by radiation, and no rise in temperature results. If radiation is restricted, as in a large pile densely packed, the temperature slowly rises. Now, the curve of oxidation rate, plotted against temperature, rises with great rapidity; and when the storage conditions are such as to allow a certain point (near 100°C.) to be passed, the rate of oxidation is great enough ordinarily so that the heat developed overbalances the heat radiated, and the temperature will rise to the ignition point if the air supply is adequate. The importance, therefore, can be seen of guarding against even moderate heating in the coal, either from internal spontaneous causes or by radiation from external sources. Increased loss of heating value and of volatile matter occurs at moderately increased temperatures, even though the ignition point is not reached.

The amount of surface exposed to oxidation in a given mass depends on the size of the particles and increases rapidly as the fineness approaches that of dust. Dust is therefore a dangerous thing in a coal pile, particularly if it is mixed with larger-sized coal which form air passages to the interior. Spontaneous combustion is brought about by slow oxidation in an air supply sufficient to support the oxidation but insufficient to carry away all the heat formed. There is a wide variation among coals in friability. In comparative rattler tests under certain standard conditions, Pocahontas, New River, and Cambria county, Pennsylvania, coals produced nearly twice as much dust (through ⅛-in. screen) as a sample from the Pittsburg bed. This is a large factor in spontaneous combustion. Mixed lump and fine, that is, run-of-mine, with a large

*Presented, by permission of the Director, Bureau of Mines, at a joint meeting of the New York sections Amer. Chem. Soc., Amer. Electrochem. Soc., and the Soc. of Chem. Ind., New York, November 10, 1911.