THE EUREKA LODE,

OF

EUREKA, EASTERN NEVADA.

By W. S. KEYES, of San Francisco.

THE EUREKA-RICHMOND CASE,

AND

WHAT IS A PIPE VEIN?

By R. W. RAYMOND, of New York.

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THE EUREKA LODE, OF EUREKA, EASTERN NEVADA.

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EASTERN NEVADA.

THE State of Nevada, known *par excellence* as "the Silver State," occupies the major portion of the wide plateau, or so-called Great Basin, lying between the Sierra Nevada range on the west and the Wahsatch range of the Rocky Mountains on the east. It extends from the 114th degree to the 120th degree of longitude, west of Greenwich. It is limited, on the north, by the 42d degree of latitude, and on the extreme south by the 35th degree of latitude. Its general shape is that of an irregular parallelogram, from which the lower or southwestern portion has been cut off by a diagonal southeasterly line; the missing portion forms a part of the State of California on the west.

The Great Basin is made up of a succession of low hills, or minor mountain ranges, running very nearly north and south, with long valleys between them. All of these mountains are more or less metalliferous. On the western rim, marking the eastern flank or foothills of the Sierra, we find granites, porphyries, and propylites. Here we note the great Comstock lode, with its free-milling gold and silver ores, and still further south the once prominent and the now reviving gold and silver-bearing districts of Esmeralda County, Nevada, and of Morro County, California. Next, at some distance to the east, we find the mining districts at and near Unionville, in Humboldt County. Still further to the east we find the Battle Mountain copper-silver district, north from the railroad, and southerly therefrom the Austin or Reese River, Belmont, and other districts. Still further east and north of the railroad, we find the Tuscarora, a new district of very great promise, and the Cornucopia district; and south of these the Cortez, Eureka, Morey, and Danville districts. Eastward again lie the Cherry Creek, White Pine, Sacramento, Patterson, Bristol, and Pioche districts, and, most easterly of all, the Deep Creek and other

purely lead-bearing districts, which assimilate most nearly to the smelting-ore mines of the Territory of Utah.

Very nearly in the middle of Eastern Nevada, we find a belt of carboniferous strata, commencing in the vicinity of the town of Carlin, on the line of the Central Pacific Railroad, passing southwardly about 25 miles east of the town of Eureka, and reappearing a little west of south at a point from 100 to 150 miles east of the town of Darwin, in the State of California. The coal seams of this belt are, in its northern part, thin, and rendered very impure by a large proportion of intercalated black bituminous shales, so that, up to the present time, they have proved of slight commercial importance. Those farther south, on the other hand, are reported to be large, and may, possibly, in the future, become available for the use of railroads and smelting works.

The western portion of the State carries, predominantly, "free-milling" ores, or such as readily yield the precious metals by simple amalgamation. The eastern portion, however, with the exception of the Tuscarora, Cornucopia, Cherry Creek, Pioche, and some minor districts, carries in the main, the lead or smelting ores.

Eastern Nevada is made up almost entirely of a succession of irregularly connected low mountain ranges, running northerly and southerly, which are due to the elevation of the beds of dolomitic or mountain limestone, with intercalated strata of sandstones, quartzites, and calcareous and argillaceous shales. The valleys between the ranges are filled mainly with the products of erosion, and have an average altitude of between 4000 and 6000 feet above the sea-level. The primal granites are visible at a few places, as, for example, in Steptoe Valley, where they show gold quartz veins, and, father south, on or near the same parallel, while the intrusive rocks, porphyries, and lavas, with the accompanying trachytic tufas, are found almost invariably in the vicinity of the metal-bearing districts. The limestones have been determined as belonging to the paleozoic series of rocks of the Cambrian, Silurian, and Devonian eras, and the explorations on the fortieth parallel, under the direction of Mr. Clarence King, have shown their maximum thickness to exceed 30,000 feet. The uplifting of these strata has given rise to the north and south mountain ranges, and hence we observe the anticlinal folds, dipping, in the main, easterly and westerly. This portion of the State is measurably well watered. We find bodies of water, nearly large enough to be denominated lakes, in Deep Creek, Spring Valley, Steptoe Valley, and Ruby Valley, and smaller creeks or streams are not uncommon in all the other depressions between the ranges. The climate is highly salubrious. The snowfall, except upon the mountain tops, is comparatively insignificant. Most of the hardier vegetables and cereals are cultivated with ease and profit. Cattle raising and sheep farming are, aside from mining, the chief industries, for which the bunch grass and white sage offer an admirable and plenteous pasturage. The mountain mahogany, as it is called, a species of iron-wood, and the piñon, or nut-pine, are found in sufficient abundance for the purposes of fuel. The rainfall is, as a rule, slight, but, according to the observation of the longest residents, it has annually been increasing. In fact it has been remarked by the Indians that the white man brings his climate with him, that is, that it rains now more than formerly. In proof we have the fact that Walker's Lake, near the Sierra, has, in recent years, so much enlarged its area that the old stage road is now under water four or five miles from the shore, and at Rush Lake, near the town of Stockton, in Utah, where, in 1866, there was merely a muddy slough, we now find a respectable lake several miles in length. The Great Salt Lake, as is well known, is much less strongly impregnated with salt than formerly, and has risen from twelve to fourteen feet.

Population in the Great Basin is quite scanty. The entire State of Nevada has only about 54,000 inhabitants, of whom the far larger portion are to be found near Virginia City, on its western limits. Eastern Nevada is very sparsely settled, the population being principally confined to the neighborhood of the mining villages, which now are, as they always have been, the forerunners of advancing civilization.

EUREKA.

The town of Eureka is situated in the county of Eureka, in the eastern part of the State, ninety-one miles south of Palisade Station, on the Central Pacific Railroad, with which it is connected by a narrow-gauge railroad. This road was built and equipped without aid either from the State or county. It has nowhere a grade of over one hundred feet to the mile, and is reported to have cost something more than $1,000,000.

Eureka, which, in the year 1869, had but one or two log cabins, has now a population of 5000 to 6000, with two daily newspapers, two lines of telegraph, a railroad, and many fine buildings. It is the second town of importance in Nevada. The territory now known

as Eureka County was formerly a portion of Lander, the "Mother of Counties." Lander was, in the year 1869, as a consequence of the White Pine excitement, divided into three portions; the northeast portion was organized as Elko County, and the southeast portion as White Pine County. The legislature of 1874 again cut off from Lander a narrow strip, running north and south, and formed thereof the present county of Eureka.

HISTORY OF THE EUREKA DISTRICT.

The Eureka mining district embraces the major portion of a spur of the Diamond range of mountains. (See Map, Plate I.) Silver ore was first discovered in this locality by some members of the Leathers' party from Austin, on their way to White Pine, in the latter part of the year 1864, or early in 1865. They had intended to follow the old road, through the pass across the Diamond Range, some three miles north of the present location of the town of Eureka, but some of the laggards of the company, deeming the cañon leading to the south the easier passage, took that direction, and found some rich mineral "float" in what is now called New York Cañon, just south of the present town. They hastily made some locations, and continued their journey to White Pine Mountain.

Little was done in the district, beyond merely adopting the Reese River mining rules and regulations, until the spring of 1869, when Major W. W. McCoy built, under the direction of Mr. C. Stetefeldt, M. E., a small furnace for the reduction of ores. This furnace was only moderately successful. The ores were very "rebellious," *i. e.*, contained a very high percentage of silica, and although some "work-lead," or bullion, was produced, still the experiment was, on the whole, non-renumerative. Meanwhile the Tannahill Company, an Eastern corporation, had done a little work, but was ultimately dissolved, or ceased operations. In the fall of 1869, Mr. G. C. Robbins, as agent for the Buttercup Company, likewise an Eastern corporation, built a small "draft furnace," which was partially successful, and subsequently a larger furnace. Owing to economical complications, this company's property was ultimately sold out by the sheriff, and it, too, disappeared. The Jackson Company also built, subsequently, a small furnace, and produced some lead bullion.

All the locations made in the district up to the summer of 1869, were in New York Cañon and on the easterly flank of the high peak

now known as Prospect Mountain. All the prospectors had sought for mineral on the east side, and had unfortunately overlooked the westerly and northwesterly foothills. At this time, however, some Cornish miners discovered a very promising ferruginous outcrop about 2½ miles west of the town of Eureka, on a northwesterly spur of Prospect Mountain, which they named Ruby Hill. From this discovery dates the beginning of the prominence and prosperity of the district.

The party located the Champion, Buckeye, Sentinel, Mammoth, and other claims, which they set to work industriously to open and develop. The owners of the Buckeye, Mammoth, Sentinel, etc., built a brush fence marking and defining their claims. They prudently took in all the law allowed them, and something more; and, subsequently, when the ground had become valuable, patrolled their boundary line with loaded rifles to keep off encroaching locators.

Soon after Messrs. Buel & Bateman, men of affairs and adventurous miners, built two small furnaces after the Cornish fashion to smelt the rich carbonate of lead ores found in the Champion. The results were highly encouraging. Subsequently a party of San Francisco capitalists bought out the owners of the Buckeye, Mammoth, Sentinel, etc., and a consolidation was effected with the Buel & Bateman Company. From the properties thus united resulted the corporation now known as the Eureka Consolidated Mining Company. This company was organized in July, 1870, and in the month of January of the succeeding year the writer took charge as superintendent of the mines and furnaces. During the next few years a large number of corporations were formed to work the mines of this district, among others the Richmond, K. K., Jackson, Phœnix, Hamburg, etc. All of these except the last (and that presumably) are situated upon what we shall call the Eureka lode. Of these the Richmond lies to the west of the Eureka Consolidated, and the K. K., Phœnix, and Jackson, in the order named, follow one another to the east of the Eureka. The Hamburg lies about three miles in a southerly direction, and is probably on a continuation of the same great lode. Quite a number of more or less promising locations have been made on both sides of Prospect Mountain. They have not, however, been developed to any great extent.

A work of very great geological interest is the tunnel recently started on the western side of Prospect Mountain. This is intended to be driven from the west entirely through the hill. At a point some few hundred feet in it is reported that the limestone has given

place to quartzite. If this is true it seems likely, judging from other parts of the district, that ore will be found lying upon either the western or at all events on the eastern side of it.

MINING LAWS.

The rules and regulations of the miners primarily in force in the district were such as usually governed throughout the State. The early locators adopted formally the Reese River code of laws, which granted 200 feet along the course of the lode to each person named in the notice of location, with an extra claim as a bonus to the discoverer of a new ledge. This code allowed also a space of 100 feet on each side of the claim for working purposes, *i. e.*, for hoisting works, dump room, and other appurtenances of the mine. In the year 1869, at the suggestion of Mr. Stetefeldt, an amendment or addition to the laws was made, whereby "square" locations, as they were called, might be taken up. These square locations consisted of a space of ground 100 by 100 feet, with the addition of the usual extra "square" for the discoverer of a new deposit. They were surface locations, pure and simple, and granted all the mineral which lay beneath them to any depth. The reason recited as the motive for this amendment was that the ores of the district did not occur in true veins, but merely in the form of isolated irregular deposits. These new regulations were adopted prior to the discovery of the ore on Ruby Hill, and hence it is proper to assume that they were not predicated upon the mode of its occurrence at this particular locality. Nevertheless all the earliest locations on Ruby Hill were made either as surface "squares" or as both "squares" and ledge locations. As examples of the latter we have the Richmond location, made by the predecessors in interest of the present Richmond Mining Company, and the Marcelina, belonging to the K. K., which was located in a similar manner by the predecessors in interest of that company. In the fall of 1869 and early in 1870, the miners seem to have begun to doubt the validity of the square locations, and without exception relocated their claims as ledges.

Eureka thus appears to have been the first, if not the only district in the State, in which such a method of location has been attempted. It is still a matter of grave doubt whether such a location could or could not be deemed to come within the meaning of any of the United States enactments governing the location of mines, after the promulgation of the law of 1866. At any rate the innovation very soon fell into disuse, or was only invoked as an additional safeguard to round out, so to speak, a ledge location. By combining both a surface claim and a ledge location the miners were enabled to evade the very troublesome and very improper permission or presumption of the old law that many different ledges might crop out and be held by different owners within the area of a single claim. This objectionable feature has been entirely obviated by the wise provision of the act of 1872, whereby all ledges, if there be more than one within the surface lines of the original location, are deemed to be the property of the first locator, in so far as they are included within the projected end-lines of the claim. The law of 1872 has so far worked admirably in practice. It might be improved, however, by enlarging the surface permitted from 600 to 1000 feet, and by making the parallelism of the end-lines mandatory instead of merely directory.

GENERAL GEOLOGY OF THE DISTRICT.

Immediately east of the long and narrow gulch, in which lies the town of Eureka, we find some high lava hills, which extend, interrupted by valleys, very nearly to White Pine, forty miles distant to the southeast. Bordering on the lava hills, and extending also west of the town a few hundred yards, are trachytic tufas of whitish or pinkish color. These rocks, probably volcanic ash, are used for building material. When freshly quarried they may be easily shaped with an axe; but, on exposure, they lose much water, and become quite hard. The tufas extend southerly along the main gulch about one mile. South of the town we note also other gulches; the most westerly, called Goodwin Cañon, skirts along Prospect Mountain; the next, called New York Cañon, runs more or less parallel with the main gulch, and ends in a species of basin against a portion of Prospect Mountain; the next to the east follows along southerly, and, crossing a low divide, forms the highway to Secret Cañon District. The main gulch receives some minor tributaries from the east, and passes on to Fish Creek Valley. At the point first mentioned, south of the town, where the tufas give out, occurs a prominent ledge of sandstone, from which rock has been taken for lining the smelting furnaces. This sandstone reef is largely developed on the eastern side of the Diamond Range, facing Newark Valley, and appears again some fifteen miles to the east, as a part of the coal

measures at Pancake. It is hence called Pancake Rock. The mechanical aggregation of its quartzy particles varies very much. In some specimens the sandstone is distinctly granular; in others it appears compact, tough, and close-grained. Only the former variety is used for the furnaces; and when so used it must be built in with the edges of the bedding exposed to the fire; otherwise it shales off in large flakes. I have found but one fossil in the Eureka reefs. This appeared like a short section of a small wood-screw, about three inches long, and nearly half an inch thick. The fossil was surrounded by a hollow cylindrical space, leaving the articulations free, the extreme ends of which formed part of the inclosing rock. The specimen has unfortunately been lost. In New York Cañon we find a series of true clay shales, which furnish the tamping for the furnaces. On the western side of the same gulch we find a high ridge of calcareo-silicious rock, called Silver Hill. This last contains some specimens of ore, and has been located for mining purposes. In places it has yielded some very rich ore carrying chloro-bromide of silver. No well-marked deposit has, however, as yet been uncovered. A similar ore in similar rock has also been found on and near Adams Hill, about three miles west from the town.

Adjoining the town, a little south of west, are two hills of trachytic tufas, and again west of these an isolated hill of massive quartz or quartzite, called Caribou Hill. In places this hill shows some very rich specimens of chloro-bromide of silver, but not as yet in any great quantity.

Due south of the town and west of the main gulch, not delineated upon the map, is a high mountain of massive quartz or quartzite, whereon are situated the Hoosac and other mines. The Hoosac has yielded large quantities of antimoniacal lead ores, some of which were very rich in silver, but carried no gold.

In this respect they, in common with the ores found in the silicious lime ridges, differ from the lead-bearing ores of the dolomitic limestone, all of which latter carry more or less gold.

Southwest of Caribou Hill we come to Ajax Hill and Ruby Hill. The former is merely an easterly continuation of the latter. The quartzites and silicified limestones extend in a northerly and southerly direction from Adams Hill on the north to and beyond the Hoosac Mine on the south. A heavy line of calcareous shales is found, more or less continuously, between the same points. They seem to bear some fixed relationship to the quartzites, and are probably the remnants of conformably deposited beds. Back of Ruby Hill, to the

south, the high peak of Prospect Mountain towers about 2000 feet above the valley. It consists superficially of limestone, and has, on both flanks, many outcrops of ore which seem to occupy a succession of gash veins. The ore is quite distinct from that of Ruby Hill. On the western side of the mountain, the quartzite reappears and extends to the south for several miles in the direction of Spring Valley. Still west again we find the limestones, wherein there are some few mining locations. The limestones extend onward to the west, a distance of about sixty miles, until we approach Smoky Valley, which bounds, on the east, the Toyabe range of mountains, in which are the granite formations of the Reese River and other districts. To the east of Eureka, the same broad belt of dolomitic limestone extends quite to the limits of the Great Basin, and is broken only by the valleys, and by occasional outpourings of the volcanic rocks, and rare appearances of the deep-lying granites.

The Eureka limestones carry Silurian and Devonian trilobites in but two places, as far as known at present. The one is at a point near the northwesterly end of Ruby Hill in the direction of the extreme southerly spur of Adams Hill, and the other is in New York Cañon directly east of the Mortimer Mine, at a point about 2½ miles south of the town. These fossils are all small; the largest being about the size of a finger-nail.

GEOLOGY OF RUBY HILL.

The geology of Ruby Hill is quite simple. To the south we have a belt of quartzite. Just south of the claims of the Eureka Consolidated and Richmond we find the quartzite grooved out, and forming a narrow gulch running down to the valley on the west. Across this small gulch it rises and forms a small bare hill. To the east the quartzite continues along the K. K. and Phœnix claims, and then turns to the southeast, behind the claims of the Jackson, Jefferson, Shoo Fly, etc. Superimposed upon the quartzite we find an altered bed of dolomitic limestone, striking easterly and westerly, and dipping to the north and northeast. This forms the mineralogical zone, treated in this paper as a single lode or vein, whereon are located the Tiptop and Richmond claims, the Eureka Consolidated claims, the K. K., Phœnix, Jackson and other claims. Beyond and geologically above this mineralized zone or vein limestone we find a more or less conformable belt of calcareous and argillaceous shales. Still further to the north and east we find the horizontally lying beds

of country limestone, in which are occasional intercalations of an earthy stratum, apparently marl. The strata of the country limestone vary in thickness from an inch to a foot and over.

THE QUARTZITE.

This forms the footwall of the metal-bearing zone. Its general course through Ruby Hill is very nearly east and west, and its dip is variable, being sometimes nearly vertical, and again quite flat; on the average we may call it about 45° northerly. It seems to have exerted a predominating influence on the deposition and distribution of the ore bodies in the vein limestone. As early as 1864 in Mexico, and subsequently in 1867 in Montana Territory, I observed that the more permanent mines in the dolomitic limestones were always found at or near the points of junction with the quartzites, thus indicating that the latter had some bearing on the ore deposition. This observation has received abundant confirmation from the ore formation and distribution on Ruby Hill, as will appear more fully in the following pages.

After leaving Ruby Hill proper, and just before coming to the Jackson Mine, we find the quartzite gradually curving around to the southeast and south. This change of direction of the footwall gives rise to two anticlinal folds in the vein limestone. The main folding occurs south of the Phœnix, and accords with the general north and south lines of upheaval of the district. The other, or minor folding, occurs on and near Ruby Hill, where the vein limestone on the south side of the hill dips to the south, and that on the north side dips to the north. As a consequence of the variation of strike, we find the quartzite footwall bulging or buckling to the north, and forming great capes, or promontories, which jut out into the vein limestone. On the line of claims heretofore mentioned, we find one very large and two smaller promontories, viz., one at the seventh level of the K. K., where, as will be observed on the map, the footwall drift makes out far to the northeast; another at the extreme westerly end of the fifth level of the Eureka Consolidated, where the footwall turns suddenly to the south; and another, the largest of all, at the ninth level of the Eureka Consolidated, where its thickness is shown by the straight gallery, to be over 200 feet. These capes form wide basins between them, and in these depressions the ore is accumulated. The thickness of the quartzite footwall has not yet been determined. The K. K. has driven into it, at one place, 150 feet; the Eureka drifts have penetrated it from 250 to 300 feet, and the Jackson Company has explored it by drifts for a distance of nearly 750 feet. The quartzite on the plane of contact with the vein limestone is, almost universally, stained red and black with the oxides of iron and manganese; and where the surface waters have percolated along it, we find it soft, decomposed, and covered with a species of plastic clay "gouge," often several feet in thickness. Where, on the contrary, the dip is steep, say from 80 to 85 degrees, and unexposed to the action of water, we find it hard, and in close contact with the vein limestone. Marks of motion are plainly visible, showing the effects of the sliding of the limestone. Often, as in the Phœnix, we observe the clayey face of the footwall, with a half inch of manganese matted upon it, hard, and polished like ebony, with deep striæ running up and down. Near the contact, and for some distance away from it, we often find the footwall irregularly impregnated with iron pyrites yielding, on assay, small amounts of gold. In but a single instance has this pyrites been found in a mass of any magnitude, viz, near the bottom of the Phœnix shaft, which passed through it for 12 feet. Such contact impregnations, as is well known, are quite common in the wall-rocks of metalliferous veins.

Near the vein limestone, the quartzite is much decomposed. Back from the line of contact it is hard and crystalline; so hard, indeed, that it requires blasting, and shows but faintly the original lines of bedding. At one time, encouraged by traces of gold and silver, the Eureka miners imagined that the quartzite would prove to be a ledge of milling ore. Many feet of drifts were excavated in the hope of finding pay ore, but all to no purpose. The rock was useful as a silicious flux for a temporary overplus of iron in the ore from the vein; and hence the cost of exploration was not wholly lost. Of late years no further attempts have been made to find "pay" in it, particularly as the traces of gold became less, the further the drifts were advanced away from the vein.

THE VEIN LIMESTONE.

During the progress of the recent litigation between the Eureka Consolidated and the Richmond companies, a number of analyses were put in evidence by both parties. We have three by Messrs. Luckhardt & Huhn, of the Nevada Metallurgical Works, and ten by Prof. Price of San Francisco.

Those made by the former gentlemen prove the vein limestone to be, beyond question, a typical dolomite. Pure dolomite, as is well known, is a definite compound of about 46 parts of carbonate of

magnesia, and about 54 parts of carbonate of lime. But it very often happens that limestones present, to a greater or less degree, mechanical admixtures of the carbonate of lime, with dolomite, so that geologists, to avoid ambiguity, make use of the terms magnesian or dolomitic limestone. Dana's *Mineralogy* gives analyses of dolomites carrying as high as 57 per cent. of carbonate of lime, and running as low as 32 per cent. of carbonate of magnesia, with some even as low as 25 per cent. of the latter.

Several of the analyses presented by the Richmond Company showed the rock to be a nearly typical dolomite, and but a single analysis showed it to contain less than 6¾ per cent. of the carbonate of magnesia.

The analyses of the vein limestone made by Messrs. Luckhardt & Huhn are marked Nos. I, II, III, as follows:

	I.	II.	III.
Carbonate of lime,	52.04	64.50	59.23
Carbonate of magnesia,	43.24	34.20	36.63
Oxide of iron and alumina,	1.19	0.70	2.70
Silica,	1.65	0 12	0.43
Alkaline carbonates and loss,	1.88	0.48	1.01
Totals,	100 00	100.00	100.00

No. I was a sample taken from the main drift of the third level of the K. K. mine, 100 feet northeast of the shaft.

No. II was a sample of brecciated matter taken from the tenth level of the Eureka Consolidated.

No. III was a sample taken for a distance of twenty-five feet along the main drift of the eighth level of the Richmond Mine, commencing at a point about 125 feet northeast from the quartzite footwall of the ledge.

The analyses of the vein limestone made by Prof. Price, marked from No. 4 to 13, both inclusive, are as follows:

No.	Carbonate of lime.	Carbonate of magnesia.	Carbonate of iron.	Alumina.	Silica and Silicate of alumina.	Totals.
4	53.14	44.35	2.32	traces.	0.12	99.93
5	68.20	25.21	3.19	traces.	2.50	99.10
6	79.25	17.38	1.17	traces.	0.71	98.51
7	82.15	14.06	2.32	traces.	0.80	99.33
8	85.32	11.03	0.87	traces.	1.83	99·05
9	69.23	9.82	traces.	19.60	0.25	98.90
10	89.20	7.56	1.59	traces.	1.69	100.04
11	88.32	6.83	2.61	traces.	1.32	99.08
12	89 26	6.74	1.88	traces.	1.13	99.01
13	92.12	1.06	2.17	traces.	4.10	99.45

No. 4 was a sample taken near the ore at the Tiptop incline of the Richmond Mine; No. 5, soft limestone from the second left-hand crosscut from the main Richmond shaft, near the end of the drift on the 800-foot level; No. 6, from the Bell shaft tunnel, 50 feet from the shale towards the shaft; No. 7, from the end of the Bell shaft tunnel; No. 8, hard limestone, taken from the 800-foot level of the Richmond Mine, inside of No. 1 winze; No. 9, from the stratum on which the ore rests at the Tiptop incline of the Richmond Mine; No. 10, from the Bell shaft tunnel, taken a few inches from the line of contact with the shale; No. 11, from the limestone overlying the ore body in the Potts Chamber, between the fifth and sixth levels of the Richmond Mine; No. 12, from several places in the Lizette tunnel, between the Rossiter incline and the Champion "winze up;" No. 13, from a point near the Richmond Boarding-House, on a line of contact with the shales.

We have also another analysis of the limestone, marked No. 14, which was made from a sample taken at a point from the top of Ruby Hill, in a line directly south of the Bell shaft, on the claim of the Eureka Consolidated. This sample was analyzed by Messrs. Luckhardt & Huhn, and was apparently a piece of nearly pure calcspar. It contained carbonate of lime, 93.20; carbonate of magnesia, 1.68; alumina and oxide of iron, 0.60; silica, 2.05; water, 0.12; and alkaline carbonates and loss, 2.35; total, 100.

None of the samples analyzed for the Richmond Company were presented in court. Hence no description of them was attainable, other than the designation of the localities as above given.

No. 13 of the Richmond series was like No. 14 of the Eureka series, very probably a piece of nearly pure calcspar.

From all of these analyses it will be apparent that even the seemingly pure calcspar is more or less magnesian. Also that the vein limestone is but very slightly silicious.

PHYSICAL PECULIARITIES OF THE VEIN LIMESTONE.

The most prominent of the physical appearances of the vein limestone, is an entire absence of stratification, with the single exception of a small space of the surface ground, near the extreme western point on Ajax Hill, near the dividing line between the claims of K. K. and Phœnix companies.

Here the apparently stratified limestone conforms in both strike and dip to the underlying quartzite. In the first level of the Phœnix,

at a point a little farther east, we find some remnants of this stratification. The limestone is, however, highly charged with oxide of iron, is soft and muddy, and crumbles to pieces at a touch. This spot seems to have escaped the general crushing of the strata. On the surface, aside from the ore outcrops, we find the vein limestone often stained red and black with the oxides of iron and manganese; also ribbed and streaked where the carbonate of lime has been dissolved out by the pattering rain-drops charged with free carbonic acid, leaving the carbonate of magnesia in high relief. Below the surface, we observe that the vein limestone has been crushed and shattered in every conceivable direction, sometimes in huge blocks, sometimes roughly crumbled like small fragments of marble, again crushed or disintegrated more finely, like coarsely powdered glass, and still again, as fine as the finest sand. This sandy limestone—by the term sandy, we describe merely its mechanical aggregation—occurs generally over the ore bodies, and rarely on the footwall. When found on the footwall it is accompanied by large boulders of limestone, which appear as if worn and rounded by the action of water.

The fine material frequently gives rise to what the miners term "a run," filling up the slopes, mixing with the ore, and causing the workings to cave in. It has not yet been analyzed, but is, doubtless, the residue of the less soluble portion of the dolomite. In color, it is sometimes nearly white, sometimes ashy, drab, bluish or reddish.

The vein limestone is in many places brecciated and cemented together by calcareous exudations or infiltrations. This re-cementation has frequently been carried to such an extent that the vein matter has lost not only all traces of its original stratification, but appears hard and compact, and rings under the hammer. Stains of iron and manganese, vugs containing low grade ore, and large and small cavities, are found irregularly distributed throughout.

These cavities often form huge natural caverns many feet in extent, both laterally and vertically, the sides and tops of which are covered with glittering stalactites and thick incrustations of acicular crystals of arragonite. In the bottoms of the caves ore is invariably found.

The first discovered of the larger caverns was near the surface, on the southern side of the hill, beneath the original ore-body of the Champion claim. This was from 30 to 40 feet wide, about 20 feet high, and some 60 feet long. It lay almost in a direct line above the latest discovered huge cavern, the largest of all, at the

extreme west end of the ninth level of the Eureka Consolidated. Another large cavern was found about two and a half years ago, above the so-called fifth-level bonanza of the Eureka, the roof of which fell in and crushed through three levels of the mine, killing several miners. A large cavern was also found at the second level of the K. K., and in a line therewith a series of such caverns extended downward to the fifth level, where one could advance in an easterly direction a distance of 150 feet. Recently a large cavern has been discovered in the Jackson Mine, beneath which, as is usual, a large body of ore appears.

These caverns form a marked characteristic of the vein limestone. They are nowhere found outside of the mineralized zone, and are due, beyond question, to the easy solubility of the carbonate of lime in surface water charged with free carbonic acid, coupled with the peculiar accessibility of such waters to the interior of this crushed and broken zone. Aside from the numberless fissurings in the mass of the vein limestone, we find two main systems of fissure planes; one in which the cross fissures run nearly north and south, at right angles to the underlying footwall, and the other more or less nearly parallel therewith. An exception to these two predominating lines of fissures we find at the Lizette tunnel in the Richmond Mine. Here the fissure planes have the appearance of nearly level floors. All these fissure planes are strictly internal, are confined to the mineralized zone, never pass out into the underlying footwall, and never penetrate into the overhanging country rock, and hence, in no respect resemble veins of any kind; they are strictly subordinate, and are merely local phenomena of the vein as a whole.

The most prominent of the cross fissures is to be seen at the second level of the K. K., a little west of the main shaft. It runs from the hanging wall to, or nearly to the underlying quartzite, has upon its sides vertical lines of motion, and reaches above the level a distance of 55 feet. It dips slightly to the east. Ore was found upon it a short distance north of the shaft, and thence was found extending back to the footwall. Here, as elsewhere, under similar conditions, the one has plainly been carried forward from the footwall along the fissure plane, and its position on the footwall cannot, by any stretch of imagination, be justly attributed to the fissure plane itself as a source of supply. At this point, the K. K. second level, ore was found upon the cross-break a distance of nearly 200 feet from the footwall, while the fissure plane extended some 80 or 90 feet farther in the same direction, without any ore or sign

of ore, quite to the hanging wall. All these longer fissure planes, whether forming cross breaks or parallel breaks, seem to have resulted from some natural disturbance in the zone of mineralized limestone, and seem to bear some distinct relationship to the folding, bulging, or slipping of the underlying footwall. Beneath the long cross-break at the K. K. second level, developments have shown a sudden sinking or falling away of the quartzite, which fact readily accounts for the vertical fissuring just above it.

The nearly vertical fissurings in the Richmond Mine, which that company sought to have recognized as a distinct vein, were not vertically the one over the other, but were at each succeeding level, further to the north. The footwall beneath them has, we believe, caused their peculiar formation. As yet, the quartzite beneath the Richmond has been but slightly developed. Enough, however, has been shown by its abrupt change of course at the extreme end of the Eureka fifth level, and by its southerly or abnormal dip at the southerly end of the Richmond sixth level, to warrant the conclusion that these fissurings were due to the change of strike and dip of the quartzite. To account for the floor-like fissurings at the Lizette tunnel, we need only note the fact that this is the end of the hill overlooking the valley, and hence the body of limestone had free scope to push forward or slide upon itself. Such floor-like fissuring could not occur at any other point, for the reason that the vein limestone is everywhere else closely hemmed in by the adjoining formations. These fissure planes all have a marked tendency to approach the quartzite, and wherever they have been followed down to the footwall the ore is found extending upon the footwall, both above and below them, thus again showing that the ore upon them was taken from the footwall. In the vein limestone we occasionally find extravasations of crystallized calcspar. They are, however, small in extent, and of such rarity as hardly to be worthy of mention.

This mineralized zone of limestone varies in width from a few inches up to 450 feet, both distances being measured at a right angle with the underlying quartzite. Its mean width is about 250 feet. The vein has a greater apparent width at the surface near the centre of the Eureka claims, and at the Richmond. This is due to the crowding over of the limestone to the south, above a surface fold of the quartzite, whence has resulted the second southerly-dipping anticlinal, heretofore mentioned. The narrowest portion of the vein is found in the Jackson claim, where the abrupt change in course of

the footwall has so far pushed out the quartzite that nothing but a seam of ore is found between the hanging and the foot wall.

THE CLAY SHALE.

Bounding the vein limestone on the north, and marking the limits of mineralization of the zone, we find a distinct line of calcareous and argillaceous shale. This shale has been uncovered in the deep workings in the Jackson, and both on the surface and in the lower levels of the K. K., Eureka, and Richmond claims. It has been traced in the K. K., on the third and fourth levels, a distance of nearly 200 feet in each; on the tenth level of the Eureka about 200 feet, and for a considerable distance on the seventh and eighth levels of the Richmond.

Its general course, where exposed, after leaving the Jackson, is more or less nearly ten degrees north or south of an east and west line. Its dip is much steeper than the average dip of the quartzite, varying from 80 to 85 degrees. It is plastic, with a slightly greasy look, and in color greenish or yellowish, like a talcose mineral. Although containing iron it is never reddened.

We have three analyses, Nos. XV, XVI, and XVII, of this material, made by Professor Price, as follows:

	XV.	XVI.	XVII.
Carbonate of lime,	66.92	10.29	26.12
Carbonate of magnesia,	1.96	0.75	1.05
Carbonate of iron,	5.82	6.09	17.50
Alumina,	traces	traces	traces
Silica and silicate of alumina,	24.81	82.21	54.50
Totals,	99 51	99.34	99.17

No. XV was a sample taken from the Bell shaft tunnel.

No. XVI was a sample taken at the foot of the seventh level of the Richmond.

No. XVII was a sample taken from the face of the eighth level of the Richmond.

Judging from these analyses, the shale is simply an argillaceous material, more or less mixed with carbonate of lime. The shale at the Bell shaft tunnel is within a very few feet of the surface, and seems to carry much less silicate of alumina than samples taken from the Richmond, at points 700 and 800 feet beneath the surface. The percentages of clay are, however, amply sufficient to identify all three samples, and to distinguish them from the vein limestone.

EXTERIOR LIMESTONE.

Beyond the line of clay shale to the north, we find a second body of dolomitic limestone, which forms the hanging wall country. This is distinguishable from the vein limestone from the fact that it contains no ore, no caverns, and no ore stains or oxide of iron, except at two isolated minor localities. Near the surface it is apparently unstratified, or shows very faint signs of stratification. Beneath the surface, on the contrary, it is generally very plainly stratified, and has its lines of bedding resting upon and dipping slightly towards the clay shale.

The stratified country limestone can be seen to the best advantage at the Jackson mines. This company's new main shaft was located at a point several hundred feet north of the quartzite outcrop, and was sunk a distance of 460 feet, all the way through distinctly stratified country rock. At the depths of 300 and 460 feet, levels were driven off to tap the vein. Both of them passed through the stratified limestone, cut the clay shale hanging wall, and passed into the metamorphosed unstratified vein limestone, through which they advanced to the quartzite footwall.

We have three analyses of this material, by Messrs. Luckhardt & Huhn, marked Nos. XVIII, XIX, and XX, which prove it to be a typical dolomite, as follows:

	XVIII.	XIX.	XX.
Carbonate of lime,	52.01	54.34	54.76
Carbonate of magnesia,	43.88	43.49	39.66
Alumina and oxide of iron,	1.13	0.37	1.74
Silica,	0.50	1.79	1.00
Water,	0.09		0.12
Alkaline carbonates and loss,	2.39	0.01	2.72
	100.00	100.00	100.00

No. XVIII was taken 30 feet north of the clay shale, in the Bell shaft tunnel.

No. XIX from a point 120 feet north of the clay shale, in front of the Bell shaft tunnel.

No. XX in the third level of the K. K., on the main drift easterly from the shaft, from a point about six inches to the north of the clay shale hanging wall.

We have also some analyses made by Prof. Price, marked Nos. 21 to 27, both inclusive, as follows:

No.	Carbonate of lime.	Carbonate of magnesia.	Carbonate of iron.	Alumina.	Silica and Silicate of alumina.	Totals.
21	58.24	37.80	1.32	1.02	0.63	99.01
22	68.23	27.46	2.32	traces.	0.92	98.93
23	52.92	32.48	3.62	traces.	10.15	99.17
24	88.34	4.98	1.59	traces.	4.83	99.74
25	91.61	1.21	1.59	traces.	4.73	99.14
26	88.21	1.36	2.32	traces.	6.12	98.01
27	92.60	2.95	0.87	traces.	1.62	98.01

No. 21, was taken on the northern side of the hill, very near the mouth of the Bell shaft tunnel; No. 22, from inside the Bell shaft tunnel; No. 23, from a small shaft between the Bell shaft and the main Richmond shaft; No. 24, a sample of the stratified limestone taken from a point twenty feet from the end of the seventh level of the Richmond Mine. No. 25, was a sample of the stratified limestone taken from a point on the eighth level of the Richmond Mine near the line of contact with the shale; No. 26, from a point near the Richmond Boarding-House, on the northwesterly side of the hill; No. 27, from a point on the southwesterly spur of Adam's Hill, to the north of and opposite to the Richmond Boarding-House.

The specimens from which these analyses were made, were not shown in court, and hence no description is obtainable beyond the mention of the localities. It will be observed, however, that the analyses Nos. 21, 22, 23, from samples taken from the Bell shaft tunnel and its vicinity, correspond satisfactorily with the results obtained by Messrs. Luckhardt and Huhn. These still further confirm the statement that the rock is very nearly a typical dolomite. Every sample, without exception, proves the country rock to be more or less magnesian.

MICROSCOPICAL ANALYSIS.

In order more definitely to investigate the interior or vein limestone, and the exterior or country limestone, specimens of each were ground down to a thin film and carefully examined. The samples thus selected were portions of the same pieces from which analyses Nos. 2 and 19 were made by Messrs. Luckhardt & Huhn. The former is a characteristic sample of the vein limestone, and the latter

of the country limestone. Examined under the microscope, the exterior limestone appeared homogeneous, while the vein limestone, on the contrary, showed an entirely different mechanical aggregation of the particles. The different particles seem to be cemented together with a pasty substance in a manner unlike those of the country rock.

Beyond the exterior or country limestone, we find a comparatively broad belt of highly tilted calcareous shales, which have been heretofore mentioned in describing the general geology of the district.

MAP AND MODEL.

To the better explanation of the vein phenomena and workings, a complete map and a model of glass were made by Mr. T. J. Read, C. E., and presented in court. The map (Plate II) shows on a horizontal projection nearly all the superficial and deep-lying ore bodies, as well as all the main shafts, tunnels, drifts, winzes, and connections of the K. K., Eureka Consolidated, and Richmond mines. The foot and hanging walls, wherever developed, are shown upon it. Each of the levels is designated by appropriate numbers and letters; and the ore chambers are so marked as to correspond with the respective levels whereon they are found. Low grade ore, and ore stains, *i. e.*, oxide of iron, carrying traces of lead, gold, and silver, are indicated by shading on each side of the levels and winzes. The workings of the Phœnix and Jackson claims are not delineated upon the map.

The model shows the principal ore bodies in the vein as they appear beneath the surface, looking through the hill from the east, or from the west. (Stereoscopic views of this model were exhibited at the meeting.) The model consists of sixteen glass plates set vertically one inch apart, and is constructed on a scale of 100 feet to the inch. Nos. I, II, III, IV, and V, represent vertical sections, through the Richmond Mine; No. VI represents a section through the end-lines of the adjoining patents of the Eureka and Richmond claims. The remaining plates represent sections through the Eureka Mine.

The ore bodies, placed upon the model, show, from actual survey, the spaces from which mineral was extracted and worked in the furnaces. Around and particularly beneath nearly all of them, large masses of ore are still left standing, which are of too low a grade to be worked at present. Two very prominent, and at one time very rich ore chambers, to the south of or below the surface

chamber of the Champion, are not delineated either upon the map or model. This was owing to the fact that a survey was impossible because they were long since worked out, and have caved and been filled up. Also, quite a large number of the smaller isolated ore bodies were left off, either because they came between the plates or because on the scale of 100 feet to the inch they would have to be represented by small dots. The contour of the surface, it will be observed, is represented by waving lines, and the places of the hanging and foot walls by inclined lines on the north and south.

With a few explanations the map will be fully intelligible. At the lower southwesterly portion we find the Tip Top, Richmond, and Lookout claims patented to the Richmond Company. In the centre we find the Nuget, Champion, At Last Margaret or Lupita, Savage, Buckeye, Mammoth, Sentinel, and Elliptic, belonging to the Eureka Consolidated. All of them have been patented except the last.

The original workings of the Richmond were at the Richmond Tiptop incline, whence they followed down on a series of more or less closely connecting ore bodies to and beneath the point marked "Potts Chamber, fifth level." Here, it will be observed, the shoot of ore has passed laterally across the dividing line of the claims extended on the dip of the lode, and has come into the ground of the Eureka Consolidated. The present main working shaft of the Richmond is marked "Richmond Shaft." It is situated on the northerly slope of the hill, about 200 feet below the comb of the ridge, which passes along easterly and southeasterly through the Lookout claim, at about the At Last Margaret dividing line. From this shaft seven levels have been run out both easterly and westerly. The deposit is 900 feet from the surface.

The mines of the Eureka Consolidated were, like those of the Richmond, originally worked from the southerly slope of the hill. The Eureka workings were at the Champion and Buckeye, and on the northeasterly slope at the surface ore chamber of the Sentinel. The old shafts marked upon the map are the Windsail and Buckeye; the former is about 250 feet deep, and the latter about 150 feet. Both of these reached the quartzite. Three levels were run off from the Windsail shaft, and one from the Buckeye. Besides these, there were quite a number of small shafts and inclines sunk on or near the footwall on the Nuget, Champion, Savage, and Buckeye, which are not delineated on the map. The Bell shaft, on the northern side of the hill, was sunk a short distance and then abandoned. The present main working shaft of the Eureka is at the point marked "Lawton

Shaft," on the extreme easterly line of the Elliptic. From this shaft nine levels have been driven, the deepest being 730 feet from the surface. An inner level, not directly connecting with the shaft, has been run from the bottom of the 100-foot winze at the point 9 V on the ninth level. The first leve of the Eureka is called the Lawton Tunnel. It connects with the main shaft by a short side drift. This tunnel starts in the narrow ravine below or to the east of the K. K. hoisting works, and runs entirely through the hill in a southwesterly direction. It passes within a few feet of the Buckeye shaft, connects with it, and also with several of the old ore stopes on the southern side of the hill.

The K. K. has four minor shafts, and one main working shaft on the ground, delineated upon the map. The main shaft is at the point marked "K. K. Shaft." From it, seven levels have been run out, the deepest being 725 feet below the surface.

The Richmond shaft enters the footwall, between its sixth and seventh levels, at a point about 650 feet below the surface. The Eureka shaft enters the footwall, between its sixth and seventh levels, at a point about 450 feet below the surface. The K. K. shaft enters the footwall, between its fifth and sixth levels, at a point about 550 feet below the surface. The collar of the Richmond shaft is 170 feet, and that of the K. K. shaft 58 feet below the collar of the Eureka shaft.

It will hence be observed that the K. K. shaft, lying only 120 feet east of the Lawton, enters the footwall at a point 158 feet deeper than the latter. This statement, showing a sudden falling away of quartzite, will render clear the explanation as to the K. K. second level cross-break, heretofore alluded to.

The numbers on the map indicate points referred to in the evidence during the recent lawsuit. Where a number is followed by a letter, the former indicates the level. Thus, 8 H is the point H on the eighth level. Heavy marking of the sides of the levels indicates ore or "orey matter," according to Mr. Read's testimony in court.

ORES AND ORE BODIES.

All the ores of the Eureka lode are of one general character. They consist, in the main, of highly ferruginous carbonates of lead. Subordinately, we find oxide of lead, arsenio-chloride of lead, molybdate of lead, sulphate of lead, arseniate and carbonate of iron, oxide of zinc, galena, iron pyrites, and rarely oxides and carbonates of copper. They are, in a word, chiefly oxidized ores, the product of the decomposition of galena and of iron arsenical pyrites, all carrying a greater or less percentage of gold and silver. The workable ore ranges in value from $40 to $70, and upward, in gold and silver, with from 16 to 30 per cent. of lead to the ton of 2000 pounds. The richest ore is that species of carbonate of lead called by the miners "black carbonate."

This ore carries 60 to 70 per cent. of lead, and assays in gold and silver from $100 to $300 per ton. It occurs most commonly in streaks and masses on or near the footwall.

At the K. K. third level, we find a huge mass of nearly pure quartz ore carrying scarcely a trace of lead. This occurrence is entirely unusual in the mines of Ruby Hill. This ore is quite rich in gold and silver, yielding by assay, from $25 to $175 per ton. It lies nearly midway in the ore channel, extends above the level about 25 feet, and below it a distance of about 45 feet; the cross drift shows its width to be nearly 90 feet. Its length has not yet been definitely developed. Over it was found a rich streak of carbonate of lead, which dipped down behind it to the footwall. The quartz is not hard and compact, but has a sugary texture, as if deposited from water. It lies directly beneath the narrow gulch which heads on Prospect Mountain. The only ore ever found on the hill resembling this was a portion of the outcrop at the Buckeye, which was very silicious. The ores in general, as well as the vein limestone, carry very small amounts of silica.

The outcropping of ore on Ruby Hill was originally found on the Champion and Buckeye claims on the south side. It appeared here as an earthy-looking oxide of iron, with which some carbonate of lead and galena were intermingled. This ferruginous matter was found irregularly distributed over a space 480 feet in width, between what is now called the Lupita excavation on the north and the Buckeye on the south. To describe the outcrops in their order, we may begin at the extreme westerly end of the hill. There we find the Richmond Tiptop ore body appearing in a small cave on the side of the hill, and two or three smaller bodies of low grade ore at the shafts further to the northwest. Below them and near the quarzite contact, other bodies of ore were subsequently found.

Between the Tiptop incline and the Champion claim we find, also, a rather prominent outcrop at the Virginia or Iron shaft, and three minor patches of low grade ore at the points marked II, III, and IV on the map. Thence proceeding easterly, we find the large surface chamber of the Champion; then the huge connected outcrop at

the Buckeye; thence nearly due east we find the surface ore chamber of the Sentinel; thence easterly again, in the ground of the K. K., we have the Marcellina outcrop, most unaccountably left off the map; thence, in the same direction, we have the two outcrops at the two small shafts in the gulch; thence a little south of east, and still upon the K. K. claim, we find the Carson outcrop; thence south of east we have the Deap and Phœnix outcrops, and lastly, southeast, we find the Jackson outcrop.

Between the Jackson and the Tiptop we can enumerate a total of thirty-four outcrops, all of considerable extent. Most of them were originally quite small, some, like the Buckeye and Champion, developed to an enormous extent. The extreme points of these claims are over 800 feet apart, as may be seen upon the map, and the ore has been traced almost the entire distance.

When first discovered, the ground between these points appeared to be nothing but limestone, which, however, subsequently proved to be merely cropping of cemented debris.

The largest surface body visible in 1869 and 1870 was the first bonanza of the Jackson. This was an egg-shaped mass of ore, about 70 feet long, 20 feet high, and 30 feet broad. It did not descend to any further depth, and showed no visible connection with any other ore body.

The Tiptop outcrop, as already stated, was found inside a small cave. So little did it attract attention, that the Richmond locators, who had placed their notice, as is reported, at the Iron shaft, very near it, failed to observe it. They took no steps to secure it until ore was found in it by the Tiptop miners. To the latter it properly belonged, but the former party claimed it as being on their location, and after much wrangling the dividing line was fixed at the cave.

None of the Buckeye or Champion surface ore bodies extended to any great depth, for the reason that the quartzite footwall lay close beneath them, to which they, in almost every instance, extended. The exceptions to this well-defined law of the ore bodies were the first surface chamber of the Champion, and some minor stringers near the Buckeye shaft. These ran up the hill to a thin point, and were in shape something like the glass Prince Rupert drops. Beneath both, however, were other large and valuable bodies of ore which dipped down to the footwall.

Pursuing our investigations beneath the surface, we find the main ore bodies either upon or tending directly towards the underlying quartzite. Those which do not obey this law are simply spurs and branches, making up into the vein limestone. In the K. K., below

the third level, all the ore is found immediately upon the contact. On the fifth level we follow the pay ore along the quartzite a distance of nearly 300 feet. The new fourth-level ore body starts in the vein limestone, and as it dips will soon reach the quartzite.

In the Eureka we find the ore along the contact for a distance of 50 to 150 feet. The largest and most valuable shoot of ore ever discovered in this mine is found upon the quartzite at the extreme westerly end of the fifth level. Here the footwall, as already mentioned, makes a sudden bend to the southwest, and upon it is found a thick mass of rich black carbonate, making downward on both sides of the promontory. A portion of this ore continues down on the westerly side of the quartzite cape, passes across the dividing line of the claims, and becomes the property of the Richmond Company. Another and probably larger portion makes its way downward northeasterly along the contact (not, however, with uniform and connected richness), till it expands into a very large body at the ninth level. Here we find a huge cavern at the northwest end, in and beneath which the bonanza attains its greatest development. Beneath the ninth level the ore continues downward, on the line of contact, as far as the workings extend, a distance of 160 feet. At the lowest point a level has been driven east along the quartzite over 200 feet, which carries high grade ore the entire distance.

The Jackson Mine, also, half a mile to the southeast, carries fine black carbonate on the footwall, at the 460-foot level, for a distance of about 200 feet. The ore body underneath the cavern in this mine is not upon the footwall, but its dip is such as will certainly carry it to that point.

The Richmond ore bodies, on a superficial examination as far as the fifth level, would seem to belong to a different system. The outcrop starts in limestone, whence the ore dips down gradually to the bottom of the incline. Here we find the stopes extending northeasterly and quite flatly, to a point a little beyond the northeasterly side line of the Lookout patent. At this point we pass down through the Rossiter Incline, and come to the Flat Chamber, an almost horizontal body of ore. Thence we pass down through steep winzes, through the intermediate levels, until we come to the Potts Chamber. The ore is not continuous throughout the entire distance, but is broken at two places, where the ore-stains are either very scanty or totally absent.

Viewed as a whole, this ore-shoot is made up of a string of ore bodies following one another irregularly downward and forward to the northeast. The developments have taken this direction rather

than a northerly or northwesterly course. Had the latter been pursued, the ore-shoot would very likely have been shown to connect with the ore-bodies at the west of the shaft on the fifth level.

One portion of the Potts Chamber connects with the quartzite. Low grade ore and ore-stains are found upon the footwall, and from thence to the ore stopes only ten feet distant. On the Richmond footwall, at the point 69 B, fine carbonate ore is found.

It will thus be seen that the Richmond series of ore-bodies, like all the rest in the mineralized zone, approach the footwall in depth. Below the Richmond sixth level, in the drift 6 L, low grade ore is found extending southerly, a distance of fully 100 feet. Directly opposite to this drift, at the same depth, we find the Eureka drift, 10 E, advancing to meet it; ore-stains and low grade ore are found in this also. There now remain but a very few feet to connect the two. There is no reason to doubt that the low grade ore will continue, and thus bring the Richmond ore-shoot definitely down to the footwall.

Besides the ore-bodies in or near the quartzite, we find, as the walls approach in depth, considerable deposits upon the hanging wall. Still again we find numerous isolated bodies away from either contact. The Eureka has uncovered such bodies on several of its levels. The Richmond, also, has two such bodies on its fifth level west of the shaft, which are quite large, and which promise to be valuable.

They have another isolated body near to the shaft on the eighth level, at a point 44 feet away from the footwall; also, several smaller bodies in the winze near the shaft connecting with the ninth level; also, at several places in the Lizette Tunnel. In addition to the isolated bodies just enumerated, we find low grade ore and ore-stains very generally scattered throughout the vein limestone wherever drifts have penetrated it.

Assays of a large number of these ore-stains, taken from various localities on the surface and beneath it, were put in evidence in the recent suit. As fair samples we may present the following: No. 2, $12.55; No. 3, $5.80; No. 4, $2.19; No. 44, $3.60; No. 47, $5.74; No. 48, $3.92; No. 49, $3.14.

Numbers 2, 3, and 4, were from the surface of the Richmond at the points marked on the Map II, III, and IV. No. 44, was from the extreme westerly end of the Eureka third level; Nos. 47, 48, and 49, were from the Eureka ninth level.

Ore extends in the Jackson Mine from wall to wall at the point on the 460-foot level where the quartzite and shale come nearly together.

A like phenomenon is visible at the K. K., third level, where the walls are 280 feet apart.

The Potts Chamber also touches the hanging wall at the bottom of the winze, 6 G, on the sixth level of the Richmond, and comes within ten feet of the footwall at the point on the level above, heretofore noted. The ore-bodies generally follow the depressions of the footwall, and occasionally pass across the promontories.

Those in the Richmond pitch northerly and northeasterly; those in the Eureka, northerly, northwesterly and northeasterly; while those in the K. K. pitch mainly northeasterly. I use the word pitch, as contradistinguished from dip, to denote the inclination of the ore-shoots laterally. The dip, in strictness, must be at right angles to the course, and hence does not describe a variation from that direction.

The surface map exhibited is also the work of Mr. Read, whose skilful, patient, and constant labors have done so much to elucidate the relations of the ore-bodies in Ruby Hill.

Elaborate maps were also put in evidence during the late suit by the Richmond Company, prepared by their surveyor, Mr. Wescoatt. The company, moreover, exhibited a glass model, constructed on a different system from that above described. In this model the main sections were horizontal, and vertical sections, taken at will, were represented by introducing vertical glass plates between the horizontal ones. The effect was to give a striking representation of those bodies of ore which it was desired to emphasize, and to omit the rest almost entirely. The two models, reduced to the same scale and taken together, would have given a far more complete picture.

It will sufficiently appear from the foregoing description that the mineralized limestone zone of Ruby Hill, which I have called a lode or vein, is not so called because it conforms strictly to the definition of a fissure-vein, given in the books. The term has been used in the miners' sense, and in the sense in which, as the court declared, it is employed in the law. At the same time my object has been to describe fully the thing itself; and if any exact and recognized English name for it can be suggested, I shall be glad to hear it. The latest writers, at home and abroad, confess that the deposits of lead ore in limestone do not strictly fall under the old Saxon classification. This is from the declaration of Prof. Cotta, who may be regarded as one of the authors, and the chief representative of that classification. But I leave to other hands the theoretical discussion of the phenomena, and of the principles, both of geology and of mining law, illustrated by them.

THE EUREKA-RICHMOND CASE.

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(Read at the Amenia Meeting, October, 1877.)

In the case of The Eureka Consolidated Mining Company *v.* The Richmond Mining Company of Nevada, recently tried at San Francisco, California, the real defendant was the Richmond Consolidated Mining Company, of London; but this being a foreign corporation, holds its mining property in Nevada through the Nevada corporation of similar name, in which the London Company owns all the stock, except the few shares necessary to "qualify" the American directors. The trial would naturally have taken place in the Circuit Court at Carson City, Nevada, and before a jury. But by stipulation of the parties, the case was tried in San Francisco, before Hon. Stephen J. Field, Justice of the Supreme Court of the United States, Hon. Lorenzo Sawyer, United States Circuit Judge of the Ninth Circuit, and Hon. E. W. Hillyer, United States District Judge, for the District of Nevada. The hearing began July 23d, 1877. The witnesses occupied two weeks, and the argument of counsel three days. Very eminent lawyers were engaged on both sides; for the plaintiff, Messrs. Solomon Heydenfeldt, R. S. Mesick, John Garber, and H. J. Thornton; for the defendant, Messrs. S. M. Wilson, Thomas Wren, and J. J. Williams. The court held the case under advisement until August 22d, when Mr. Justice Field delivered its unanimous opinion in favor of the plaintiff. The action was a complaint in ejectment, and an appeal was taken to the United States Supreme Court.

The questions at issue between the Eureka and the Richmond Company in this suit, comprised several points in the construction of the mining law of the United States, and its relation to the customs and regulations of the mining districts, which possess an importance and an applicability far beyond the limits of the case in which they arose. It is my purpose to state these points, the arguments concerning them on both sides, and the grounds on which they were decided by the court. The case involved also an interesting discussion of the nature and process of formation of the argentiferous lead deposit of Ruby Hill, which I shall attempt to sketch. For a description of the locality and its vein-phenomena, I refer to the elaborate paper of Mr. W. S. Keyes, which is presented to the Institute simultaneously with this one, and to which this is intended as a companion. Mr. Keyes's paper being accompanied with accurate maps, it will be unnecessary for me to offer any such illustrations of the statements herein made.

The contest between the two companies turned upon two questions: First. Are the two mines working upon the same vein or lode, within the meaning of the law? Secondly. If they are upon the same vein, where should the boundary-plane be drawn between them? And if upon different veins, how are the respective rights of the parties affected by the locations, patents, and former agreements?

The first question involved two inquiries. The first of these relating to the nature of the deposit in dispute, and the theory of its formation, possesses a scientific interest outside of its application to the immediate argument; the second, relating to the meaning of the terms, "vein," "lode," and "ledge," as used in the United States law, is universally applicable to mines held by titles proceeding from that law.

Again, this latter inquiry involves an investigation of the popular and scientific usage of the terms referred to, and of the bearing of strict geological classifications upon questions of mining rights.

It involves also a determination of the force of a boundary-line, established between two mines on the surface, and the direction of its projection in a plane underground.

1. THEORY OF THE FORMATION OF THE RUBY HILL DEPOSIT.

It was admitted on both sides that the ore-bodies of Ruby Hill occur in a zone of limestone, lying upon quartzite, and highly tilted and broken up; that none of the fissures in this limestone had been found to penetrate the quartzite or to pass beyond a certain layer of argillaceous shale, alleged to bound this limestone zone on the hanging-wall side. This clay or shale has been exposed in numerous places, by cross-cuts underground, at varying distances from the quartzite. It is also visible on the surface. The experts of the Eureka Company considered it to be demonstrated as a continuous

layer, and as a boundary of the ore-bearing limestone. Beyond it, they found limestone again, which they described as different in character and appearance from that within the ore-bearing zone. Microscopic slides were produced, to show that in its minute structure, the limestone of the zone shows the result of crushing, disintegration, solution, infiltration, recementation, and mineral deposition, which are comparatively absent from the exterior overlying limestone. Both are magnesian. The experts of the Richmond Company did not deny (I think) that the layer of argillaceous shale or clay might be continuous; but they thought this was not proved, and some of them believed the different exposures made of it to have no connection with each other. They denied also any essential difference between the limestone within and without the alleged zone. While the facts as there developed left room for differences of opinion on these points, the great preponderance of probability as to the existence of a continuous boundary on the north of the ore-bearing limestone zone, in the form of a layer of shale, lies with the affirmative. The fact is, indeed, as clearly proved as the nature of the case would permit. As to the difference in the limestones above and below (north and south of) this layer, one fact was necessarily admitted,—that no ore-bodies have been found near it on the north side, while the limestone zone on the south contains numerous and extensive ones, and is of such a character that explorations anywhere in it may at any time expose ore. The bulges of the quartzite footwall, described in the paper of Mr. Keyes, were also admitted, under various names, by all the experts. Some called them capes; some spoke of the intervening spaces as bays or grooves in the quartzite. Some of the Richmond experts did not consider these irregularities in the surface of the quartzite as the results of pressure and "buckling," but thought they might have existed in the surface on which the limestone was deposited. This view was, however, not seriously insisted upon, and certainly does not, in my opinion agree with all the facts.

According to the theory held by the experts of the Eureka Company, the deposits of Ruby Hill, in their present form, are due to the following processes:

The quartzite is a metamorphosed sedimentary rock. It has been lifted, with the superincumbent limestone strata, to its present position, by forces connected with the general upheavals forming the north and south ranges of mountains in Nevada. The volcanic rocks

appearing to the eastward are probably connected with the same process. But it is noteworthy that the quartzite under Ruby Hill was lifted along a line departing from the north and south line of the mountains of which Ruby Hill is a spur. The strike of the Ruby Hill quartzite shows moreover that it was curved and doubled, as well as lifted. The result of this movement was, that the quartzite layer had less room in depth than along the present outcrop, and the uplifted quartzite formed a sort of basin, buckling or bulging in depth near the points of greatest curve in course. But this buckling of the quartzite could not take place without intrusion into the solid limestone above, and hence the limestone, subjected to oblique upheaval and torsion, and to the intrusion of the quartzite, was much more violently shattered and fissured than by an ordinary upheaval. The process need not have been rapid; a very slow operation of lifting, rubbing, and side-pushing, from the underlying quartzite, would account for the crushing of the limestone, and for the existence of smooth planes of movement, in various directions, upon masses of limestone not crushed, or upon aggregates once crushed and subsequently cemented together again.

This action was limited, comparatively, to the zone of limestone immediately overlying the quartzite. In this zone or layer, which may have been from two hundred to three hundred and fifty feet thick, there appears to have been no argillaceous strata. But at that distance above the quartzite there seems to have been a bed of clay-shale and lime-shale, along which the limestone beds in process of upheaval and contortion could part and slip. The slipping is traceable on the present clay hanging wall in all the mines of this series, from the Richmond to the Jackson; this clay being the remainder of the former laminated beds, from which percolating water has removed a portion of their lime. The present varying thickness of the clay is due, in large part, to the effects of the slipping, which has rubbed it thin in some places, to bunch it up in others. This clay dips from the surface more steeply than the quartzite, a peculiarity due to the internal movements of the limestone zone between them. There is no reason to doubt that the contact-planes between shale and limestone, limestone and quartzite, were originally parallel. But the side-presure attending the upheaval, causing the quartzite to buckle or bulge, and intrude upon the limestone, not only crushed and shattered the latter, but forced it to move in considerable masses to make room for the intruding "capes," or swellings of the footwall. These might push the fragments of limestone among themselves right and left, as

well as up or down, at first; but the fragments first moved, wedging among the pieces of broken limestone, still in place, would move them in some direction; and the general resultant of all these internal movements, would be to drive masses of fragments or solid wedges of limestone upwards toward the outcrop. The zone of limestone between the shale and the quartzite is, therefore, wider near the outcrop than it is below, because, near the outcrop it contains limestone which has been squeezed and jammed up into that portion of it from portions lower down on the dip. The lateral movements within the ore-bearing zone were, perhaps, most extensive in the Jackson Mine, where the quartzite swings round to what appears to be its regular north and south course, and the convex curve of the quartzite has crowded the limestone aside in all directions, until the clay hanging wall and the quartzite are almost in contact, with a seam of ore between.

The limestone zone thus crushed and dislocated presents, on a large scale, the phenomena described under the head of "Veins of Attrition" (*Contritionsgänge*), in the treatise of Weissenbach, published posthumously by Cotta, in the first volume of the *Gangstudien*, Freiberg, 1850. The classification is partly quoted in Whitney's *Metallic Wealth of the United States*, Philadelphia, 1853. Weissenbach discusses chiefly under the head of *Contritionsgänge*, the processes by which fissure-veins are filled to greater or lesser extent with the products of the disintegration, crushing, etc., of the country rock of one or both walls. He says (p. 24), that in consequence of the movements of the walls, aided by decomposing influences, "the whole vein itself may be filled up with such crushed, split, shifted, and cemented fragments of the country rock." After describing these phenomena, as presented by fissure-veins intersecting the stratification, he continues: "Finally, this kind of products of crushing from the disintegrated country rock occur frequently in a perfectly similar manner along the lines of stratification and cleavage in the older schists." It is evident that whether the plane of the action be that of a fissure across the stratification, or that of a parting between two sedimentary rocks, or two layers of the same rock, the effect of the crushing of one wall to a certain distance by the movements and pressure of the other wall, would be to produce a zone of material full of fissures and interstices. And the aggregate of these interstices and fissures would constitute, in that case, the equivalent of a fissure open to receive liquid solutions or gaseous emanations of metallic ores, just as we say, when a river like the

Humboldt ceases to flow visibly on the surface, but continues for some distance to percolate beneath the surface through gravel or sand, that the interstices in this material are the equivalent of an open channel. In a zone of rock, thus shattered and dislocated, the deposition of ore may take place from the same causes, and in the same manner, as in a single open fissure.

Into the limestone zone of Ruby Hill, thus prepared as a matrix, heated mineral solutions and gases are believed to have ascended, permeating the limestone breccia and filling the interstices with metallic sulphides, arsenides, and chlorides. The traces of this original deposition are found in the iron pyrites, arsenical pyrites, and galena, which occur sparingly in the mines at present. Probably, these ore-bearing solutions entered through fissures in the quartzite; but these may be at greater depths than will ever be reached in mining. All that can be definitely declared is, that they penetrated throughout the limestone zone, bounded by a practically water-tight wall of quartzite on one side, and a practically water-tight wall of clay or shale on the other. If this process had gone on alone, and no other change had followed, we might expect the whole zone to present a network of small threads, seams, druses, and nodules, of these unoxidized ores. Possibly, there would have been considerable bodies of ore, here and there, but the probable absence of large open spaces in the limestone would not have favored such accumulations.

During this process, however, and particularly after it had impregnated the zone between the two walls described, a third and most important process began, namely, the infiltration of water from above, the effects of which are now predominant throughout the accessible portions of the zone. To this cause are to be ascribed the chemical changes throughout the zone which precipitated the oxide of iron, arseniates of iron and lead, carbonate of lead, molybdate of lead, sulphate of lead, sulphate of lime, sulphate of magnesia, "black carbonate," etc. Furthermore, this cause produced the natural caverns, by enlarging the original fissures and interstices in the crushed and broken limestone. All that is necessary to effect these results is the presence, dissolved in the surface-waters, of carbonic acid and air. But the transformation of sulphides and arsenides into oxides and carbonates is attended with a considerable increase of volume; and as Bischof has shown, with regard to galena and cerussite, in his *Chemical Geology*, a part of the oxidized salts is carried away in solution. This agency, together with the transportation of materials in suspension, has contributed to the formation of large

ore-bodies, which are accumulations of the disseminated minerals, once more widely scattered in the zone from the quartzite to the shale. These minerals have been oxidized and carried along in solution or suspension, to be deposited or precipitated where the current was interrupted, or some convenient bottom or cavity was encountered to receive and retain the deposited material. The form, size, and position of the ore-bodies in this zone of crushed limestone, and, in general, the distribution of ore in the zone is, according to this theory, the final result of several processes, the last of which has determined the present condition of the zone in these respects. In confirmation of this view numerous facts may be cited. For instance, the natural caverns found in the mines have deposits of ore in and under them. There are seams of oxidized material along the quartzite footwall, and the ore-bodies, however irregular in shape, generally either lie on the footwall or tend towards it in depth, precisely as they might be expected to do if deposited by waters percolating downwards. Where the footwall is steep, there is less ore accumulated on or near it; where it is flat or concave, experience in the K. K. and Eureka mines, leads the miner to expect large ore-bodies.

Another confirmation of the theory, according to which all the ore-bodies in this zone have a common origin and are related to one another as subordinate features of the same deposit, was furnished, somewhat to the discomfiture of the Richmond party, by explorations made in the mines while the suit was pending. These explorations established, beyond dispute, the connection of the ore-body in dispute with the footwall seam of ore and with an ore-body in the acknowledged ground of the Eureka. The opportune demonstration of this connection merely corroborated the views already expressed, on other grounds, by the Eureka experts. [I should, perhaps, explain that when the trial of the case began, the connection of these two ore-bodies was denied by the Richmond party, and through a considerable part of the trial that position was maintained. The testimony of the two bodies of experts was somewhat contradictory as to the existence of any clearly-traceable seam of ore, or "orey-matter," leading from one to the other. But the arrival in San Francisco of Mr. Clarence King, who had remained later at Eureka than any other expert on either side, and had examined openings in the mines made after the rest had gone, changed the situation materially. Mr. King testified to a connection between the two ore-bodies, and the only course left to the Richmond party was to claim the "Eureka ninth-level ore-body" as a "spur of the Richmond vein."]

In opposition to this theory of the formation of the Ruby Hill deposits, the experts of the Richmond Company declared that the limestone was traversed by distinct and independent fissures, "or systems of fissures," of which the Richmond Mine possessed one, called by them the Richmond vein; that this vein could be traced from the surface downward through all the workings; that the disputed "Potts Chamber" or ore-body belonged to it; that it possessed a course oblique to the course of the limestone zone, namely, that the Richmond vein coursed west of north and east of south, and dipped (at right angles to this course) eastwardly into the Eureka ground. Since the "fissure or system of fissures," thus described, could not be proved to extend in either direction beyond the limestone zone, and the horizontal extent of it was limited, the theory was set up that it constituted a "pipe-vein."

This name, as applied in mining literature hitherto, refers not to a separate ore-deposit, but to what we call an ore-body, or "chimney," of a certain elongated shape, lying in, or connected with, other ore-deposits. The term has never been used very generally by miners; it originated apparently in Derbyshire; but its use even there appears to have died out. At least the latest writer concerning that district does not employ it; and it has survived in textbooks merely by the process of quotation. But some of the experts who defended its use in the present case declared, that if they had never before seen or heard of a pipe-vein, they would feel justified in inventing the term for the Richmond deposit. To this, as a piece of scientific classification, there would be several objections. In the first place, it is always unwise to revive an old and obsolescent term in a new sense. In the second place, the naming of an ore-deposit merely according to its form, is not scientific. It is true that names now exist, inherited from the miners, and conveniently related to systems of exploitation, which have no better foundation than the form of the deposit. But geologists are well aware that the use of these names often involves the confusion of real distinctions and the concealment of real similarities. At a time when men of science are seeking to frame a classification of ore-deposits representing their true genesis and relations, it seems puerile to propose a new class, differing from known classes, not in chemical or mineralogical features, or method of formation, but simply in the form of the paying ore-body. It is true as Posepny has well shown in his treatise on the lead deposits of Carinthia, and as Cotta long ago admitted, that metalliferous formations like the whole zone of Ruby

Hill require to be classed by themselves. A new name, even if it were a good one, might be acceptable; but it is needed for the whole formation, not for a small interior feature of it. In the essay already referred to, Posepny forcibly shows how by the adoption of such partial diagnosis, the several parts of one and the same ore-deposit have been classed as deposits of different kinds, and fissure-veins, contact-veins, beds, stockworks, and impregnations have been mixed together in wild confusion.

But the Richmond pipe-vein either in the old, "historical," or the new "actual" sense of the name, has ceased for all parties. Explorations made during the trial, and continued since, have demonstrated, in the second and fourth levels of the Richmond Mine, a large and rich body of ore—the most valuable, perhaps, that has ever been exposed in the mine—lying on the quartzite, and completely contradicting by its form, position, and direction the "pipe-vein" theory. But for adherence to that theory, this body could have been discovered earlier. Its discovery and exploitation now, confirm the opinion expressed in San Francisco by the writer, that the degree of apparent unity and continuity of the ore-bodies constituting the Richmond "vein," was due rather to the form of the underground workings than to the distribution of ore in the zone. In other words, by selecting certain bodies and their connecting clefts, and pursuing these upon a theory, without exploring ground outside of them, a delusive appearance was given (not intentionally, but almost inevitably) to the underground exposures. The Eureka Company, exploring systematically along the quartzite footwall, and cross-cutting to the shaft at intervals, obtained a much clearer view of the whole zone. The Richmond Company, following a single direction, deceived itself into the belief that its ore-bodies were not distributed through the limestone like those of the Eureka, and that they had no such relation to the quartzite footwall as was admitted to have been shown in the Eureka. But now the simple adoption of the Eureka system of exploration puts a new face on the whole matter. The zone is proved to be similar throughout. Nature did not draw the boundary line between the two mines, and operate differently on the two sides of it. It was men who created both the arbitrary line and the imaginary difference.*

* Since the reading of this paper, the work in both mines has further confirmed these conclusions; and has proved, moreover, so enormously profitable to the two companies, that even the parties defeated in the late contest may well afford to be content with a "formation" so much better for their interests than they were willing to believe it. See the Report of the Richmond Investigating Committee (London, May, 1878), and articles thereon in the Engineering and Mining Journal of July 13, 20, and 27.

2. PRACTICAL UNITY OF THE RUBY HILL DEPOSIT.

But the geological argument was not the essential or controlling one in the late suit. The theory adopted by the Eureka experts might have been proved wholly at fault as to the manner of origin of the deposit; and still the question would have remained, whether in view of all the facts, the limestone zone of Ruby Hill, definitely bounded between two walls, and carrying throughout irregular bodies of the same ore, was not a lode or vein within the meaning of the law? It is true that the theory above referred to, by showing a unity of origin, and by ascribing the present form and position of the ore-bodies in a great degree to secondary action, strengthened the Eureka case. But without any theory at all, the case was strong; and the decision of the court indicates that quite apart from the struggle which so deeply interested the experts, fact, not theory, won the day.

It is a well-known principle that the law follows the ordinary, popular meaning of words, where it does not itself define them. The meaning of the terms "lode," "vein," and "ledge," which seem to be employed as synonymous in the law, is made clear by the following considerations.

1. These terms are all drawn from the miner's vocabulary, and in their origin were applied indifferently to fissure-veins, contact-veins, segregations, and even to beds. The word "lode" is a corruption of "lead," and signifies at bottom merely the channel in the rocks which leads or guides the miner. Its use in the compound "lode-stone" has the same significance. The German word *Gang* is from *gehen*, "to go;" and it meant at first simply the way or path of the ore. It is quite true that scientific writers have adopted these words in a narrow sense, often prefacing them, however, with defining terms (fissure-vein, true vein, *wahrer Gang*, *Spaltungsgang*). But the wider sense is not obsolete.

2. Present usage among miners, engineers, geologists, and even authors shows the force of the words to go beyond the technical definitions. Thus we hear of coal veins, of the magnetite veins of New Jersey, of the copper veins of Ducktown, Tennessee, and many other cases in this country, in which the ore-deposits are admitted

to be beds. In England, and even in Europe, the same thing may be observed, though it is more common in the English language than elsewhere, because that language lacks a convenient term to designate a mineral deposit, the precise character of which has not been ascertained. Miners finding an outcrop call it a vein, or ledge, or lode at once, before they know more about it; and the name sticks to it in spite of subsequent explanations.* Nay, even the scientists themselves, after clearly explaining the technical sense of the term, drop comfortably into the popular sense.†

* In order not to burden this paper with citations, I here group together a number of references, going to show, first, the nature of the definition of a lode, and the transition of one class of ore-deposits into another; secondly, the adoption of the popular usage by authors, who apply the terms "vein" and "lode" to deposits not fissure-veins, and even to beds; thirdly, the peculiar nature of lead-ore deposits in magnesian limestone; and, fourthly, the nature of "pipe-veins." The authorities are:

Cotta's Ore Deposits (Prime's translation), pp. 26, 155, 157, 178, 179, 182, 185, 252, 254, 269, 332, 333, 334, 338, 431, 432, 479, 497.

Grimm's Erzlagerstätten (Pribram, 1869), pp. 15, 231.

De la Beche's Geological Observer, p. 644.

Gaetzschmann's Auf-und Untersuchung, etc. (Freiberg), p. 70.

Whitney's Metallic Wealth of the United States (Philadelphia, 1854), pp. 40, 187, 189, 190, 273, 302, 302, 303, 312, 322, 323, 324, 347, 361, 365, 370, 373, 374, 377, 378, 395, 414, 412, 422.

Posepny's treatise on the lead and zinc deposits of Carinthia (Geologische Reichsanstalt, Vienna, 1873), p. 390, 410 and passim. This is a very strong authority, being recent, eminent, and thorough; and being, moreover, based on the study of deposits strikingly similar to those of Ruby Hill. I believe that Mr. Posepny has, during a recent visit to this country, himself visited Eureka, and recognized the similarity. It is sufficiently evident from a study of the maps of the mines. This author proposes the term "typhon-formation" for such deposits, in allusion to the geode-structure of the ore-bodies.

Henwood on Metalliferous Deposits, Part i, pp. 619, 620. This authority was quoted incautiously on behalf of the Richmond, in the trial, because it mentions a "pipe-vein." But an examination of the passage shows the pipe-vein to be included in a "lode" of limestone!

It would be easy to multiply authorities on the points referred to; but I forbear.

† Since presenting this paper, and preparing it for publication, I have received from Dr. Foster a copy of his paper on the Great Flat Lode in Cornwall, printed in the Quarterly Journal of the Geological Society for August, 1878. The following passage bears directly upon one of the questions involved in the case discussed in this paper:

"The terms lode or mineral vein, commonly regarded as synonymous, are usually taken to mean the mineral contents of a fissure. . . . I have endeavored to show in paragraph ii, that the Great Flat Lode is, in the main, a band of altered rock. Much of the veinstone extracted from some of the largest Cornish mines, such as Dolcoath, Cook's Kitchen, Tincroft, Carn Brea, and Phœnix, for instance, closely resembles the contents of the Great Flat Lode, and was probably formed in a similar manner; indeed, I question very much whether at least half the tin-ore of the county is not obtained from tabular masses of stanniferous altered granite. If, then, many of the important lodes of such classic ground as Cornwall do not satisfy the common definition, one of two things ought to be done: either the miner should give up the term lode for these repositories, or else the meaning attached to the word by geologists should be extended. I need hardly say that the first alternative is not likely to be adopted; nor do I think it is one to be recommended; for I believe that one and the same fissure traversing killas and granite may produce the two kinds of lodes. . . . I should propose, therefore, that the term lode, or mineral vein, should include not only the contents of fissures, but also such tabular masses of metalliferous rock as those I have been describing. . . . If, however, this course should be thought on the whole undesirable, the geologist and miner must agree to differ in their language; and some of the *lodes* of the latter will have to be designated as tabular stockworks by men of science."

3. The law itself makes but two classes of metalliferous deposits, namely, "veins" or "lodes," or "ledges" of "rock in place," and placer deposits. The inference is clear that the first class includes more than technical fissure-veins merely. But this inference is raised to certainty by the express inclusion of quicksilver deposits under the terms referred to, and the actual location and purchase of such deposits under the law, although they are, in this country at least, not fissure-veins, but impregnations and masses of ore distributed through zones of rock.

Now in the case of Ruby Hill, the "rock in place," contemplated by the law, is plainly the limestone zone, and the limestone zone, therefore, is in the eye of the law, for the purposes of the law (and, as it has now turned out, for the purposes of the miner also), the lode. That it is a fissure-vein, nobody ever pretended. That its not being a fissure-vein could prevent its being located and held under United States law, nobody ought to have pretended. The principle followed in this part of the decision of the court is simply common sense. It has been asserted by over-hasty or interested critics that the application of this principle will unsettle many mining titles. This is not true. There is nothing in the decision which involves the conclusion that has been drawn from it, that whole mountain ranges, or whole mining districts, must be held to be single veins. The courts will continue to investigate facts; and when the facts, interpreted by common sense, prove a given zone of rock to be in the practical sense and for practical purposes a vein, they will not feel bound to call upon learned geologists to say whether it is a fissure-vein; that is all. The law is confessedly loose and de-

fective. Probably we shall never have a law free from difficulty in administration until the system of vertical boundary-planes, now prevalent in our older States and elsewhere throughout the world, is adopted. But we are still far from that happy time; and meanwhile, the decision in this case has done much to put an end to pedantic constructions which aggravate existing evils. The admirable language employed by Mr. Justice Field, in announcing the decision of the court, completely states the case. He says: "It is difficult to give any definition of the term (lode) as understood and used in the Acts of Congress, which will not be subject to criticism. A fissure in the earth's crust . . . would seem to be essential to the definition of a lode in the judgment of geologists. But to the practical miner, the fissure and its walls are only of importance as indicating the boundaries within which he may look for and reasonably expect to find the ore he seeks. . . . We are of opinion, therefore, that the term as used in the Acts of Congress, is applicable to any zone or belt of mineralized rock lying within boundaries clearly separating it from the neighboring rock."

3. THE FORCE OF UNITED STATES PATENTS.

The Richmond party contended for the following points, involving questions of general importance to American miners:

1. It was contended that certain patents put in evidence by the Eureka were void on their face, because they covered locations of which the end-lines were not parallel, whereas, the law of 1872, under which they were granted, requires that the end-lines shall be parallel. As to this point, the court held that the defect did not void the patents, nor concern the Richmond Company.*

* The precise language of the decision is, "In the first place, it does not appear upon what locations the patents were issued. They may have been, and probably were, issued upon locations made under the Act of 1866, when such parallelism was not required. . . . If under any possible circumstances a patent for a location without such parallelism may be valid, the law will presume that such circumstances existed. A patent of the United States for land, whether agricultural or mineral, is something upon which its holder can rely for peace and security in his possessions. In its potency it is iron-clad against all mere speculative inferences. In the second place, the provision of the statute of 1872, requiring the lines of each claim to be parallel to each other, is merely directory, and no consequence is attached to a deviation from its direction. Its object is to secure parallel end-lines drawn vertically down, and that was effected in these cases by taking the extreme points of the respective locations on the length of the lode. In the third place, the defect alleged does not concern the defendant, and no one but the Government has the right to complain."

2. It was contended that two patents held by the Richmond, although granted under the Act of 1872, upon application made after the passage of that Act, were based upon locations made under the Act of 1866, and conveyed to the patentees certain rights, accruing under the earlier Act, and explicitly continued by the provisions of the later one. The chief of these was the right to take a certain number of feet on the course of the main lode located, and follow the lode, throughout that distance, downward on its dip, unrestrained by the end-lines of the patented survey. In other words, it was claimed that since the so-called Richmond lode ran obliquely across the patented survey of the Richmond, and dipped into adjoining ground outside of the planes formed by projecting the end-lines of that survey vertically downward, and since that lode was held by a patent granted under the Act of 1872, but based on a location made under the Act of 1866, the owners of the Richmond claim could follow the ore on its dip into the disputed ground, notwithstanding the boundary planes presumptively established by the patent.

This claim involves some very important questions of construction of the law, and deserves a careful analysis. It asserts, first, that the Act of 1866 authorized the location of so many linear feet of a lode, and that the patent under that Act conveyed the title to that number of linear feet, "together with all its dips, angles, and variations, to any depth, although it may enter the land adjoining," with a certain amount of surface ground, merely for convenient working, but that the grant of the surface had no limiting effect upon the extent of the miner's claim, thus confirmed to him by sale. This, it will be remembered, was one of the points involved in the Emma-Illinois case in Utah, where, the Emma patent survey having been so made as to lie across the vein, the Court is said to have held that the patentees were nevertheless entitled to the full length of the claim, and to follow it *on the strike* or course, to that extent, outside of the patented boundaries. That decision was questioned in many quarters; but a compromise between the parties prevented any appeal and review by higher authority. The Hercules case, in Colorado, presented a similar question, and was decided by Judge Buford in the opposite sense. The point remained undecided by higher authority. My own views concerning it were expressed editorially at various times in the *Engineering and Mining Journal*, and officially in 1876, I believe, before the Committee on Foreign Relations of the House of Representatives on the "Emma Mine Investigation." I see no reason to change them, now that they have received at many points the con-

firmation of high judicial authority. That the Act of 1866 was in many respects obscure, is admitted; but I think a fair construction of it clearly shows that under it the patentee of a mine is bound by the end-lines of his patented survey. In attempting to establish this proposition, I shall pay no attention to the decisions which have from time to time emanated from the General Land Office. "Department law," as it is called, is not binding upon courts; and the law laid down by this particular department has been, under some of the commissioners, remarkably bad. Nor shall I confine myself to the points adduced by either side or by the Court in the case now under review.

The Act of 1866 recognized and confirmed, where it did not overrule, the customs of miners. It was universally the custom of miners on the public domain, to locate and record claims upon discovered lodes by linear feet, measured from the "discovery shaft," the length of each claim, the width of surface-ground controlled as an easement or appurtenance for mining purposes (buildings, roads, dumps, etc.), and the nature of the possessory tenure, being governed by local regulations in each district. Since priority of location and record determined all disputes as to possessory title, it was necessary to make such record as early as possible after discovery, and, therefore, before the true course of the lode could be ascertained. Hence the discoverer, though he usually included in his record a statement as to the course of the lode, might find upon futher developments, that he had been entirely mistaken. To make a new location and record, containing the corrected facts, might involve the sacrifice of precious priority; since in most cases (particularly if the lode was rich) hosts of other claimants would be located in the vicinity, some of them already occupying the ground which the discoverer meant to claim, and to which in equity he was entitled. A striking instance occurred in the case of the famous Eberhardt Mine at White Pine, which was originally supposed (and described in the record) to run east and west, whereas it really ran north and south. Numerous shafts were sunk side by side on alleged parallel veins, which turned out to be all on the course of the Eberhardt. Such complications are apt to be settled in new communities by violence as well as litigation, ending generally in compromise. But it is fair to say that the mining communities, apart from the persons interested in any special case, recognized the right of the earlier locator to "swing his claim," that is, to take the full number of linear feet to which he was entitled, without regard to the course described in his original record

of location. This is simply an equitable application of the well-known principle of "the worthier landmark." If, in a deed of land, the description of the land says that one of its boundary lines extends from a bend in a creek twenty chains north to a certain rock, and it is subsequently found upon re-survey that the rock (fully identified) is thirty chains south of the bend in the creek, the erroneous course and distance given in the deed are disregarded, and the natural objects described, being deemed the worthier landmarks, are permitted to establish the boundary in spite of the literal document. Similarly, when a miner records his claim to a certain number of feet upon a lode which he has discovered at one point only, it is the lode itself which is his landmark, and if, in obedience to a custom intended to assist other miners in recognizing the limits of his claim, he states in the record, as well as he can, the direction in which he supposes its course to lie, he ought not to be cheated out of the reward of his discovery or priority by reason of any inaccuracy in this description.

But to permit this state of things to continue indefinitely, would be contrary to public policy; and public policy—namely, the public benefit to be derived from the encouragement of mining—is the motive of the Acts of Congress by which the miner upon the public lands has been removed from the relation of a trespasser and created a tenant, with the privilege of becoming a proprietor. In the Act of 1866, the Government says substantially to the miner, "I own this land in which you are digging. I can make what rules I please to control your operations, or eject you altogether. But, for the public good, I will give you the right to occupy, and explore, and mine, and carry away my treasure, and to make what regulations you please to govern your relations to other miners, provided you obey certain conditions which I impose. One of these conditions limits your claim as an individual to two hundred feet as a maximum, and the claim of an association to three thousand feet. If you wish to obtain a title better than this permission, a title which does not depend on local regulations and cannot be affected by them, I will sell you a mine outright, provided that after you have done enough work to prove your good faith and define your claim, you will furnish an exact description of it by surface survey, establish your undisputed possession, and pay for it by the acre of surface. The right to follow your vein *in depth*, you shall retain; but you must define the length of your claim, so that your fellow-citizens may know where your property ends, and they may explore or mine,

and I may sell without wronging you. You cannot 'swing your claim' after it is patented. That privilege belongs necessarily to the period of exploration and mere tenancy. When you come to me for a better-defined title, you must be prepared to abide by the definition."

That this is the meaning of the Act of 1866, a careful study of its words will show. Section 2 of that Act provides that "whenever any person or association of persons claim a vein, ... it shall and may be lawful for said claimant or association of claimants to file in the local land office a diagram of the same, so extended laterally or otherwise as to conform to the local laws, customs, and rules of miners, and to enter such tract and receive a patent therefor, granting such mine, together with the right to such vein or lode, with its dips, angles, and variations, to any depth, although it may enter the land adjoining, which land adjoining shall be sold subject to this condition." (I have omitted some of the pre-requisite conditions, not essential to this argument.) We find here that a person "claiming a vein," may file a diagram of "the same," enter "such tract," receive a patent "therefor" granting "such mine," together with the right to follow "such vein" to "any depth."

Now to unravel this somewhat involved statement. What is "the same," of which a diagram is to be filed? It cannot be the vein, because the diagram is to be extended laterally or otherwise, according to the local laws. A diagram of a vein must be extended according to the facts. Local laws affect the dimensions of claims only; hence it must be the surface of the claim of which the diagram is required. The subsequent terms, "such tract," "therefor," and "such mine," all necessarily refer to the same thing, namely, the claim; and we are forced to the conclusion that the claimant is to furnish a diagram of his claim, enter the tract as homestead tracts or pre-emption tracts are entered, and receive a patent for it as purchasers of agricultural lands receive patents. This patent is to convey to him the tract, together with the right to follow the vein out of it, *to any depth*. There is no declaration here or elsewhere in the law, that a certain number of linear feet on the vein are to be conveyed to him, irrespective of the boundaries of his surveyed claim. Section 4 provides that no *location* hereafter made shall exceed 200 feet for each location, etc., and thereby overrules local laws, if any such exist, permitting larger locations. But this concerns merely the proper preliminaries to an application for purchase and patent. When that application is made, the applicant must not base it upon

a location of more than 200 feet. But it is not said that he shall receive a patent for 200 feet or any other number of feet. He is to receive it for the "tract" and the "mine" actually described in his diagram.

Section 3 confirms this view, providing that after due formalities of advertising, etc., the Surveyor-General shall survey "the premises" and make a plat thereof, and that after certain other formalities, including the payment by the applicant of $5 per acre, the register shall transmit to the General Land Office "said plat, survey, and description, and a patent shall issue for the same" thereupon. Language could scarcely describe more plainly the purchase of a defined piece of land. The final sentence of this section, however, raises a difficulty. It provides that "said plat, survey, or description, shall in no case cover more than one vein or lode, and no patent shall issue for more than one vein or lode, which shall be expressed in the patent issued." This has been held to mean that the grant of the patent is for so many feet on the lode; that the "tract" is not granted, but only the use of the surface for mining purposes; that another patent can be granted overlapping it, if another lode be found to exist within the surveyed area. But this construction overrides the clear meaning of the preceding section, and a better one, I venture to think, can be easily found. The prohibition here expressed is merely directory; otherwise, it would be absurd. It is made the duty of the surveyor not to survey for the claimant on one lode a plat which includes another lode. But if, after a survey has been made, and a patent has been granted, another lode should be found within the patented area, what is the state of affairs? The patent is not voided thereby: so much is certain. The new lode may enter the tract in depth, having its outcrop or apex in the land adjoining. In that case, it is the right of the adjoining locator to follow it. Or, it may crop out within the patented area. In that case, so much of it as lies within "the tract" (*i. e.*, the surface and the space beneath it, bounded by vertical planes), belongs to the patentee by reason of the grant of the tract, or else it still belongs to the government, by reason of the reservation now under consideration. In the latter case, it can be located and worked within the tract by nobody but the patentee, or some one whom he may permit to enter upon his land for the purpose. For the patentee owns the land, either completely and with all it contains, or else for mining purposes; and in either case, no other claimant can intrude upon it. If the patentee is forbidden

to touch the new lode, then it is within that area practically locked up. But we are not forced to any such absurd conclusion. The patent, as we have seen, grants two things: first, a certain tract *with all that it contains*, subject to one reservation, namely, the right of an adjoining owner to follow into it, in depth, the vein named in his patent; secondly, it grants a similar right with reference to the vein named in the first patent. The patent thus issues for the tract, and *for the lode in its downward continuation outside of the tract.* Now the law simply provides that the latter grant shall apply in each case to one lode only. Every patentee may have to submit to one intrusion, but one only, from his adjoining neighbor, following a vein downward into his tract. Every patentee may make one such intrusion, and one only, into his adjoining neighbor's ground. With this exception, the lines of ownership, under this law, have precisely the same effect as under the common law. They carry everything within the boundaries, and nothing outside. But whether I am correct in this view of the complete ownership of the tract or not, the force of the end-lines of the plat as bounding the claim upon the lode, which the patent is intended to cover, is undeniable. The Act of 1872 makes no change in this respect. It simply renders more positive and specific what was really the meaning of the Act of 1866, and extends the right to follow in depth, between the end-lines, to all lodes having their outcrop or apex within the tract. If, then, the right to disregard the end-lines of the survey did not accrue to the patentee under the Act of 1866, it cannot be one of the vested rights excepted from the operations of the Act of 1872.

But the contention we are discussing involves also the proposition that, assuming the grant of a patent under the earlier Act to have carried with it the privilege just discussed, then that privilege is a *right*, belonging to parties who made no application for patent until after the passage of the Act of 1872. Up to a certain time (let us assume for the sake of argument) the Government offered certain terms to purchasers of its mineral lands. During this period the Richmond claimants made no offer to purchase, but rested on their free right of exploration, etc., holding possessory title under the liberal terms of Section 1 of the Act of 1866. But after the government had changed its offer, and limited (as is asserted) the rights it was willing to sell, they became purchasers, and now claim the benefit of the bargain which they might have made, but did not! To a tenant on my farm, I offer the farm, together with a water-power,

at a certain price. He prefers to remain as tenant, and declines to buy. After awhile I decide not to sell the water-power, and my tenant, seeing the farm advertised, buys it, and then claims the water-power also, because, having once had a chance to buy it, he acquired thereby an "inchoate right" to it! This point was not clearly passed upon by the Court in the case here discussed, because the decision denies the right even of patentees under the Act of 1866 to disregard the end-lines of their surveys, and *a fortiori*, the "inchoate right" of mere locators, not applying for patent, falls to the ground.

4. THE FORCE OF A BOUNDARY FIXED BY AGREEMENT.

As the result of a previous litigation between the parties, a boundary-line had been established by compromise between them in 1873. This line (see map accompanying the paper of Mr. Keyes, line X W R, Plate VIII) was, with the exception of a small distance next the quartzite footwall, where the special transfer of a triangle of ground necessitated a deflection, exactly the line of the boundary between the two adjacent patents, and constituted the northwestern end-line of one patent and the southeastern end of the other. The Richmond party, claiming the right to follow its alleged vein in depth without regard to patent-lines, was obliged to meet the additional objection furnished by its own former act, and, to overcome this objection, asserted that "the agreement and deeds of compromise of June 16th, 1873, have no effect upon the rights of the parties to the land in dispute, except so far as the defendant (the Richmond) obtained new rights by conveyance of the Lookout ground at patent. With that exception, the parties stand on their original rights. The parties were only bound by the line *beginning* at point X on the diagram, and ending at R. *Beginning* at one point and ending at another, excludes the idea or possibility of any other beginning or ending of a line."

The Eureka party, on the other hand, claimed that "by the agreement and deeds of June 16th, 1873, the line W X, and necessarily W X, extended, was made the permanent boundary-line between the claims of the parties. The agreement says it was the object and intention to fix a permanent boundary-line between the claims of the parties. The claims of the parties were vein or lode claims. To make a boundary between them, the line necessarily must extend across the veins or lodes to the extent of the dips, or

the intention of the parties would not be accomplished. The deeds are in accordance with the agreement."

The deeds referred to are one from the Eureka to the Richmond, and one from the Richmond to the Eureka. By the former, the Eureka conveyed the Lookout ground, and also all the mining ground lying on the northwesterly side of the line designated, with the ores, precious metals, veins, lodes, ledges, deposits, dips, spurs or angles, on, in, or under the same. By the latter, the Richmond conveyed, with warranty against its own acts, all its right, title, or interest in and to all mining ground situated in the Eureka mining district on the southeasterly side of the designated line, "together with all the dips, spurs, and angles, and also all the metals, ores, gold and silver bearing quartz, rock, and earth therein, and all the rights, privileges, and franchises thereto incident, appendant, and appurtenant, or therewith usually had and enjoyed." The agreement declares it to be "the object and intention of the said parties hereto to confine the workings of the party of the second part (the Richmond) to the northwesterly side of the said line continued downward to the centre of the earth, which line is hereby agreed upon as the permanent boundary-line between the claims of the said parties."

On the issue thus raised, the following observations seem pertinent:

1. The decision of the Court as to the practical unity of the Ruby Hill deposit, involving its legal identity as one lode, covers the whole case, and renders the discussion of the present point unnecessary.

2. The decision of the Court as to the force of the end-lines of a United States patent has the same effect, so far as the claim of the Richmond to the ground in dispute (part of the Potts Chamber) is concerned. The compromise line, W X, was at the same time a patent end-line; and as such it must be, according to the decision, extended indefinitely on the surface, and projected downward in a plane to the centre of the earth, to form the legal boundary. Whether the Eureka, however, could claim the disputed ground under this ruling alone, would depend on its ability to prove that the ore-body of the Potts Chamber was part of a vein having its outcrop or apex within the patented ground of the Eureka.

3. Assuming now, for the sake of the inquiry, that either by a different decision of the Court, or by a different state of the facts, the Eureka could not claim this disputed ground by reason of the unity of the ore-bearing limestone zone, or by reason of any force in patent boundary-lines, we are to look at the compromise alone, and discover

what was its effect. This question, though less extensive and important in its general bearings than others settled by the decision of the Court, involves, nevertheless, an important principle, which may often receive application in mining matters. It will be considered here in its general aspect only; yet the remark seems to be warranted, in passing, that the peculiar circumstances of this case put equity as well as law on the side of the Eureka. The compromise was apparently an attempt to end all possibility of future dispute; and the subsequent denial of its force, to a certain extent, by the Richmond party, seems to be a technical evasion. But it is not necessary to impugn the sincerity of the counsel who, in the discharge of their duty, contended for this, as for every other proposition of law which favored their client.

The decision of the Court was, that the line agreed upon as a boundary between mining claims, must be extended along the dip of the veins. This obviously follows from the nature of such claims. A "claim" upon a vein is not a given surface only; nor is it only a given surface with what underlies it. It includes the right to follow the vein, and the ownership of the contents of the vein, on its dip beyond the surface lines, and between the end-lines. Hence all lines dividing such claims must be extended till they are coterminous with "all that the location on the surface carries," as the Court says, otherwise, they would not serve as boundaries.

It follows from this very reasonable decision, that when two proprietors of adjacent claims agree upon a partition boundary, whether it be a point or a line, the real boundary so fixed is a vertical plane, indefinitely extended so as to divide everything covered by the claims. If a different construction is intended by the parties, then it must be specially expressed.

Thus on every issue raised in the case, the decision was against the Richmond party. The case has been appealed; and the Supreme Court will doubtless be called upon, in course of time, to review the judgments of the Circuit Court, which I have in this paper at some length discussed. That the present analysis of these topics was not postponed until after the hearing of the appeal is due to three reasons. First, there will be a delay of months, perhaps years, in reaching this case on the Supreme Court calendar; secondly, it was necessary, if this paper were to be written at all, that it should be written while the subject-matter was fresh in mind; thirdly, the great interest taken in the late decision by the mining community and the legal fraternity, calls for such a full explanation of its bear-

ings as I have tried to furnish; and finally, the defeated party in this lawsuit, and some other parties, including mining journals in England, have indulged in unworthy insinuations as to "American justice," and ascribed the result in this instance to the circumstance that one of the contending parties was a British corporation. This sort of talk might be pertinent to an ordinary trial by jury. Its application to a case so patiently and thoroughly heard, and so convincingly settled by judges of eminence, is preposterous. Apart from the foolish insult which it conveys to men of high character and long experience, it ignores the force of the arguments used in their decision; and the best means of showing its utter baselessness, is a thorough discussion of the points and principles involved in the case so flippantly criticized. This I have attempted to give; and, in the light thus furnished, I think it evident enough that the Court had better reasons for its decision than any mere bias of patriotic feeling.

WHAT IS A PIPE-VEIN?

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(Read at the Amenia Meeting, October, 1877.)

THE term "pipe-vein" has recently been applied in this country to certain deposits of lead ore in magnesian limestone. The use of the term has been twofold. It has been revived as a term found in textbooks on mineral veins, with the implied or declared assertion that the ore-deposits thus named in this country are similar to those which have borne the title abroad. It has also been advanced as an appropriate name for a new class of deposits, even if such a class had not previously been recognized. In either case, the assumption is that pipe-veins form a group or class by themselves, and are not merely interior and subordinate features in larger deposits. The peculiar mining law of the United States, which regards "the vein," whatever that may be, as the basis of title, lends a special interest to these claims. But the object of this paper is rather to discuss the subject from the standpoint of geology and technical literature. I shall briefly answer two questions: (1) What are pipe-veins as described in technical literature? and (2) Is the name appropriate or necessary for a new class of deposits?

The term "pipe-ore," as applied, for instance, to irregular, cylindrical, sometimes hollow concretions of limonite, etc., probably came from Germany; but "pipe-vein" is of English origin—a miner's term, arising probably, in Staffordshire or Derbyshire. It is worthy of notice that the word "lode," as used by the Cornish and English miners, often carries among them a wider meaning than "vein;" so that more than one vein may be included in one lode. Thus, in a footnote to Henwood's "Metalliferous Deposits" (*Trans. of the Roy. Geol. Soc. of Cornwall*, vol. viii, part i, pp. 619, 620), a pipe-vein is mentioned as occurring within a lode of metalliferous limestone.

The first writer, so far as I know, who made a separate class of pipe-veins was Westgarth Foster, who published, early in this century, a work chiefly devoted to a section of the rocks across Great

Britain. In this book, he gives a general definition of pipe-veins, and a description of their general appearance. The description has been copied into a number of textbooks without the definition. This is the case, for instance, in Jukes's excellent manual of geology. The reason appears to be that Foster's classification was never generally accepted, and is long since out of date. He was an adherent of the theories of Werner, and his work, however praiseworthy in its time, shared the fate of the system of geology which he had adopted.

Sir Henry T. de la Beche, in his *Geological Observer*, gave, for the first time, a rational classification of the ore-bodies known in Cumberland and Derbyshire as "pipes," "flats," "rakes," and "skrins" (Am. ed., 1851, p. 644); and Prof. Bernhard Cotta has quoted (Cotta's *Ore Deposits*, Prime's transl. p. 431) the description and the diagram of de la Beche. It is noteworthy, however, that Cotta restores the word "vein" in this connection, which de la Beche had carefully omitted. The language of the latter is significant. He says:

> "The cavities in that district wherein sulphuret of lead has been discovered are very numerous. When they rise through the beds, they are usually termed *pipes*, and when interposed between them, *flat* works. Upon studying the cavities in limestone districts of this character, it will be evident that these distinctions are not always very applicable, and that irregular cavities rising upward may have numerous branches from them, running amid the beds themselves, that joints may cross the cavities and real dislocations traverse the whole."

In other words, the terms *pipe* and *flat* are applicable, not to separate classes of deposits, but merely to the forms and positions which may be assumed by different portions of the same deposit. In the diagram and explanation which follow, the author shows how lead ore, introduced into a bed of limestone, may occupy true deep fissures (rakes), enlarged spaces between the beds (flats), joints contrary to the bedding (skrins), or irregular cavities connected with the rakes, and caused, according to his diagram, by the intersection of these with the planes of the bedding. It is easy to see that along the line of such an intersection, an irregular elongated space might be formed through enlargement by water-currents, attacking the four corners of limestone exposed, and that the disposition of ore in such a space would result in a "pipe," or elongated ore-body, common to, and subordinate to both the rake and the flat. But de la Beche does not call it a pipe-vein. And Cotta says: "It is evident that the whole mass of limestone is traversed, in all accessible fissures and cavities, by ores and vein-stones, which have penetrated subsequent

to its formation;" adding, a little further on, "The only veins now generally exploited in Derbyshire, are the rake-veins." This furnishes a striking practical confirmation of de la Beche's explanation. If the pipes are merely subordinate features of the rake-veins, then the working of the latter would be likely to become the main enterprise, and the pipes when encountered and exploited, would be regarded merely as ore-bodies in the veins. To such an extent has this become in fact the case, that Mr. William Wallace, the latest authority on the subject, does not mention pipe-veins at all in his exhaustive description of the very district which gave the term to technical literature (*The Laws which Regulate the Deposition of Lead Ore in Veins;* Illustrated by an Examination of the Geological Structure of the Mining District of Alston Moor. By William Wallace. London, 1861). But Plate XVI, of his book (opposite p. 144) presents what is evidently a pipe—namely, an elongated ore-body, following the intersection of a vertical vein with a horizontal bedding-plane. It is called, however, not a pipe, but "a rich lead-ore deposit *in Handsome Mea great cross vein.*"

The mines of Alston Moor were represented at the London Exhibition of 1851, by a most elaborate and beautiful model, exhibiting all their underground works, and giving, as Prof. Whitney remarked, "the features of every part of the district." It has been asserted that this model exhibits the pipe-veins. Fortunately, it is preserved at the Royal School of Mines in London, so that if it could ever throw any light on the question, it can do so at present, as well as in 1851. Not having seen it for nearly twenty years, and not wishing to trust a merely negative memory as to what it exhibits, or to rely upon the fact alone that the description of the model contained in the catalogue of the School of Mines makes no mention of pipe-veins, I applied through a friend to the School itself, and received from one of the officers of its Museum of Practical Geology the reply, that the model contains "no indications of pipe-veins." This is positive evidence of the subordinate character of the pipes of ore.

Similar testimony is given by Prof. L. Moissenet, of the Paris Ecole des Mines (*Observations on the Rich Parts of the Lodes of Cornwall, etc.* Translated by J. H. Collins, F.G.S. London, 1877), who says (p. 2) of the lead-veins of the mountain limestone—the same as Wallace discusses—"To these lodes the pipe-veins and flats are attached; these are *accessory deposits* occurring in some of the limestone beds." (Italics mine.) Again, speaking (p. 10) of the

ore-deposits of Cornwall, he says: "Floors and carbonas are accessory deposits. . . . The floors are analogous in structure to the 'flats' of the lead mines of carboniferous limestone. . . . The carbonas are rich masses of tin ore occurring in granite, the true equivalents of the pipe-veins of the North of England. . . . Mr. Henwood has described how they are related to the lodes."

Vague reference having been made by some advocates of the independent character of pipe-veins to the occurrence of such veins in Cornwall, and a paper by Dr. Clement Le Neve Foster, the Royal Inspector of Mines for that district, having been alluded to as authority, I attempted to verify this reference. In my collection of Dr. Foster's writings, which are everywhere recognized as among the most trustworthy and important contributions of the present generation to the science of mineral veins, I could find nothing to warrant this citation of him. Prof. Moissenet says in a footnote (p. 10): "Deposits of tin ore resembling pipe-veins occur at East Wheal Lovell, in Wendron, and were described in a paper read to the Royal Geological Society of Cornwall, in 1875, by Dr. C. Le Neve Foster." This paper does not bear out the conclusions sought to be drawn; and to make sure that there was not some other to which the reference might have applied, I wrote to Dr. Foster, and received from him several letters, setting forth his views on the veins of Cornwall with much clearness and force. I take the liberty of quoting a few sentences immediately concerning the point now under consideration:

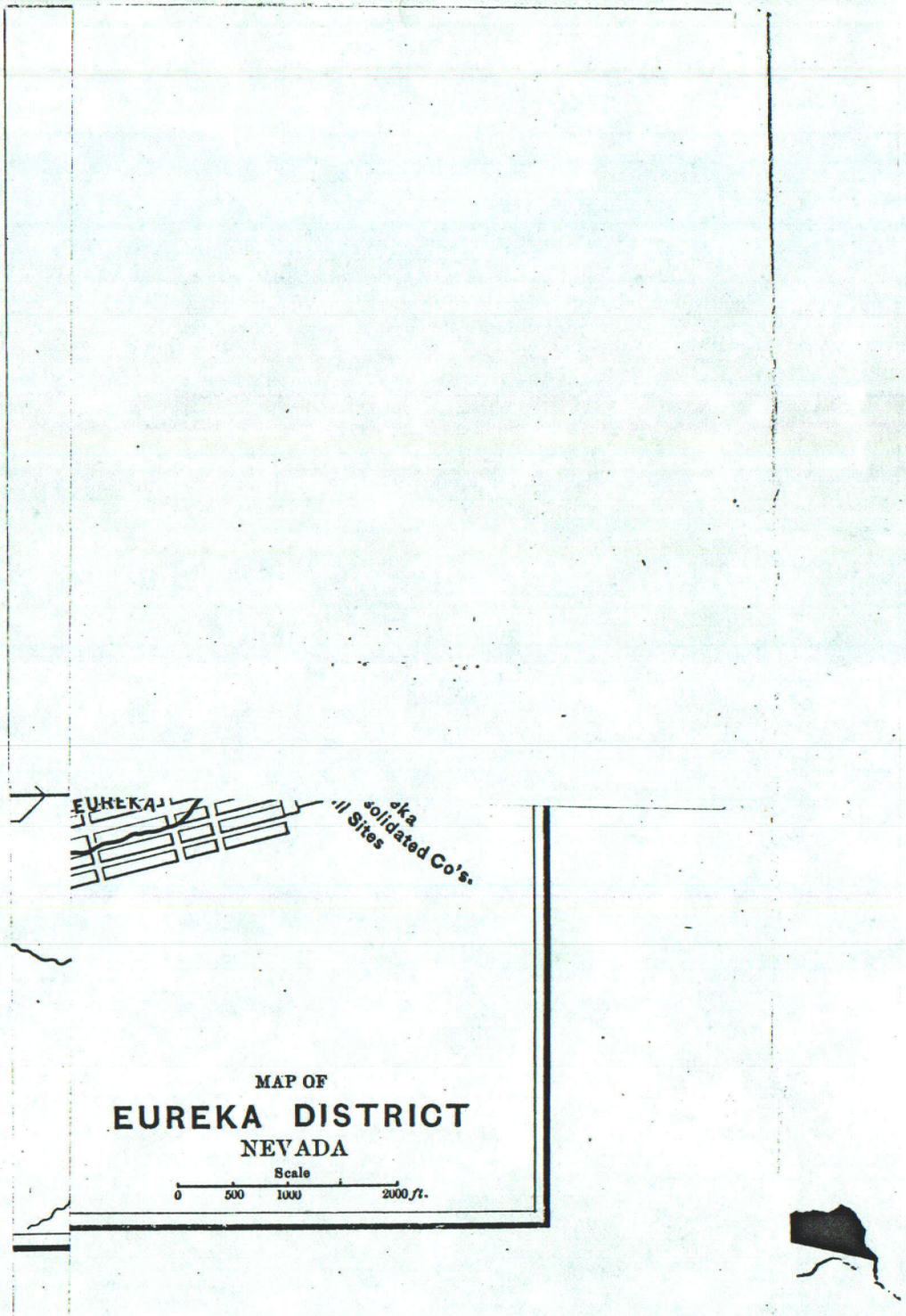
> "The paper referred to . . . was probably one I read about two years ago on East Lovell Mine. I send you a copy by this post. I have not used the term 'pipe-vein.' I merely called some of the ore-bodies 'pipes.' I have used the word 'pipe' to designate a long, narrow ore-body, a narrow *shoot* (or 'chute,' as you write it) of ore, in fact. . . . All the 'pipes' at East Lovell are merely altered granite on the sides of fissures; and I am coming round to the opinion that most Cornish tin mines in granite are merely bands of altered rock. . . . The *carbonas* of Cornwall, which are supposed to correspond to *pipe-veins*, are merely altered granite . . . The *carbona* is a mass of stanniferous schorl-rock formed by the alteration of granite. It is not a large chamber in the granite, subsequently filled by minerals. . . . I doubt whether the *carbonas* are the equivalent of the *pipe-veins*. I have never seen a true pipe-vein in limestone myself, so cannot speak authoritatively."

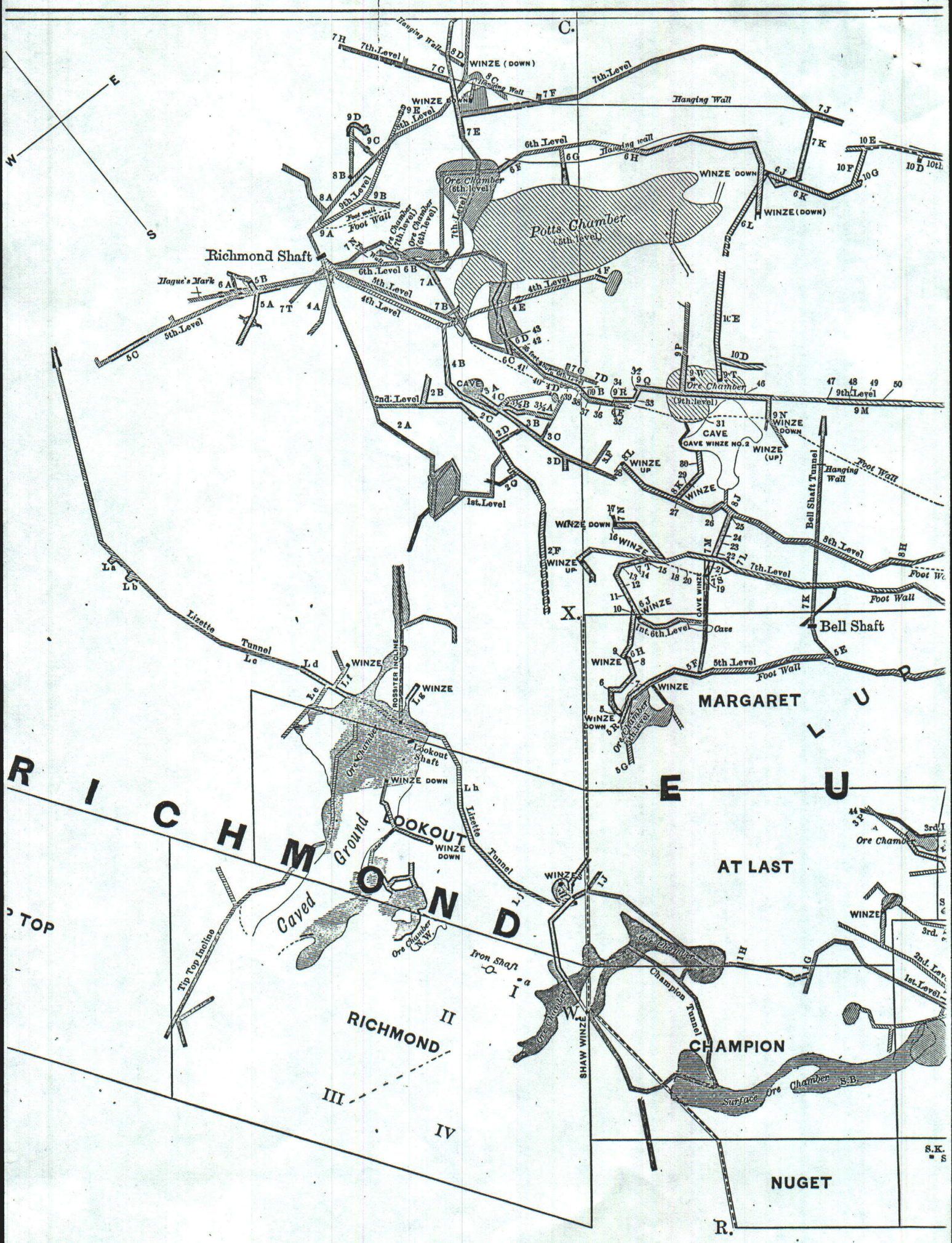
Having examined all the authorities cited by those who assert that pipe-veins, as hitherto known in literature, are independent ore-deposits, I am led to conclude that this view is not fairly deducible from anything that has been quoted in its favor. Whatever may have been anciently believed, it is now clear that the term pipe-vein applies only to an ore-body of a certain shape, which may be part of a fissure-vein, a bed, or a stockwork.

The question remains, whether this name should be revived, and applied, either (1), as some have proposed, to ore-deposits in which the ore has ascended "through pipes instead of fissures," or (2), as others have proposed, to fissure or other veins, in which elongated bodies of ore occur. To this I would say, in general reply, that the revival of an old name for a new thing is objectionable, and unnecessary. But there is no new thing presented. The three chief mines in the United States which have lately received this name at the hands of some are, the Emma in Utah, the Richmond in Nevada, and the Union at Cerro Gordo, California. Neither of these is a pipe-vein in the old sense, though each of them may contain, as subordinate interior features, a great many pipe-veins. It is much better to class them geologically as metalliferous beds, containing, if you please, pipes, chimneys, chambers, strings, and what not, of ore. A new name for this class of ore-deposits might indeed be convenient, not because they are not well known already, for the greater part of the lead product of the world is derived from just such deposits, but because the present names do not briefly and clearly define them. Yet the name of pipe-vein would be no relief. It might apply to one of the deposits of this class, by reason of the shape of the ore-bodies, and fail for the same reason to fit another deposit of the same class, or another part of the same deposit. The notion that ore-deposits exist, in which "pipes," apart from fissures, have been conduits for ascending solutions or sublimations, lacks proof.

The most mischievous result of such a nomenclature would be its legal effect, if our courts were not too wise to permit it to influence their construction of the law. Title, under the United States Mining Law, is referred to the strike and dip of the veins claimed, and it is universally understood that the strike and dip must be taken at right angles to each other. But in the famous Eureka-Richmond Case, a distinguished advocate, himself a mining expert, arguing that the Richmond ore-body was a "pipe-vein," declared that the dip of such a body "is the inclination at which it enters the earth. When you follow the body of ore downward into the earth, you are following it on its dip. And you may call the direction at which it enters the earth by any name that you like; you cannot divest it of that name. That applies to it, no matter whether it be also the course or not." (Argument of Hon. Thomas Wren, p. 31.) This

confusion of strike and dip would naturally result from applying the terms to a deposit, the horizontal section of which shows no principal, longest axis. It might be troublesome to ascertain the strike of a stockwork or mass. But nothing would give quite as much trouble as a "pipe," the dip of which, if taken by itself as an independent body, might be plausibly urged to be the same as its pitch—or, in plain words, "it dips wherever it goes." On the whole, therefore, it seems best not to erect such an ore-body into a new class. Let the "pipe" be an ore-body, and give to the deposit containing it and its associated bodies such a name as the facts will justify.





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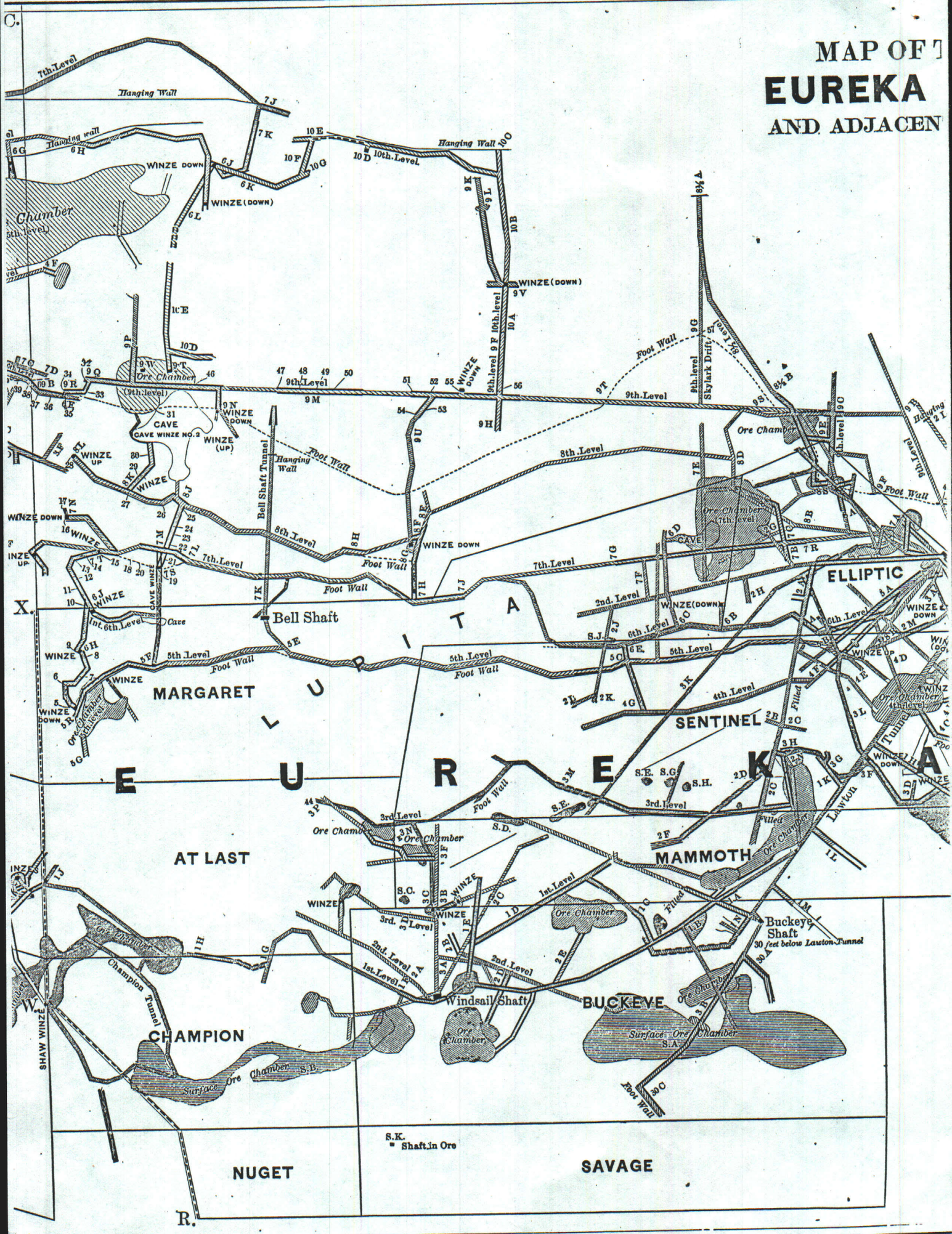

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MAP OF THE EUREKA MINE AND ADJACENT MINES

SURVEYED AND DRAWN
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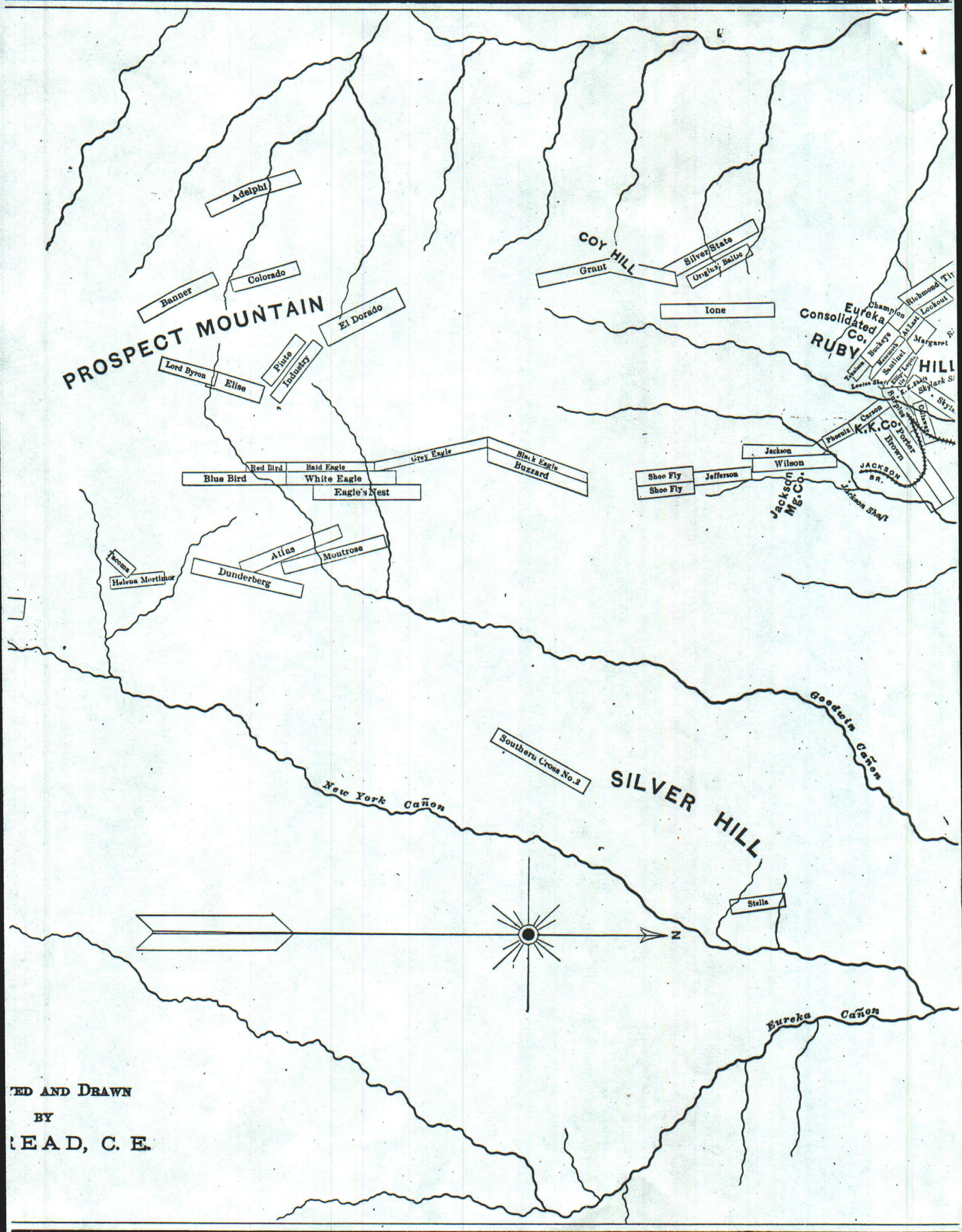

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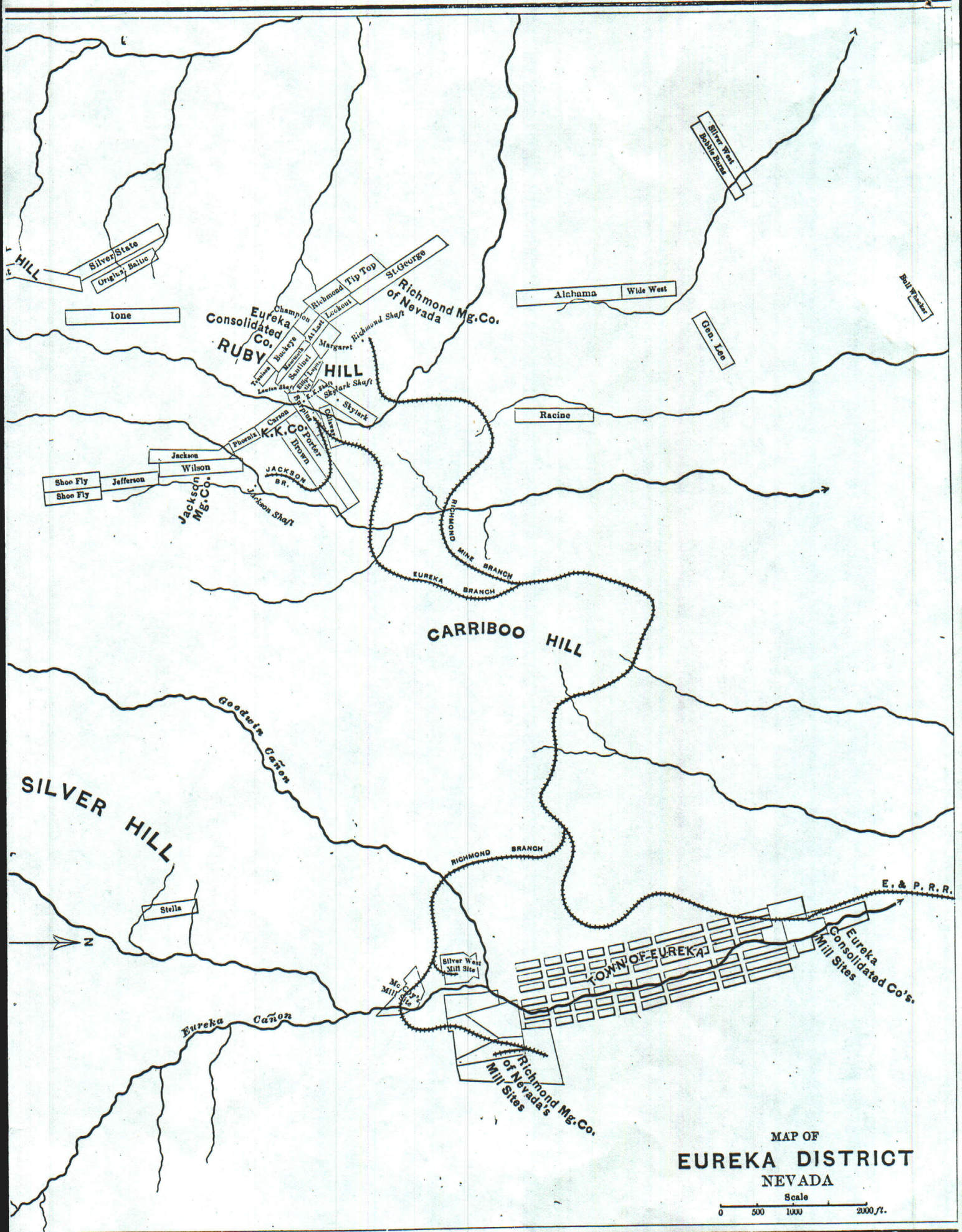

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