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Origin of the Primary Ores.

~~[illegible] thinks the primary ores are pyrogenic.~~

~~Magmatic waters may do the trick, but note that we have here again an intrusion penetrating a syncline, making a means of entrance for ~~magmatic~~ meteoric waters.~~

~~On the NE side of the porphyry belt fissure (vein) deposits of PbS & ZnS are mined. (in ls.)~~

~~S of the belt, some gold is being mined.~~

Shasta District, Calif.

Fol. 138. The Klamath Mts. are at the meeting place of the Sierra Nevada & the C.R. The Sierra Nevada is an example of the Basin Range type, the fault being on the E side of the Mts.

~~Ol.~~

Oldest rocks are Pre-Devonian mica & amphibolite schists. The Devonian rocks rest on their eroded surface.

Pre-Devonian (An ancient andesite, the Copely meta-andesite, lies between the Devonian & the pre-Devonian. It is in the form of lava flows & tuffs.)

2/19/17.

The Balaklala rhyolite is ass. with the Copley meta-andesite, & was supposed to have immediately followed it.

The next formation is the Middle Devonian Kennett formation, consisting of black sh., ss., leases of fossilif ls. totaling 865'.

↓ Uplift un-attended with folding next occurred.

Sea in Carboniferous; Missis. strata - Bragdon formation laid down. Sh., ss., congl., 3000' thick.

Miss. { Baird Formation next. Volc. tuffs - 500' at base. ss., sh. 150'

Penn. { McLeod Ls - form high cliffs on shores of McLeod River. 2000'.

Naomy tuff - tuff, sh., ss. 500'-1200'.

Unconformity

Triassic. { Pitt Formation ss., ls., sh. 2000' + volc. - Dekkes Andes. Bully Hill Rhy.

"Hosselcus" ls. Lenticular. 200' at thickest.

Brock sh. 400'.

Jurassic { Modin formation. Tuff at bottom, with Bagley and. sh., shaly ss., leases of ls. 3000' thick.

Potem Form. ss., sh., tuffs, several thousands'

Uplift accompanied by great intrusions of granite throughout Sierras.

Cretaceous. Knoxville absent. Chico earliest present.

Chico ss., sh., congl. at base 500'.

Tertiary: Ione formation - gravel, sand, clay - fresh water origin + lignite. 50'
{ Tuscan Tuff. 25'-40'
{ Basalt flows - small.

Quaternary Red Bluff formation. Continental. Red color, Much red stream gravel. Pyroxene andesite rest on the Red Bluff terraces.

Alluvial Deposits of Sacto. River.

Copper Ores.

2 districts - Kennett, W side river.
Bully Hill E side "

Ore confined to (1) Bala plala (Kennett) rhyolite.
(2) Bully Hill (C. Bully Hill)

The Balaplala rhyolite is now supposed to be also Triassic.

Ore bodies lie in shear zones - ore in form of lenses, boundaries sometimes well defined - up to several 100 ft. in diameter, max. diam. in direction of dip. Lenses lie generally in ∥ disposition. May succeed one another in line of strike or they may over-lap. (Several in width of one shear zone) Greatest known depth < 1000'.

Pyrite (cupriferous?)
Chalcopyrite. Primary copper ore.
Chalcocite

Outcrops - Rusty honeycombed limonite - Cu leached. Below gossan zone of chalcocite - as nodules & black sooty powder, & stringers & veins shooting thru primary sulfides.

Bornite, Tetrahedrite, Cuprite, Malachite, Native copper, ZnS PbS, Ag., wad (Mn).

Gangue is barite or qtz.
Bully Hill Barite
Iron Mt. (Kennett) quartz

Kennett

Iron Mt. Lode - in Balaklala rhy. 1 mi. long, strike NE. Gossan prominent; 100' in depth. Principal ore-body is 800' long, 100-400' wide, 600' deep. Pyrite, chalcopyite, ZnS. Gangue is qtz.; brit is not abundant. <5% - 7%. <$ Au per ton, $1 ± Ag.

Balaklala Lode. ½ mi. long. Str. N 70 E, dip NW. Longest ore-body = 1000', l. 500 d., 20' th. Ores = pyrite, chalcop.; little quartz. <2% Cu.

Mammoth Lode - in same body of rhyolite.

X-section Balaklala ore-body

Origin of these Orebodies is very obscure.

Bully Hill. de la Mar lode, N 10 E 90°. ½ mile long, 20' wide, mined to a depth of 800'. In shear zone at contact with rhyolite with dike of basalt. Walls sometimes sharp, sometimes vague. Ore-bodies succeed one another. Lenses are deeper than long or wide, resembling ore-shoots. Gossan similar to Kennett, boundary irregular, bet. gos. & sulf. Ore somewhat enriched, black thin sooty chalcocite

Anchor Lode - 11 to above, 200 yds. W, wholly in rhyolite. 2/3 mi. long. Zn S increases with depth. Some malachite in gossan. gangue is barite.

Copper City - 4 mi. S Bully Hill. Ore body mostly copper-bearing Zn S. Gangue barite.

by soda-rich hydrothermal solutions which permeated the mass in late magmatic or early post-magmatic time.

Studies of the hydrothermally altered rocks both near and remote from the ore deposits indicate that the different altered products can be attributed to rather definite progressive alteration, chiefly with the development of mineral assemblages stable under the existing new conditions.

Breccias of both intrusive and cataclastic origin are of genetic significance, not only with regard to their own origin and time of development, but also with respect to the localization and age of the metallization.

NONDEPOSITIONAL SURFACES OFF THE CALIFORNIA COAST

BY FRANCIS P. SHEPARD

Recent explorations on the Scripps Institution vessel have confirmed the impression obtained from previous work that there were extensive areas off the California Coast where deposition is either very slow or nonexistent. Dredging and coring operations show either rock bottom or very thin sediment cover on most of the deep banks off Southern California, on many steep submarine slopes, on the walls and even on the floors of submarine canyons, and on the outer portions of the continental shelves. Depth seems to have little bearing on these occurrences. Further possible evidence of absence of important deposition comes from the finding of sand and gravel in very deep portions of submarine canyons where mud should be the chief sediment. Sand was discovered even in portions of the troughs and basins off Southern California at depths ranging around half a mile. This sand is significant because the chief sediment being supplied to the deep areas at present, insofar as can be determined, is silt and clay. The importance of bottom currents and of submarine mud flows in preventing deposition will be discussed. (Geological Society Project.)

STRATIGRAPHY AND INSOLUBLE RESIDUES OF THE MADISON GROUP OF MONTANA

BY LAURENCE L. SLOSS *

The Madison group comprises three Lower Mississippian formations totalling 500 to 1800 feet. The group is prominently exposed in the mountainous areas of Montana and is encountered at depth in the plains areas where it is locally oil producing. The lowest unit, the Paine formation, consists of interbedded thin cherty limestones and calcareous shales. A basal member of black conodont shale is present in some localities. The Woodhurst limestone is a series of well-bedded blocky limestones with numerous massive zones composed almost entirely of fossil fragments. The extremely massive poorly bedded upper unit—the Mission Canyon limestone—is recognized by bold solution-pitted cliffs.

Although the Madison limestones are highly fossiliferous the enclosing matrix is such that suitable fossils for identification are difficult to obtain, and paleontologic correlation is hindered. The absence of an adequate microfauna coupled with slight lithologic variation over a wide stratigraphic range has made accurate subsurface stratigraphy impossible. Methods of correlation by insoluble residues have been applied to these Montana limestones with encouraging results. Drill cuttings and samples collected from accurately measured sections were digested in hydrochloric acid, leaving a residue of quartz grains, minute quartz crystals, glauconite, clay and chert molds of dolomite crystals, chert fragments, a variety of accessory minerals, and silicified fossil fragments. Assemblages of these residue components have been found to be diagnostic in defining and correlating zones in the Madison limestones over fairly wide areas.

* Introduced by Eugene S. Perry.

G.S.A. Berkeley Meeting, 1939.

ORIGIN OF KILBOURNE HOLE, NEW MEXICO

BY PARRY REICHE *

Kilbourne Hole, the larger of the two "Afton Craters," was described by Lee in 1907. It is of irregular shape, with a mean diameter of nearly 1½ miles, a depth of about 300 feet, below the general level, and a nearly encircling rim which rises in places 150 feet above it. On the basis of ejecta exposed in the rim, the origin of the Hole by steam explosion has heretofore been favored. Recent study establishes a more complex history, of which the final episode, responsible for the present land form, was subsidence. Attendant circumstances, suggestive but inconclusive, favor solution and collapse as the cause.

QUATERNARY HISTORY OF LOUISIANA

BY RICHARD JOEL RUSSELL

Five Pleistocene glaciations lowered sea levels sufficiently to rejuvenate the Mississippi River system, enabling it to cut valley systems in Louisiana 100 to more than 300 feet deep. Rising seas of waning glaciation permitted alluvial drowning of these valley systems and the deposition of five Quaternary formations.

Regional tilting, caused by subsidence of the deltas and a compensating elevation inland, has preserved the surfaces of the four Pleistocene formations as terraces, which extend continuously both coastwise and inland along major streams. In central Louisiana the oldest surface slopes at 10 feet per mile, younger surfaces at rates of about six, two, and one feet. The Recent surface slopes at less than half a foot. Slopes of terraces flatten inland, and intervals are more constant in northern Louisiana. Slopes steepen coastward, particularly toward later deltas, and each formation passes below more recent deposits.

Basal gravels of each formation have been identified under the Recent deltaic plain, and positions of maximum deposition have been located for four of the five Quaternary formations. Each of these positions is characterized by lenticular thickening downward, so that at least three of the formations attain a maximum thickness of about 3000 feet. Each lens marks the position of the delta of its period. No two center in exactly the same place.

Seven subdeltas of the latest Recent have been identified, heaviest deposition being centered southeast of Baton Rouge. The highest land of the lower Mississippi Valley is in northwestern Mississippi, the result of subsidence of the Recent delta.

PETROLOGY OF THE BALAKLALA CHONOLITH, SHASTA COUNTY, CALIFORNIA

BY GEORGE F. SEAGER †

Certain of the igneous masses exposed in the southern Klamath Mountains have long attracted attention because of their distinctive petrologic features, their bearing upon the general geologic history of the Klamaths and northern Sierra Nevada, and their genetic relationship to mineral deposits. Among these is the Balaklala intrusive, of late Jurassic age, which lies west of the Sacramento River and includes all the known copper deposits of the western part of the Shasta County copper belt.

Chemically, the rocks of the Balaklala intrusive are distinctive in their very high silica and abnormally low potash content; mineralogically, the almost invariable occurrence of sodic plagioclase, generally albite, and the absence of primary mafic constituents are noteworthy. Microscopic evidence, both mineralogical and textural, rather conclusively indicates that the rocks are the product of widespread and thorough albitization of types bearing originally a more calcic plagioclase, presumably

* Introduced by C. A. Anderson.
† Introduced by Alan M. Bateman.

AGE OF THE DEKKAS-BULLY HILL VOLCANICS OF THE KLAMATH MOUNTAINS

BY HARRY E. WHEELER *

The Dekkas andesite and Bully Hill rhyolite of supposed Triassic age overlie the Permian Nosoni formation in the southern Klamath Mountains and are overlain by the Middle? Triassic Pitt shale.

The discovery of an unconformity between the volcanic and Pitt sequences involving, in places, the complete removal of the Bully Hill rhyolite, together with the development of thick basal Pitt conglomerates, and the absence of lava above the unconformity, suggests a post-Bully Hill and pre-Pitt erosion interval of appreciable duration. In addition, the remarkable similarity of these relationships to those in the Humboldt Range of northwestern Nevada and in the northern Sierra Nevada, where the volcanics are of known Permian age, forces the conclusion that these Klamath Mountain effusives and pyroclastics should also be assigned to the Permian.

TERTIARY STRATIGRAPHY OF THE DAYVILLE QUADRANGLE

BY W. D. WILKINSON †

The completed areal map of the Dayville Quadrangle in central Oregon shows an unusually complete geologic section including Mississippian, Permian, Upper Triassic, Jurassic, and Upper Cretaceous marine formations. The nonmarine formations of this region south of the Ochoco Range include the John Day, Columbia River basalts, two Neocene formations not yet definitely correlated with either the Mascall or Rattlesnake of the John Day Basin, and a late Tertiary or Pleistocene series of basaltic flows apparently unrepresented within the Picture Gorge or Mitchell quadrangles north of the Ochoco Range.

AGE OF CRATER LAKE, OREGON

BY HOWEL WILLIAMS

The caldera containing Crater Lake was formed by collapse of the summit of the volcano Mount Mazama, following violent eruptions of pumice and scoria. The date of this catastrophe may be estimated approximately from the following criteria: (1) Size of the glaciers on Mazama at the time of the last pumice eruptions, as indicated by the distribution of the ejecta; (2) degree of erosion of the pumice and scoria deposits infilling the old glacial canyons; (3) character of the vegetation destroyed by the pumice; (4) degree of erosion of the caldera walls; (5) presence of human remains and artifacts beneath pumice; (6) relation of pumice to lake deposits in the neighboring lowlands; and (7) age of the last eruptions of the post-caldera cone of Wizard Island, as indicated by the oldest living trees.

Taken together, these criteria suggest that the engulfment of the top of Mount Mazama occurred no more than a few thousand years ago, long after the period of maximum glaciation, and when the adjacent parts of Oregon were already inhabited by man.

* Introduced by Vincent P. Gianella.
† Introduced by E. L. Packard.

trusion, which forms the east or hanging wall. This intrusion is not noted on the sheet of the structural geology, as given in the 'Redding Quadrangle' of the U. S Geological Survey. Exposures of similar intrusions are found at other places in the area of the Bully Hill rhyolite.

The orebodies are lenticular in form, but their vertical axis is far in excess of their horizontal axis. In the Bully Hill mine, the vein has persisted to a depth of 900 ft. and is still strong at that depth.

There is not only a structural difference between the ore deposits east and west of the Sacramento river, but also a pronounced mineralogical difference. The ores of the Bully Hill district are richer in gold and silver, and a conspicuous percentage of zinc-blende. Their copper content is also much higher, and the secondary enrichment is far more important than west of the Sacramento river and more persistent in depth. The bottom has not yet been reached in the Bully Hill mine.

There is every reason to assume that the ore deposits in both portions of the Shasta County copper belt have been formed during the great post-Jurassic disturbance of the Sierra region. While the data in my possession are not sufficient to state positively that the ore deposits west of the river are restricted to certain flows, or to certain differentiation in the Balaklala rhyolite, there are some indications that the material enclosing those deposits differs from that at a distance from the orebodies, more especially in the classification of the feldspars, which in the latter belong more prominently to the soda-lime series.

The presence of more basic intrusives reaching the surface in the Bully Hill district justifies the hypothesis that here a magmatic differentiation has taken place, that the ascending waters obtained their metallic solutions from the more basic material, and deposited the minerals in fracture-planes of the overlying more silicious portions, the later intrusions of the more basic portions into the overlying strata taking place along the same lines of weakness in those strata.

West of the Sacramento river, no such basic intrusions have as yet been exposed. There is a possibility that similar magmatic differentiation has taken place in depth, and that these underlying basic portions have not been intruded into the overlying more silicious material, but yet have been the source from which the ascending waters have obtained their metallic charges.

It may also be that the hypothesis of a magmatic differentiation is in both cases erroneous, and that the ascending waters obtained their metallic charges from a more deeply seated source. This view is partially confirmed by the fact that the pyrite in the country rock is not an original constituent of the rock.

All these points can only be fully determined by a detailed study. The able mining engineers who conduct the various enterprises in this belt are in position to solve them, and to them we must look for more positive data.

WILLIAM FORSTNER.

San Francisco, May 8.

Acetylene Lamps.

The Editor:

Sir—I observed in your recent article on Guanajuato a reference to acetylene lamps. Possibly the following may interest you:

At the Newhouse Tunnel we first tried, some six months ago, to substitute acetylene lamps for candles in the headings, with the object of securing better light. We are now using them exclusively, except at points along the main tunnel which can be illuminated by incandescent lamps taking their current from the trolley line.

The lamps we use are of the Wolf pattern, cost $2.25 each, and weigh 2¼ lb. empty, or 4 lb. fully charged. The receptacle for carbide when full holds half a pound, which will burn for from 12 to 14 hours.

The light given depends on the rate of admission of water to the generating chamber, and this can be closely regulated by turning a screw on the outside of the lamp. We have never measured the intensity of the light, but it must be equal to that of at least six candles. In places where candles can only be used enclosed in a can ('bug' or 'go-devil') the acetylene flame needs no shield excepting the reflector behind it.

Carbide costs us 6c. per lb. delivered at Idaho Springs, in ton lots. We find the average expense per lamp per month to be approximately $1, of which 90c. is for carbide and 10c. for repairs. Candles cost about $2 per man per month, excepting in draughty places, around machine drills, etc., when they are excessively wasteful and unsatisfactory, and probably cost more than twice this rate.

All our lamps are stamped with a number, and each man is held responsible for his own lamp. They are cleaned and filled by the enginemen on spare time, and no account is taken of the cost of cleaning and filling, in the estimate of monthly cost. The lamps are left in the power-house by the men to whom they have been allotted, on going off shift, and are ready for use when called for next shift.

We have had no complaint whatever in respect of headaches, even from the men who clean and fill the lamps. This may be due to the altitude; I have noticed that headaches from handling dynamite, etc., are more severe and frequent at lower altitudes. I have tried other types of acetylene lamps elsewhere, and found them troublesome; but can recommend these for use in mines where they can be properly cared for.

GEORGE E. COLLINS.

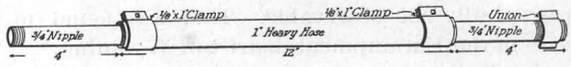
Denver, April 29.

An Idea.

The Editor:

Sir—Some years since I discovered that in mines where machine-drills were used a great deal of labor and air-pipe was lost in turns and sharp bends in drifts, stopes, and in other places in mines where air-pipes had to be placed.

The following device I have used for some time, and have often wondered why no one thought of it before: For ¾-in. pipe, use pieces of 1-in. heavy hose (old air hose will do) 12 in. long, with 4-in. by ¾-in. nipple



screwed into each end of hose and clamped in with clamps, ⅛-in. by 1-in. iron, around the hose at each end. Unions can be attached to one or both nipples for convenience, or not used at all, as desired. If 1-in. pipe, use 1¼-in. hose and 1-in. nipples, and for 2-in. pipe, 2½-in. steam hose can be used to advantage. If the nipples are warmed just before putting into the hose they will be sure to be air-tight. Application has been made for a patent.

W. S. HASKINS.

April 27.

[Such suggestions are most useful. We thank Mr. Haskins cordially.—Editor.]

ADEQUATE ventilation is one of the best preservatives for timber. A steamy atmosphere may rot 12-in. Oregon pine in six or eight weeks. Timber with cold water dripping on it will last longer than that in a dry drift, as the spores of dry rot are washed off the wet sets.

Discussion.

Readers of the MINING AND SCIENTIFIC PRESS are invited to use this department for the discussion of technical and other matters pertaining to mining and metallurgy.

Copper in Shasta County, California.

The Editor:

Sir—I have read with great interest the article of Mr. Donald F. Campbell on the geology of the Shasta copper belt in your issue of January 5. The efforts of Mr. Campbell to shed some light on the local geology must be highly appreciated by all engineers, as reliable information on the geology of that important district is much needed. In fact, as far as I know, the articles of Mr. J. S. Diller in bulletins No. 213 and 225 of the United States Geological Survey, and his text in the folio devoted to the Redding Quadrangle are the only sources of information at hand. Any reliable contribution to this subject must then be of immediate value to all mining engineers called to work in that district, and if in the following lines I may differ from some views of Mr. Campbell, I do this, not in a spirit of criticism, but in the hope that other men more fully acquainted with the local geology will give us the results of their observations.

The genesis of the orebodies is the most important question from an economic standpoint. This, once understood, gives a reliable basis for considerations as to the probable position and arrangement of the orebodies.

The conditions in the portions of the belt on the opposite sides of the Sacramento river are very different and the two areas must be treated separately.

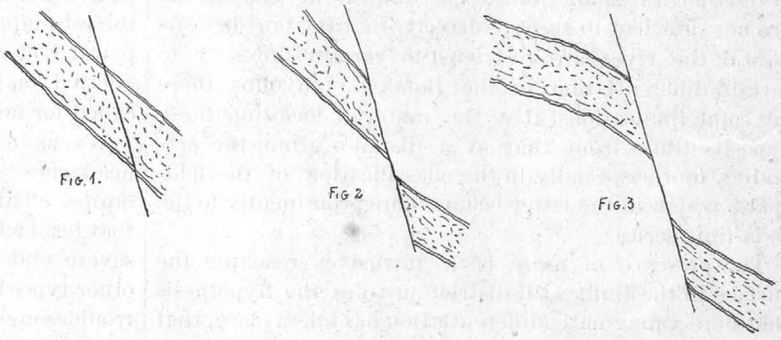
The rhyolite belt west of the Sacramento river, called the Balaklala rhyolite (U. S. G. S. Redding Quadrangle), is formed by a succession of flows, and I do not doubt but that by careful study the various flows might be differentiated in the underground workings. The question is whether the ore deposits are confined to one or more flows, or are distributed through the entire rhyolite mass. The fact that, as yet, no ore deposits have been found in the Copley andesite may be a lead in this direction.

It would also be interesting to have a careful chemical study made of the rhyolite, to determine whether that rock contains a minute quantity of copper, although even microscopically not observable. This was found to be the case in the Encampment district of Wyoming.*

It must further be noted that often, at a relatively considerable distance from the large orebodies, small aggregates of sulphides are found, principally chalcopyrite, associated with secondary silica. Why these small aggregates are so much higher in copper, or, in other words, why in these smaller aggregates pyrite forms a small portion of the sulphide deposit, while in the larger deposits it forms by far the major portion of the sulphides, is another question that demands elucidation. Assuming the generally accepted theory that these ore deposits formed in shear-zones in the rhyolite, it must be observed that the silicification of the rhyolite mentioned by Mr. Campbell is at least, to a certain extent, posterior to the formation of the sulphides. A microscopic examination will show that some of the pyrite crystals are fractured, and silica has been deposited in the fracture planes.

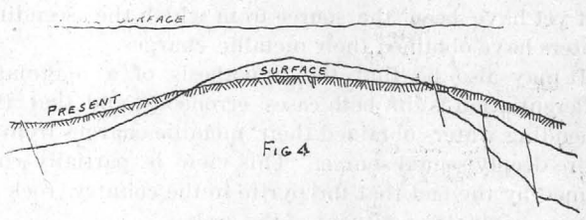
The section given by Mr. Campbell of the Iron Mountain deposits indicates, in my opinion, that the deposits on the north slope of the mountain (Hornet mine) have most probably at one time formed one deposit, which has been subsequently faulted. Some of the other deposits in the same district clearly indicate a similar history. The down-throw of these faults is, as far as determined at present, northerly. This leads me to the suggestion that the movements that caused this faulting were associated with the volcanic disturbances in the Mount Shasta region, and a sinking of the surface in that vicinity at the close of those eruptions. This faulting may reasonably account for the dispositions of the orebodies as found at present (See Fig. 1, 2, and 3), especially if we consider that, before causing faulting, a folding of the strata may have caused the formation of monoclines. If my information is correct, the deposit in the Mammoth mine lies in the form of a saddle and a reconstruction of the Iron Mountain section given by Mr. Campbell would probably give a similar form. (See Fig. 4.)

Up to the present time no intrusives have been ascertained in the Balaklala rhyolite; the copper in the solution must then either have been derived from underlying formations, or have been leached out of the rhyolite, a possibility to which I have already alluded. I incline to the former idea, especially in view of the character of the Bully Hill deposits.



The characteristics of the deposits east of the Sacramento river differ in many particulars from those in the western portion of the Shasta County copper belt.

The ore deposits are situated in a zone of mineralization, which has a northeastern strike and a steep dip.



This zone is contained within a body of rhyolite, the Bully Hill rhyolite. This rhyolite forms an I, the Bully Hill and adjoining mines are on its north branch, some copper ore deposits are found in its stem where it crosses the Pit river, and the Afterthought mine is located on its southern branch. In this district the copper deposits are, however, not restricted to the rhyolite. Some are found in the Dekkas andesite. According to Diller, the Dekkas andesite and the Bully Hill rhyolite are Triassic and consequently much younger than the pre-Devonian Copley meta-andesite and the Balaklala rhyolite. In the Bully Hill district there are intrusions of a diabasic rock in the rhyolite. The rhyolite is much more sheared than west of the Sacramento river; the shearing is so intense that in places it has a perfect laminated structure.

Of the three main ore deposits in the vicinity of Bully hill, the Winthrop, the Rising Star, and the Bully Hill, only the last is directly associated with the diabasic in-

*Arthur C. Spencer, U. S. G. S Prof. Paper No. 25, p. 35.

THE GENESIS OF THE COPPER ORES IN SHASTA COUNTY, WEST OF THE SACRAMENTO RIVER.

Written for the MINING AND SCIENTIFIC PRESS
By WILLIAM FORSTNER.

The deposits of copper ore in Shasta county, California, are in the northwestern part of the county. They can be subdivided into two belts, the Iron Mountain belt west, and the Bully Hill belt east of the Sacramento river. In both these belts the ore deposits are in the form of massive pyritic bodies, contained within acidic extrusive rocks. In the Iron Mountain belt are two pre-middle Devonian extrusives, the Copley andesite and the Balaklala rhyolite; the latter containing the copper-ore deposits. The rhyolite is undoubtedly later than the andesite, and the latter may underlie the area covered by the rhyolite. Both were extruded on land. The underlying rocks are probably the older schist-series found in Trinity and Siskiyou counties.

The Balaklala rhyolite consists of various flows which might be differentiated in the underground works by careful study, in order to decide whether the orebodies are confined to one or more flows, or are distributed through the entire rhyolite mass. Although the rhyolite is not homogeneous the following description affords a basis for further discussion. The rock is, throughout, considerably altered. Its principal primary constituents are quartz and orthoclase, occasionally plagioclase. There is also an entire absence of femic minerals. The secondary principal constituent is quartz, and the secondary accessory constituents are pyrite, calcite, sericite, and kaolin. At a distance from the orebodies the pyrite generally occurs in small aggregates of minute grains, occasionally forming bunches, which latter generally consist partly, if not principally, of chalcopyrite. Well-developed cube pyrite is very rare. Close to the orebodies the country rock becomes pitted, and the cavities are to a greater or less extent filled with pyrite, until the material changes into massive pyrite, with small inclusions of quartz. The transition zone is generally from one to two inches wide. D. F. Campbell, in the MINING AND SCIENTIFIC PRESS, January 5, 1907, p. 28, mentions the presence of mica and chlorite, the latter often in such quantities as to give a dark-green color to the rock. I presume his specimens were collected near Iron mountain. In none of my specimens, collected between Motion and Backbone creeks, was chlorite detected microscopically. Possibly the green phases of rhyolite represent the Copley meta-andesite, which contains considerable chlorite.

The orebodies consist of massive aggregations of grains of pyrite with accessory chalcopyrite. These sulphides have entirely replaced the feldspars, and also part of the quartz of the country rock. Rhyolites contain from 21.8 to 47.8% quartz (Prof. Paper No. 14, U. S. G. S.), while generally the ores contain about 5% silica, consequently a replacement of quartz by sulphides must have taken place on a large scale. A similar case occurs in Butte, Montana, where the quartz of the granite, which is chemically analogous to rhyolite, is removed, resulting in large masses composed entirely of metallic minerals (S. F. Emmons, *Trans.* A. I. M. E., Vol. XVI, p. 57). Neuman considers this replacement to be a chemical process, the removal and deposition proceeding simultaneously, molecule for molecule ('Genesis of Ore Deposits', p. 502). Sulphides of iron, copper, zinc, etc., are soluble in alkaline sulphide solutions, and also in alkaline carbonate solutions containing hydrosulphuric acid (Van Hise, *Mon.* No. 47, U. S. G. S., p. 1106). There is little to be found in the literature of the genesis of ore deposits concerning the action upon quartz of solutions containing alkaline sulphides or carbonates, and carrying dissolved metallic sulphides, sulphites, and sulphates. As the orebodies were formed within fractured portions of the country rock, they were formed within the zone of katamorphism, and below the belt of weathering, consequently in the belt of cementation. The principal reactions in the lower part of this belt are cementation and metasomatism. The cementing substances are oxides, carbonates, silicates, and sulphides. Of the former, silica is the most important. In this case the composition of the circulating waters must have been such as to produce extensive metasomatism, causing the dissolution of the feldspars and most of the quartz of the rhyolite, and their replacement by metallic sulphides.

Our imperfect knowledge of the chemical activity of thermal waters under the influence of high temperature and pressure is yet an obstacle to the clear understanding of their work in depth. Chemists agree that silica generally exists in the hot mineral waters in a colloid solution; and consequently does not diffuse through the rock-walls, which form semi-permeable membranes (W. Lindgren and F. L. Ransome, Prof. P., No. 57, p. 220; and others). The thorough elimination of the rock constituents, mainly feldspar and quartz, shows that alkali and calcium carbonates and an excess of carbon dioxide were present. The presence of calcium carbonate is probable, as calcite replaces quartz, which is dissolved by waters containing alkaline carbonates, a corresponding quantity of calcic carbonate being deposited in its place ('Genesis of Ore Deposits,' p. 525). Sericite, with free silica and potassium silicate, result from the decomposition of orthoclase by the action of water alone at high temperature and under pressure ('Geochemistry', p. 511); it also forms from quartz, in which case a complex chemical action is probably involved, a transportation of potash and alumina must be assumed ('Genesis of Ore Deposits', p. 528). It must be kept well in mind that the solutions necessarily must have been very dilute. Alkali carbonates at high temperatures are readily soluble in water; at 135° C. 100 parts of water dissolve 205 parts of K_2CO_3, and at 105° C. 45.1 parts of Na_2CO_3; calcium carbonate, however, requires a great amount of water. At 21° C. it takes 1015 parts of water saturated with carbon dioxide to dissolve one part of $CaCO_3$. Silica also requires considerable water; it is soluble in 1000 parts of pure water. When precipitated from alkaline silicates, by water saturated with carbon dioxide, one part of silica requires about 5000 parts of water; but if the silica is set free in

sufficient water to retain the silica, one part of silica can thus be held in solution by 100 parts of water.

As stated above the ore deposition took place in a zone of fracturing of the rhyolite, in the lower portion of the zone of katamorphism; the fissures through which the waters circulated were most probably exceedingly minute, the chemical action of substitution must have taken place very slowly, and it may be accepted that the entire deposition covered a long space of time. The microscopic study of the material of the orebodies and of the immediate wall-rock confirms this view, as in some specimens the pyrite is crushed, while in others such is not the case, indicating that movements had occurred in the intervening time. It then appears probable that the deposition of the orebodies was the result of a double process, first, a replacement of the feldspars and silica by means of alkaline carbonates and carbon dioxide, and then a replacement of the alteration-product by metallic sulphides by means of alkaline sulphides and hydrogen sulphide. The iron content of these solutions must have been derived either from the underlying strata, or from the residual magma, femic minerals being absent in the Balaklala rhyolite. It must be remarked that, as yet, no bodies of copper ore have been found in the Copley meta-andesite, although it is a locus of many gold-quartz veins, among which are those at Old Diggings. At the head of Motion creek, on the line of the Iron Mountain copper-belt I have found some highly altered rock, most probably derived from basic rock; this may give a lead, especially considering that the pyritic ores at Black Diamond are close to serpentine and diabase, and those at Bully Hill to basalt.

In the orebodies under discussion the pyrite is found occasionally surrounded by narrow rims of quartz, but is not associated with chlorite or epidote. The rocks have not been metamorphosed to such an extent as to justify the assumption that dynamo-chemical metamorphism has taken place, and we are thus brought to the conclusion that the orebodies were formed by hydro-thermal processes, that is, by the action of ascending thermal waters (W. Lindgren, 17th. Ann. Rep. U. S. G. S., pp. 90 to 95). The form and the size of the orebodies vary greatly; some are lenticular, others have a more tabular form. Some have been entirely eroded, leaving only the outline of part of their walls as testimony to their former existence; of others only a relatively small residual mass of limonite remains. They must have formed in zones of intense fracturing of the country and were most probably limited by subsequent cross-movements, which by attrition caused impervious belts whereby the circulation of the solutions was circumscribed within certain portions of the zones of fracturing (R. H. Sales, *Economic Geology*, Vol. III, p. 329). These may be contraction-fractures, or they may have been caused by dislocation of the strata. I am inclined to believe that the original fractures, wherein the ore deposits formed were contraction-fractures, while the fractures which caused the formation of impervious clayey strata, in many cases limiting the orebodies, were the result of earth-movements. The latter, however, were not limited to the period of ore deposition, but persisted afterward, as proved by the faulting of some of the orebodies.

THE PASSING OF THE TAILING-WHEEL.

*The tailing wheel, that familiar object on the landscape at the Rand, has long been threatened and is now quietly passing from our midst. For a long time the mechanical engineers of the various groups of mines—notably A. M. Robeson, of the Corner House—were experimenting with various forms of elevators and pumps, but the actual displacement of the tailing-wheel can now for the first time be chronicled.

It has been ousted by an improved type of centrifugal-pump, evolved after lengthy and careful experiment by the mechanical engineering department of H. Eckstein & Co., to whose initiative Rand metallurgical practice owes so much. The history of the experiments is interesting. When the tailing-wheel of the Rose Deep broke down last year a centrifugal-pump was used temporarily to replace it. A fatal flaw in the centrifugal-pump was found to be the speed with which the manganese steel liners wore out, and also the large waste of power. These were eventually overcome by replacing with locally-made cast white-iron liners, and by intelligent design, with such satisfactory results that the general adoption of this device is now only a question of time. In operating costs the centrifugal-pump possesses no advantages over the tailing-wheel; but in capital expenditure or prime cost, a marked saving is effected. The cost of a pair of pumps is, roughly, £1780; the usual cost of a tailing-wheel is £8000. For small equipments the difference in favor of the centrifugal-pump becomes more apparent than for larger ones.

The centrifugal-pump is notoriously inefficient, but its failings in this respect are greatly exaggerated. With sand the average efficiency is 40 to 45%, and it is hoped to obtain an efficiency of 50%, which nearly approaches that of modern high-lift centrifugal-pumps. The centrifugal-pump has already displaced the tailing-wheel at the Rose Deep and the Crown Deep, at both of which mines the tailing-wheel has now been finally 'scrapped.' At the New Heriot a plunger-pump has been scrapped in its favor. At the Village Main Reef, one has been erected as a stand-by, and two pumps are being erected at the Glen Deep and two at the Durban Roodepoort Deep. At all the mines that have adopted the pump, duplicates will be erected. It is noteworthy that the life of a tailing-wheel averages only 12 years, and many of the wheels on the outcrop-mines and first row of 'deeps' are now nearing their end.

Radium exists in the sea water around the coast of Ireland in special abundance, according to some experiments recently carried on. The deep-lying sediments of the ocean were found to be exceptionally rich in this metal.

Nitro-glycerine freezes at 42 to 46° Fahrenheit, but is not entirely safe even when frozen.

* Re-print from *The South African Mining Journal*, July, 1908.

The Copper of Shasta County, California.---II.

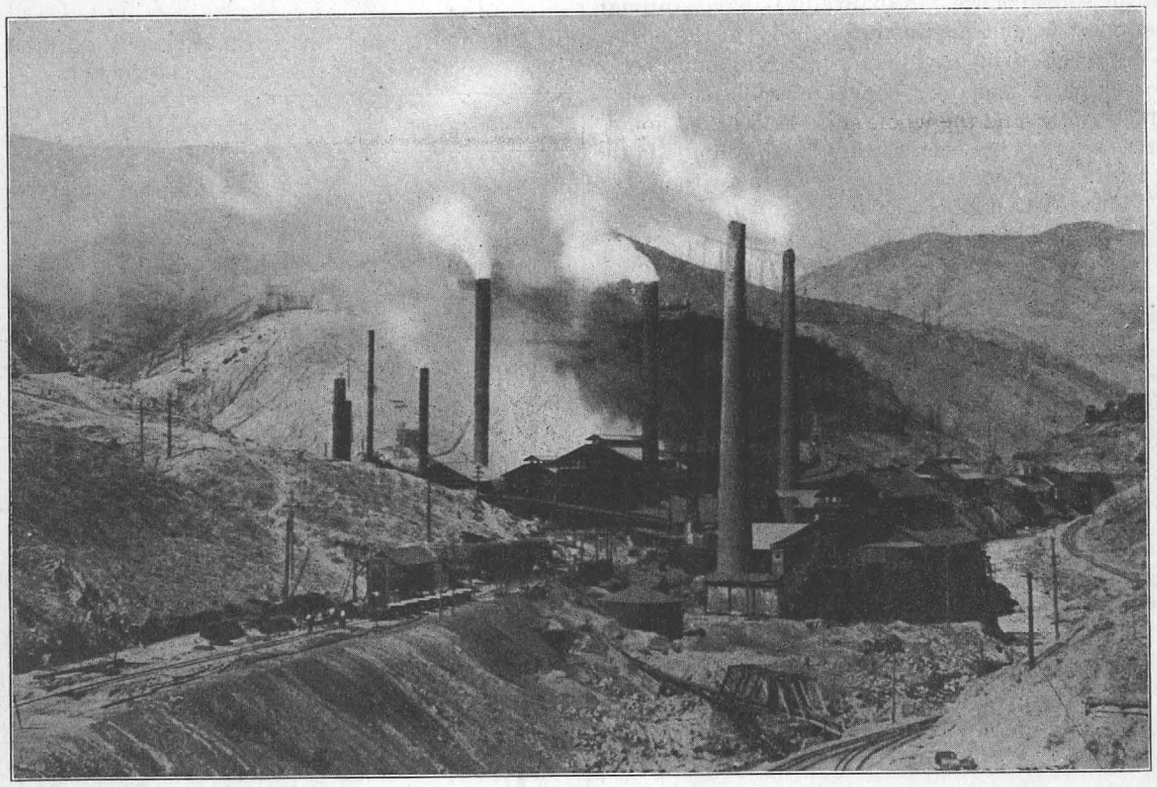
Written for the MINING AND SCIENTIFIC PRESS
By DONALD F. CAMPBELL.

The history of the active development of the copper resources of Shasta county dates back to 1896, when a strong English corporation entered the field and disclosed the great mass of ore at Iron Mountain. Prior to this, Shasta county had been the scene of some placer and pocket mining, while the outcrops of the copper deposits had yielded large returns in silver and gold, before the fact was realized that the most profitable and permanent industry was to be found in the mining of base metals. As early as the sixties, however, small shipments of oxidized copper ore were made from the Bully Hill district, and taken round the Horn to the Swansea smelters. The development of the Iron Mountain mine marked the birth of the present thriving copper industry. This mine was worked successfully as a silver and gold mine, the gossan being treated in a 10-stamp mill and the sulphides chlorinated. The chief product was silver, but the fall in price during 1893 and the presence of base ores brought the profit to zero. It was then that English capital took hold of this mine and started operations on a large scale.

This district may well be considered in detail, as it is typical of the western, or most important part of the belt, which includes also the Balaklala, Trinity, and Mammoth copper mines. In the eastern portion there are a number of mines of a different type, of which the Bully Hill and Afterthought may be taken for detailed consideration. In the former district the mines are entirely exploited by adits, while in the latter, the narrow and deep orebodies are mostly explored through shafts.

The Iron Mountain mine, the richest and most developed in the district, is connected with the smelter and Southern Pacific railroad by a narrow-gauge railroad 11 miles long and of 3.3% grade. This mountain road climbs about 2,000 ft. and is one of the most remarkable in the Western States. The numerous curves, only partially compensated, deep cuts, high trestles, and loop make it a road that would naturally be expensive to construct and maintain. The problem of railroading under these adverse conditions, hauling cordwood, flux, and supplies from the main line, switching roasted and sulphide ores in an awkwardly constructed yard, and above all, keeping up an adequate supply of ore from the mine with a small storage capacity at the smelter, has required great ingenuity and care.

Keswick, the pioneer smelter town of this important copper region, was once the scene of an activity that has never been repeated. Before pyrite smelting was introduced, the ore was mostly roasted in open piles or stalls, giving employment to hundreds of men, and great quantities of coke were required. Cord wood, partly cut from the adjacent hills and later floated down the Sacramento river, was used at the rate of 60,000 cords per year before the introduction of electric power. These operations resulted in a payroll of 1,200 men at the smelter alone. This is a great contrast to the present methods. The new smelter at Kennett is typical of a modern plant; but it is due to the development of ideas resulting from many costly experiments undertaken at Keswick. Almost every misfortune that could befall a mine and smelter had befallen this property, the list of troubles including mine fires, labor difficulties, and litigation. In spite of this, however, the problem of smelting the ores of Shasta county was worked out entirely at Keswick, the old method of roasting and smelting with coke being gradually improved and ultimately culminated in the adoption of pyrite smelting, with a remarkable run of 11 days without a pound of coke in 1905. The Keswick smeltermen have solved the local problem of ore reduction, and it is satisfactory to see such dogged industrial determination give good results, and to note that the men who directed the first smelter are now applying the methods that were developed by their skill.



Keswick Smelter.

Blast furnaces, roasters and converters, making blister copper.

The mining of the Iron Mountain orebody has presented several difficulties that are full of interest. For some years the mine has been on fire and the resulting gas and heat have made the underground conditions very bad.

That spontaneous combustion often accounts for outbreaks of fire is probable, because the fine pyrite dust, when in contact with decaying timber in a stagnant atmosphere will generate sufficient heat by decomposition to burn. The fire makes the temperature of the rock and working places high and fills the atmosphere of the mine with sulphurous acid gas, while the water is a strong solution of iron and copper sulphates with free sulphuric acid.

The conditions that seem to favor fire are rotting timber covered with pyrite dust in a semi-permeable filling in which small pieces of ore occur. Rock temperatures of 600° F. may be observed in the immediate neighborhood of the fires and yet rock of this temperature has been mined—a fact creditable to the determination of the management. The system of mining has been to extract the ore in horizontal slices, each 10 ft. thick. In addition to this, a sub-division is made on each horizontal slice so, that the two end stopes are separated by a centre pillar to prevent the spread of fire. A main adit is driven through the country-rock and across the orebody to the farther side. From this, drifts divide the stope into a number of pillars about 50 ft. square. These are 'robbed' by slices one set in width and the whole stope is 'worked home,' the entire space being well packed with filling and the timber left in position. No opening of more than two sets in width is left unfilled. The system of working is shown in the accompanying diagram.

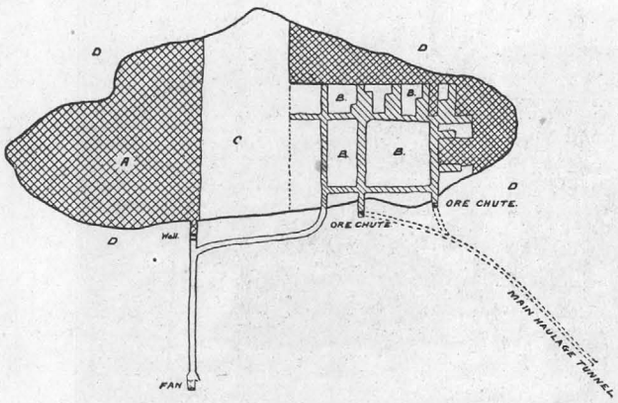


Fig. 1. Method of Working.

A, Filled ground. B, Undeveloped ore. C, Fire pillar. D, Country rock.

The rock breaks easily, being traversed by a number of fissures in certain well-defined directions; often blasting is unnecessary. In driving through old filling, serious runs of fine calcined dust have occurred without warning, which together with a sudden outburst of gas, prove dangerous. In working the hottest places where there is fire, a careful watch is kept on the rock temperature and a plentiful supply of water is piped to the face. Timbers are soaked and, after blasting, the rock is cooled with a spray. Ore may be worked at a temperature of over 800° F., but at this heat the fine ore will burn as it falls through the air, and in blasting the combustion of the fine dust makes so much gas that it is often difficult to get back directly afterward, which is necessary, as the timbers must be constantly wetted. With a rock temperature of this exceptional intensity, the air at six feet from the face can be maintained at 100° to 110° by the system of ventilation used. For blasting at this temperature, the holes are cooled by leaving a hose running in them for some time, wrapping the powder in asbestos or rags and lighting the fuse before putting the powder in the holes.

Stopes are sometimes temporarily lost through an outbreak of fire and in such cases it may be advisable to remove all machinery, cars, and rails, and shoot down timbers or build walls, so as to isolate the danger zone; but in some cases the fire may be fought and successfully subdued. If a mass of ore is known to be very hot and surrounded by smouldering filling, it is better to approach it from above and always with a low drift. If the fire is above, or the drift is broken high, the fire will fall on the lagging above the caps, where it cannot be fought as well as on the floor.

The conditions are not good for efficiency among miners, but the Italians, who alone will work under such trying circumstances, work fairly well. The gas, acid water, and great heat make extraction difficult, for, although the temperature, usually about 90° and in some cases as high as 110° F., is not so intense, it must be remembered that a dry heat is very much better than this steam-laden, gaseous atmosphere with strongly acid and coppery water dripping in many places. The cost of driving adits in the country rock—a silicified and sheared rhyolite—is shown in a table below, while the

COST* OF DRIVING IN SILICIFIED RHYOLITE.
Tunnel 8 ft. 6 in. by 9 ft. 6 in. Length 494 ft.

		Supplies.							
	Wages	Explosives	Illuminants	Timber	Total	Tool-sharpening	Track-laying	Superintendence	Total
	$	$	$	$	$	$	$	$	$
Drilling, per foot.	1.570	.....	0.043	.....	0.043	0.126	.....	.....	1.739
Blasting " "	0.504	1.047	0.0 4	.....	1.061	.....	.....	.....	1.565
Mucking " "	2.360	.....	0.057	.....	0.057	.....	.....	.....	2.417
Outside tramming, per foot..	0.900	.....	.....	.....	.....	.....	.....	.....	0.900
General " "	.....	.....	.....	.....	.....	.....	0.3 9	0.334	0.683
Timbering "	0.840	.....	.....	0. 76	0.6 6	.....	.....	.....	1.516
Total	6.174	1.047	0.114	0.6 6	1.837	0.126	0.349	0.334	8.820

Powder used per foot of tunnel.....7.88 lb.
Drill-holes, cost per foot.....$0.107
per drill sharpened.....3 5 ft.
per foot of tunnel.....$14.75
Average time of drilling round.....15.3 hr.
" " loading, blasting, and setting up..... ..... 5.44 hr.
N. B.—The tunnel was only partially timbered, 171 ft. being supported by round timbers.
Wages: Machine men and timbermen, $3 per day; muckers, $2.50.
*Exclusive of power and depreciation of machinery.

cost of extracting ore is about $1.50 per ton. The mine has several natural advantages, which help materially in keeping down the costs of extraction. The ore is easy to break and blasting is often unnecessary. Furthermore, there is no hoisting or pumping, as the mine is entirely above the level of the gulch in which the camp is situated.

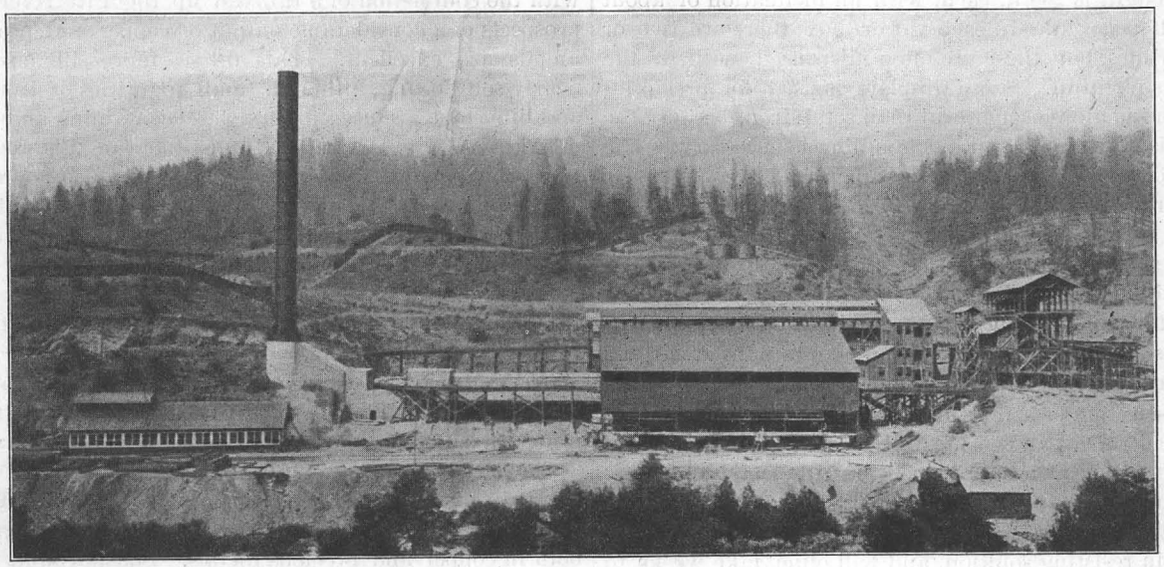
The system of ventilation is especially interesting. Several Sturtevant fans, 5 ft. diam., are used to blow air into the workings. These are carefully regulated so as to maintain an equilibrium at the end of the workings and hold back the gas in the filling, thus placing the combustible material in a neutral atmosphere. If a proper statical pressure is maintained, air will not penetrate the filling so as to fan the smoldering timbers to a blaze, and the back pressure cannot force the gas into the workings. The system, though it is simplicity itself, has solved what might have seemed an insurmountable difficulty.

Filling for the mine is partly obtained by driving for development in country rock and partly by quarrying on the surface. The ore is loaded directly into trolley cars underground and taken to bins above the railroad terminal. Here it passes through a coarse crusher and after screening, the various sizes are passed down a gravity incline to separate railroad bunkers, where it is shot into the railroad cars and taken to the lower railroad termi-

nal, to be put on the storage piles or transferred to broad-gauge cars, according as assays or circumstances require. Generally three sizes are separated: Coarse or 'run of mine' ore; 'nuts,' screened from 2 to 4 in.; and 'fines.' Special sizes are made according to order for some sulphur burners, etc. The cost of transferring ore from narrow-gauge cars to stock piles, and then to crushing and sizing plant and loading on broad-gauge cars is economically carried out. The different grades of ore, in separate piles, are loaded with a steam-shovel and may be mixed to get any desired grade. The cars are then switched and dumped into bunkers over the crusher and trommels from which the ore passes on to a picking belt and thence into broad-gauge cars. By this means the ore can be transferred, crushed, sized, and picked clean of waste and zinky stuff, and loaded, all at a cost of about six cents per ton, which includes labor and supplies.

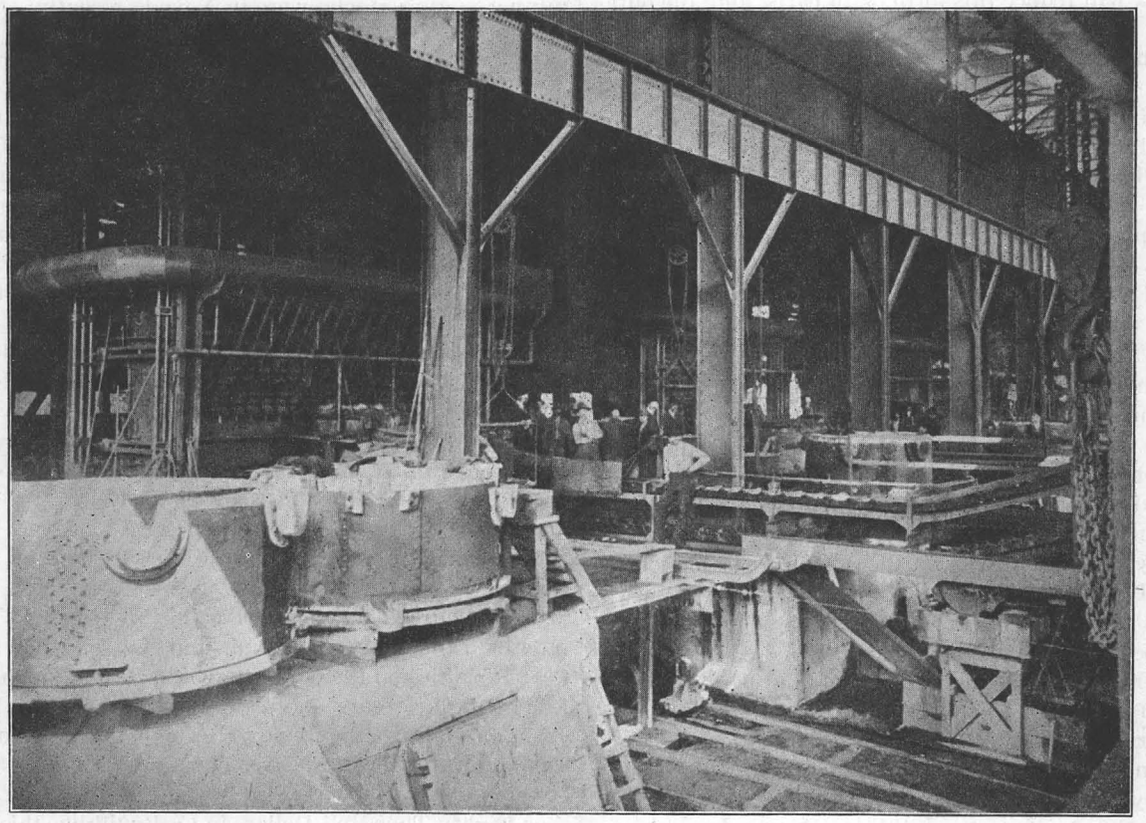
An ingenious device has been employed to overcome the difficulty of packing the fine ore in the bunkers. The ore cakes hard and forms an arch, so that the cost of transferring used to be often trebled. A hydraulic cylinder was put in the bottom of the bin, fitted by a steel plough 2 by 4 in. by 6 ft., which was fixed transversely across the end of the piston. By working this slowly to and fro, to make an undercut, the packing of the ore was entirely prevented, and a steady stream of fine ran down the chute, effecting a great saving in cost.

An important asset is the mine-water, and one which is highly profitable. The water contains free sulphuric acid, copper and ferrous sulphates, the latter being soon



Kennett Smelter.

Simple arrangement for single concentration to low-grade matte.



United States Smelter.

Showing furnaces, settlers, and slag disposal.

oxidized to ferric sulphate on exposure to air. This water, coming from the mines at a temperature varying from 80 to 130° F., is led through a series of three precipitation vats. Each vat has three compartments in parallel so that one is usually being emptied and two are in use. Their length is 200 ft. each, with an inclination of about one-half per cent. In each vat or box there are two or three riffles, but these are often dispensed with, if the water is plentiful. Scrap tin-plate is used for precipitation, and is more economical than scrap-iron, because the action is more rapid and less handling is necessary. The excess of free acid in the water liberates great quantities of hydrogen. Attempts to neutralize this acid have not proved successful, and it increases the consumption of iron to such an extent that the economic limit of copper extraction is attained when the cost of iron dissolved is equal to the value of copper obtained. This economic limit is reached when the water escapes with about ten parts per million of metallic copper.

The selection of scrap tin-plate is a matter of some importance. Fruit and fish canneries, coal-oil dealers, and the like, have splendid material, but the supply is somewhat limited and must be bought at seasonable opportunities. Lacquered tin must be avoided, as it is most persistent in resisting solution, and will often take weeks to dissolve, whereas with bright tin, the bundles are often dissolved as quickly as two men can feed them into the first vat. A good supply of water under high pressure is laid on, so that the tin can be well scoured if it becomes coated or dull. Almost the whole of the copper is deposited in the first box, but assays are regularly made to determine the losses, the outlet, and the extraction in each box. The mine-water will usually carry from 1,000 to 3,000 parts per 1,000,000 of metallic copper, but the first box will reduce this to 15 or 20 parts, and the outlet should not exceed 8 to 10 parts. With this extraction the economic limit is reached, the consumption of iron by the free acid being too high to justify the extraction of the remaining copper. When sufficient copper is precipitated, the water is sluiced off from a box, the tin raked out, and water syphoned to the next vat, and the copper cement taken to the drying furnace. This assays about 83% copper and contains some sulphuric acid. If left in a damp state in the open air, it will sometimes get red hot and form a fused mass. It is largely used for painting the bottoms of ships to prevent the growth of barnacles, owing to its poisonous character.

At the Mammoth mine the lode is extracted in slices and timbering is put in. The ore is entirely removed and the roof allowed to come down. From the mine, the ore is transported to the smelter, a distance of about three miles, by an aerial ropeway which has not proved altogether satisfactory. The Bully Hill mine differs in many respects from those on the western portion of the belt. It was opened as a gold mine, and the gossan was worked with indifferent results, until copper ore was developed at depth. Bully Hill is composed of basic and acidic eruptives, principally rhyolites and basalts, with a series of mineralized shear-zones in which lenses of ore and pyritic impregnations occur. The mine is developed on the upper levels by a number of adits, and in depth by a shaft 600 ft. deep, equipped with an electric hoist. The irregularity of the ore deposits and ill-defined zones of mineralization, make the development of this mine a matter of difficulty. Drifts are generally driven about 20 ft. in the foot-wall, cross-cuts to the vein being made at regular intervals. In this way a number of valuable deposits have been discovered, in some cases chalcopyrite, several feet in thickness, being found. In the upper workings a gouge occurs in the shear-zone that is rich in oxidized copper ore. The cost of extraction is not easily determined, as a large amount of the rock extracted is used for filling, and data as to costs are not available.

The same company is actively developing mines at Winthrop and in the adjoining Copper City district, and with the completion of a railroad up the Pitt river, the prospects of a considerable output of copper and precious metals are excellent. This ore is more silicious and nearly self-fluxing, although small quantities of iron ore and limestone are used to flux those containing an excess of silica. Barite is a marked constituent of this and the Afterthought ore, while zinc-blende is also found in large quantity. In the past, the cost of freight has killed the profitable extraction of copper, as the hauling of coke cost $8 per ton, in addition to the exorbitant rates on the Southern Pacific and Bellavista railroads. The Afterthought mine resembles the Bully Hill in many respects, but the quantity of ore is less, and the associated minerals are very troublesome. Large quantities of zinc-blende and barite occur in this district, and these minerals have caused incessant trouble to the smeltermen.

The larger and more important mines are those that occur in the western part of the belt, but in the Bully Hill district the ores are often of much higher grade, both in copper and precious metals. Shasta county will undoubtedly make its mark on copper statistics in the next few years, and while the development of large ore-bodies is more than probable, the present smelters under construction will be smelting 3,000 or 4,000 tons of ore per day in the near future.

An Interesting Letter.

The following communication was received by two mining engineers who were in Nevada recently:

GoldField Hotel, GoldField.

Messrs. Smith & Jones

Dear Sirs I see by Our Daly that You are hear looking for some Good Properties and we have Many of them from one thousand to Five Thousand to Ten Thousand up to One Hundred and twentyfive Thousand per Groupe of Claimes and in Nos fromthree to Eight in a Groupe all have well Defined Ledges that assay from threeto Twenty three Dollars per Tone and some PanFree Gold to the Valuation of twenty to thirty dols and we Have 4 Groups in the Heart of the GoldField District surounded by Properties that Money can not By such as the WhiteRock Ajoining the January Mines and Surounded by such Notied Mining Propertiesas the Florance. the Combination. the Jumbo. the Mowhawk. and the Redtop. all Heavy Shipers with great Recards. as Heavy Producers for thire age.

Terms and Prices on the White Rock Groupe of Eight Claims

One Hundred Thousand Dollars of Payments of Twelve Months From date OF Bond. and Lease. with 15 per Cent Royalties on the out Put of the Ground during the Life of the Lease first Payment Twenty thousand Dolars Cash on Making the Bond or as a bove One Hundred Thousand. and Twenty Five Thousand Dollarsin Stocks of the same.

or Eighty Thousand Dollars in Cash will bye this Property Out Right

MRS. A. B. TOMPKINS

if You wish to see Me. in regard to any of those Propites i will Be at My Home in the Tompkins Addition to Morow the25th

REGULAR stage service, twice a week, will be maintained this winter between Valdez and Fairbanks. The new winter trail saves fifty miles over the old one.

The Engineering and Mining Journal

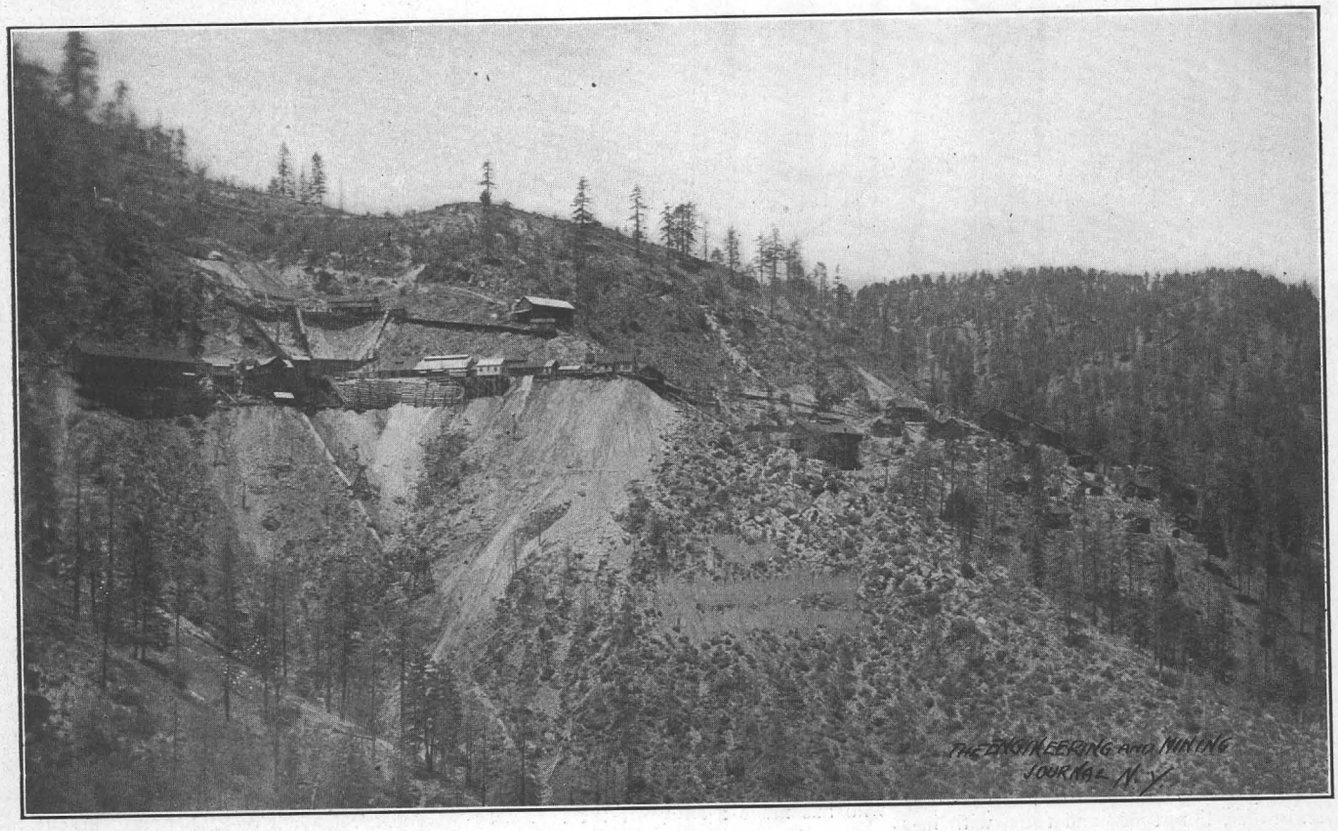
VOL. LXXXVIII. NEW YORK, AUGUST 28, 1909. NO. 9

Copper Mines and Smelteries of Shasta County

Topography Favors Mining through Adit Levels; Cost of Mining $1.65 to $2.50 per Ton; Cost of Copper 8 to 10.25 Cents per Pound

BY GEORGE A. PACKARD*

Shasta county is one of the most northerly counties of California, being separated from Oregon by Siskiyou county. Redding, the county seat, is 260 miles north of San Francisco. The climate is agreeable, though the valleys are hot in summer. Except on the highest mountains there is little snowfall. The annual rainfall varies from 35 in. in the valley toward the south, to double that quantity in the mountains to the north. This precipitation takes place largely during the winter months; in January, 1909, it reached an abnormal monthly total of 40 in., 9 in. being recorded in one day at Kennett, where the mammoth smeltery is situated. This precipitation interfered seriously with transportation, even the old main line of the Southern Pacific railroad being operated only intermittently, while the newer lines from the mines to the smelteries were more seriously interfered with.



MAMMOTH MINE, KENNETT, CAL.

Water Power

To the north and east, on the high peaks of Mount Shasta and the Lassen buttes, this precipitation is in the form of snow and furnishes an all-the-year-round supply of water in the Pitt, McCloud and Sacramento rivers and their tributaries. This results in cheap power, which is developed and sold in the district by the Northern California Power Company and the Shasta Power Company. The plant of the former is of especial interest in that the power is derived from two small streams, each having a fall of 1200 ft. On a third stream a wheel now being installed to utilize a 525-ft. fall will develop 4000 kw., and below this on the same stream another wheel will develop 6000 kw. from a fall of 370 ft. Pelton and Doble wheels are used. C. F. Elwell[1] refers to the cost of this power to the Noble Electric Steel Company as $16 per kilowatt-year, but the power company is interested in the steel plant, and other plants are supposed to pay between $40 and $50 per horsepower-year.

Topography and Geology

From the stream fall mentioned it is easily seen that the topography, at least in certain parts of the district, is favorable to mining through adit levels; and this is especially the case with the mines to the west of the Sacramento river. East of this river, and as far north as the Pitt, the country is less deeply eroded

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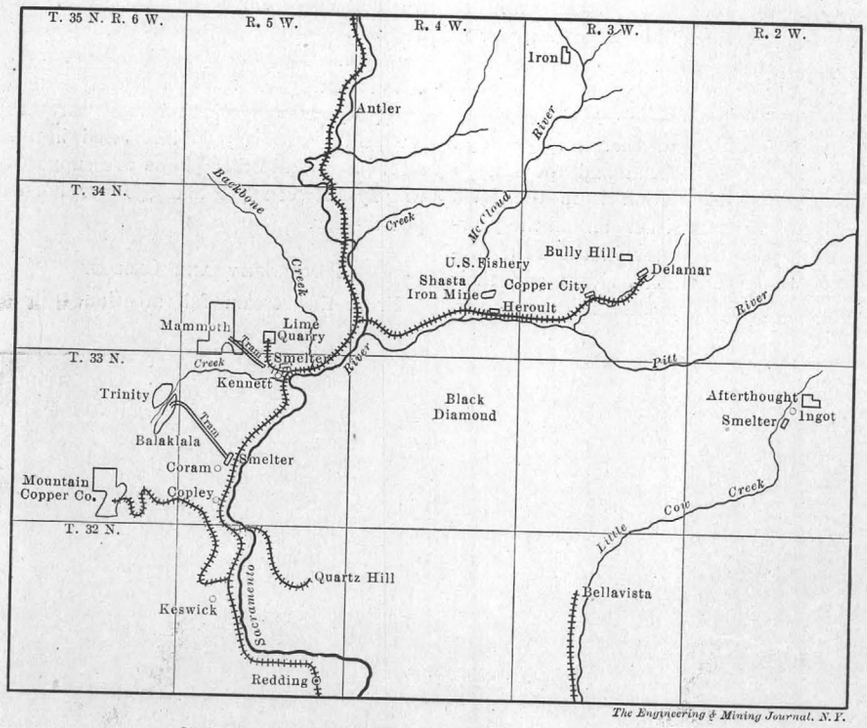
[1] "Tests on Electric Smelting of Iron Ore," *Journ., Electricity, Power and Gas*, XXI, p. 331, 1908.

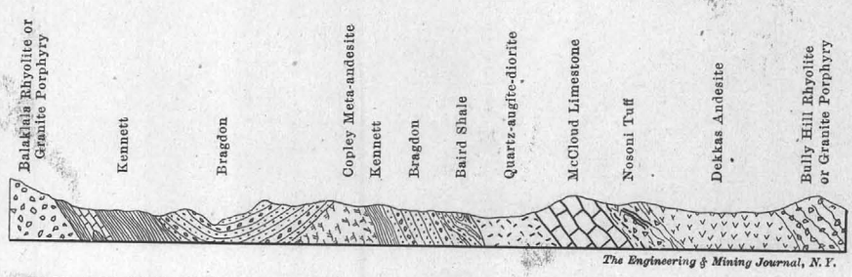
by streams. Nor has there been much mining east of Redding. In fact, looking at the "Map of the Mining Districts of the Western States," issued by the U. S. Geological Survey, one receives the impression that the entire zone of mining districts, if it may be so termed, has been faulted along an east and west line, in the vicinity of Redding, and transferred 10 miles west, from the Sierra Nevada to the Coast range.

The railroad from San Francisco traverses the Sacramento valley which, until Redding is left behind, is broad and level. Beyond Redding the valley rapidly narrows and on either side rise steep slopes covered with brush and oaks, which give place to pines near the summits. The copper mines occur in these mountains in two wide irregular areas of granite porphyry, one on each side of the Sacramento river. These areas are separated by eight miles or more of sedimentary and igneous rocks. The Redding quadrangle presents an interesting section across several thousand feet of Devonian, Carboniferous, Triassic and Jurassic sedimentaries, made up of slates, shales, sandstones, limestones and tuffs, with interbedded and intruded igneous rocks. The whole series has been uplifted, sheared, faulted, and compressed, and shows in general a sharp dip to the northeast.

An accompanying section gives an idea of the geological conditions along an east and west line, the geology of this quadrangle having been mapped by Dr. J. S. Diller[2]. Of the sedimentary formations shown, the Kennett has been assigned to the Devonian and the others to the Carboniferous. Overlying the Bully hill granite porphyry, and not shown in the figure, is the Pitt shale of the Triassic period. In this folio the crushed granite porphyries containing the copper ores have been considered as rhyolite flows of different periods, and Dr. Diller assigns the Bully hill rhyolite to the Triassic, while most of the porphyry west of the Sacramento river, termed Balaklala rhyolite, he considers Devonian, though he states that some of the dike-like masses west of Copley may belong to the Triassic. Basil Prescott, who has made a study of the region between the Sacramento river and Bully hill, apparently agrees with Dr. Diller in so far as this eastern area is concerned[3].



SKETCH MAP OF PORTION OF SHASTA COUNTY, CAL.



EAST AND WEST SECTION ACROSS PORTION OF REDDING QUADRANGLE (AFTER DILLER)

Dr. L. C. Graton, in describing these deposits briefly, says[4]: "The orebodies are invariably associated with intrusive stocks of quartz monzonite porphyry, although the ore in some places extends out into adjoining rocks." In much of this rock the quartz phenocrysts are so prominent, and the ground mass is so compact, that rhyolite would appear to be the natural field term; but doubtless microscopic study has shown that the rock is more properly termed a granite porphyry, and is an intrusion rather than a flow, since this name is preferred by those who have given the most attention to the geology recently.

Ores

The copper ores and associated minerals are only the same in part, in the two areas, while the structural character of the ore deposits is also somewhat dissimilar, tending to the conclusion that the ore deposits were not formed simultaneously; or, if the copper minerals were originally deposited under similar conditions in both areas, subsequent conditions have been dissimilar. The ore occurs in zones of crushing and shearing in the granite porphyry, and locally in adjoining shales on the west side of the Sacramento, and in an intruded basalt on the east. The occurrence in the eastern area is so different that it will be described by itself later.

From the relative location of the orebodies it is evident that the porphyry in which they occur has, in the western area, been faulted to a considerable extent since they were formed. This is well shown in the section marked "E-F" in the annual report of the Balaklala Consolidated Copper Company for 1908, reproduced in the JOURNAL of March 6, 1909, p. 503. On a line from south to north the Weil, Windy creek, and Bull orebodies are shown, each below the preceding. If this section were continued it would show, perhaps 1000 ft. further north and considerably lower, the orebodies of the Shasta King mine. Squaw Creek, between the Balaklala and the Shasta King, apparently follows an east-west fault line, and N. R. Bishop of the Balaklala states that nearly every gulch on the surface is indicated underground by a fissure or fracture, though not necessarily a fault, and that near the north and south fissures the orebodies become larger and better.

The ores on the west side of the Sacramento are a mixture of pyrite, sphalerite and chalcopyrite, in which the

[2]Redding Folio No. 138, U. S. Geological Survey.

[3]"Magnetite Ores of Shasta County, California," *Econmic Geology*, III, p. 465, 1908.

[4]"Mineral Resources of the United States," 1906, p. 392.

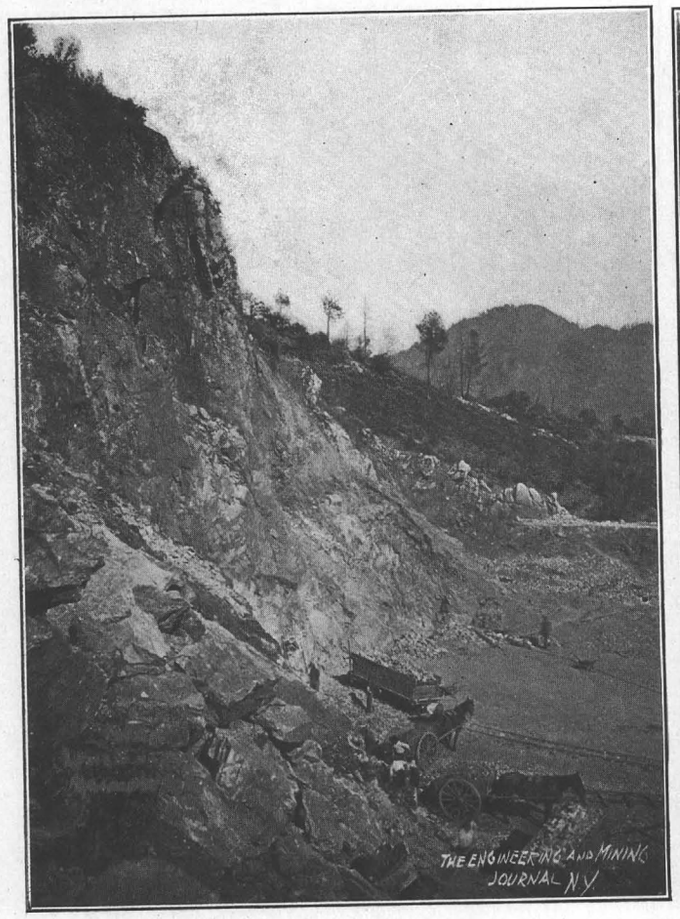
pyrite largely predominates. Some chalcocite and covellite are found and the ore carries varying, but rather small, quantities of gold and silver. It is evidently a replacement of the granite porphyry. In the Mammoth and the Iron Mountain mine of the Mountain Copper Company, this replacement has gone so far that much of the ore mined and sent to the blast furnaces contains as high as 40 per cent. sulphur and only from 5 per cent. to 12 per cent. insoluble silicious residue. The Balaklala also has large bodies of similar ore, though the general average of the ore at this mine is lower in iron and sulphur, and bands of rock high in silica occur.

The orebodies themselves have been compared by A. S. Haskell, the manager of the Mammoth, to a series of overlapping lenses of irregular size and shape, separated by tongues of less mineralized porphyry.

These orebodies are closely associated with well-defined fracture planes having various strikes within the shear zone. They contain from a few, to many thousand, tons of ore. In general the orebodies are roughly tabular in form, with a low dip to the west in the Mammoth and Balaklala. They are commonly bounded by well-defined fissures, frequently marked by a clay gouge, though sometimes the mineralization appears to fade off into the porphyry beyond the fissure bounding the solid ore. As a result of these sharply defined limits it is possible to determine ore reserves with considerable exactness. Thus, James D. Hague, in his report made at the time of the organization of the Mountain Copper Company, said: "The orebody has been developed with unusual thoroughness and its actual dimensions are known beyond doubt." Similarly, the Balaklala company has today one orebody roughly 1000 x 300 x 50 ft. in a block which is perhaps delimited on four sides by fault planes.

Naturally in a region where the temperature reaches 100 deg. in the shade, and the rainfall is 65 in. per annum, such heavy sulphide ores, where exposed, have been oxidized and leached, resulting in large areas of gossan on the surface, and zones of secondary enrichment below. The most prominent of these outcrops is that at the Iron Mountain mine, where the gossan has an extent of several hundred feet. Dr. Graton[6] refers to the zone of secondary enrichment underlying this gossan as having been wonderfully productive of copper and silver at Iron Mountain and Bully hill, but now about exhausted, and practically absent in the other mines. The thickness of the ore deposits west of the Sacramento varies in the different localities. Weed[7] says that the Iron Mountain has been worked to a depth of 600 ft. The present estimate for one point in the Balaklala is less than 50 feet.

These flat orebodies west of the Sacramento lend themselves excellently to prospecting with drills, and one company alone has done many miles of this work. From the fact that some of the managers speak of "acres of ore" it may be pre-



LIME QUARRY, MAMMOTH COPPER MINING COMPANY, KENNETH, CAL.

GRAVITY TRAMWAY, 64 PER CENT. GRADE, MAMMOTH MINE, KENNETT, CAL.

Near the fissure planes the silicification and alteration of the granite porphyry frequently obscures the porphyritic appearance. Even in the sulphides, however, "The presence of crystalline quartzphenocrysts from the rhyolite" may be shown by dissolving the ore.[5] Not all the porphyry within the shear zone has been replaced by sulphides or silica and small patches which have escaped impregnation sometimes occur between seams in the solid sulphide ore.

[5]"The Copper Mines of Shasta County, California." D. F. Campbell, *Min. and Sci. Press*, Jan. 5, 1907, p. 28.

[6]"Mineral Resources of the United States," 1906, p. 393.

[7]"Copper Mines of the World," p. 302.

sumed that this drilling has not been unsatisfactory.

Bully Hill District

East of the Sacramento river the orebodies have more of the nature of veins and are nearly vertical. I did not visit the Afterthought district, but understand the occurrence there is similar to that at the Bully hill, with perhaps more zinc. In the Bully hill district the ore occurs in a shear zone on a contact of the granite porphyry with a later basaltic rock, and in parallel shear zones, in both the basalt and the granite porphyry, but more especially in the basalt. The latter orebodies are of higher grade, and also carry silver, which is absent in the orebodies in the porphyry. Pyrite, which is so prominent west of the Sacramento, is less noticeable here.

The copper occurs not only as chalcopyrite but also as bornite and chalcocite, mixed with a large amount of sphalerite and some galena. More or less barite occurs, which carries up to three ounces of gold. Native silver is also found occasionally in the barite, and the galena carries both gold and silver. No gold is found with the blende. From the above it may readily be seen that east of the Sacramento, there is no definite ratio of gold and silver content to copper. Apparently secondary enrichment has played a much more important part here than west of the Sacramento, and the high-grade ores continue to greater depths. Compared with the western area the orebodies are much smaller. I should say 25 ft. was the thickest orebody I saw.

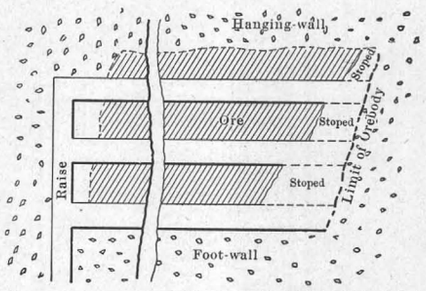
Genesis of Orebodies of Shasta County

The genesis of the Shasta county orebodies has been discussed by William Forstner[8], who reasons that since "No intrusives have been ascertained in the Balaklala rhyolite, the copper in the solution must then either have been derived from underlying formations, or have been leached out of the rhyolite." In view of the presence of basic intrusives in the Bully hill area he offers the hypothesis that a magmatic differentiation has taken place, and the basic material, intruded in the Bully hill porphyry, but perhaps underlying the Balaklala porphyry, has supplied the copper to the ascending solutions. I believe recent investigations have indicated the presence of later dikes in the Balaklala area, and as a detailed examination of this district is now being made by the U. S. Geological Survey we may expect to have a more complete statement of the geological conditions.

According to the Government report[9] the production of Shasta county for 1907, during which year the Balaklala and Bully hill smelteries were not in operation, included 288,578 tons of copper ores which yielded 23,457,417 lb. of copper, or an average of 4.06 per cent. These ores are also credited with 13,208 oz. of gold and 518,791 oz. of silver, or an average of 0.045 oz. gold and 1.7 oz. silver per ton, but this includes the precious metals derived from the silicious fluxes.

The Iron Mountain Mine

The oldest of the large copper mines is the Iron Mountain mine which is now owned by the Mountain Copper Company. It was exploited in 1880 as a large silver mine and in 1884 was equipped with 20 stamps and a pan mill for amalgamating the gold and silver contained in the gossan. Since 1895 it has been owned by English interests and worked for copper. The early reports show that the ore below the gossan averaged about 7 per cent. In 1907, according to D. F. Campbell[10], the ore averaged 6 per cent. copper, $1 in gold, 1½ oz. silver, and 48 per cent. sulphur. The original orebody as reported by Hague is now pretty well worked out. The company, however, owns much additional ground and has several million tons developed in the Hornet claim. While this ore does not average as well in copper as that in the Iron Mountain, it is high in sulphur. The mines are opened by tunnels from which an electric road delivers the ore to the bins above the narrow-gage steam road owned by the company and connecting with the Southern Pacific.



The Engineering & Mining Journal, N.Y.

PROPOSED METHOD OF MINING AT BALAKLALA MINE

Mr. Campbell describes the method of mining[11] as a slicing system in which the mine is divided into pillars 50 ft. square. These pillars are robbed by horizontal slices one set wide, 10 ft. thick, and the openings are timbered and filled, no opening more than two sets wide being allowed to exist at one time. To lessen the danger of damage by fire from which the mine has suffered in the past, a pillar is left standing across the entire orebody, separating the two end stopes. The cost of mining is said to be $1.50 per ton.

Smelteries of the Mountain Copper Company

The Mountain Copper Company owns two smelting plants, one near the mines at Keswick, and one at Martinez on San Francisco bay, built after litigation on account of fumes had closed the Keswick plant. Recently the litigation has been settled and it is announced that the Keswick plant may be started again. When I first visited this district nine years ago the ore was roasted in heaps and smelted in cupolas. Subsequently pyritic smelting with the use of a hot blast, from stoves heated with oil, was developed. The ore reserves now contain less copper than the ores formerly worked, and the resourceful management, which has successfully fought strikes, fires and litigation, has developed a scheme for utilizing the high sulphur content in making sulphuric acid and fertilizers. The ore is roasted in furnaces of the MacDougal type. The matte is converted and the copper refined at the Martinez plant. A foundry is operated at Keswick, which also makes castings for neighboring mines.

Balaklala Consolidated Copper Company

The Balaklala group, situated about four miles northeast of the property of the Mountain Copper Company, comprises 1150 acres, besides a smelter site, the townsite of Coram and the tramway right of way. The property is operated by the Balaklala Consolidated Copper Company, the stock of which is owned by the First National company. The first discovery of ore was made where the sulphides outcrop in the creek, and there is little gossan here. Another similar outcrop is now being developed on a creek further east. The property has been prospected with drills, and is opened by a number of tunnels, which have exposed four orebodies, or portions of the same orebody separated by faulting. In one place a block of ore has apparently been thrown downward below the ore on the south, east and west sides. The greatest thickness of these orebodies is about 60 ft. Plans and sections are shown in the 1908 report.[12]

The reports of the company show something over one million tons of ore averaging 2½ per cent. copper, 50c. in gold, and 0.8 oz. silver, actually blocked out, with much more than this indicated

[8] *Min. and Sci. Press*, May 18, 1907, p. 625, "Copper in Shasta County, Cal.," and Aug. 22, 1908, p. 261, "The Genesis of the Copper Ores in Shasta County, West of the Sacramento River."

[9] "Mineral Resources of the United States," Part I, 1907, p. 222.

[10] *Min. and Sci. Press*, Jan. 5, 1907, p. 28.

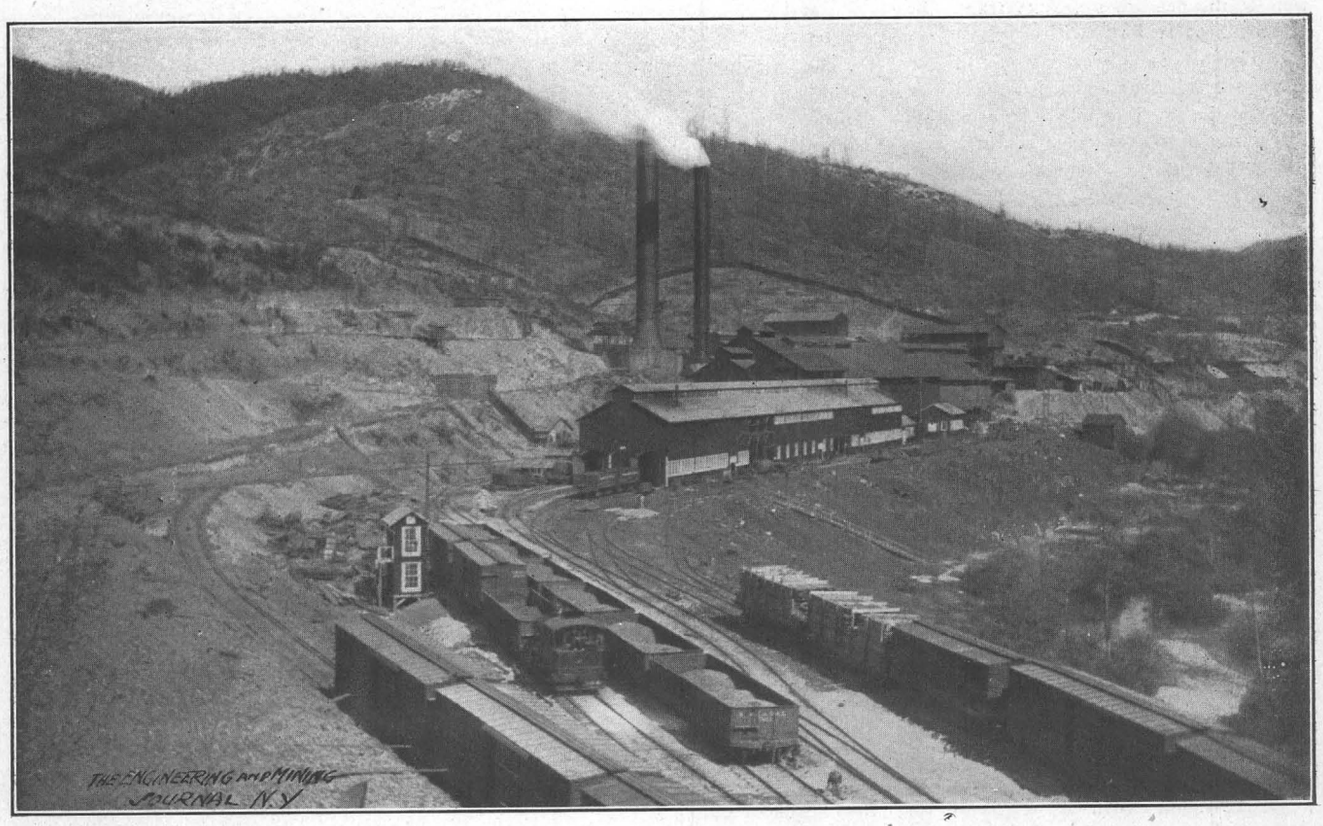
[11] *Min. and Sci. Press*, Jan. 12, 1907, p. 55.

[12] Eng. and Min. Jour., Mar. 6, 1909, p. 501.

from prospecting already done, and a considerable area not tested. The Balaklala ore differs from the ore of the Mountain Copper and Mammoth companies in that it averages nearly 30 per cent. silica. As the mine has large bodies of both high iron and high silica ores, it should be possible to secure any desired smelting mixture without purchasing fluxes other than lime. The upper orebody is quarried on the surface and delivered to the Weil tunnel, as is also the ore mined through the Windy Camp tunnel, connection having been made through a 240 ft. raise. The Weil tunnel is the main working tunnel, and from it the ore is delivered to the mine ore bins by five-car trains drawn by electric locomotives. The Bull orebody lies below the level of the Weil tunnel.

At the time of my visit mining operations had not progressed sufficiently to permit an inspection of the mining method which is proposed, as all of the ore at that time came from preparatory work. Manager Bishop has run tunnels below the orebodies, upraising at intervals in the country rock near the edge of the orebody, and from these raises he proposes driving a series of drifts, one about 15 ft. above the other, across the orebody to its farthest limit, the number of drifts depending on the thickness of the deposit. A modified slicing system of mining will then be used, the ore being mined back from the face a little faster in each drift than in the one above, as shown in an accompanying sketch.

At the same time the ore will be cut out on each side until connections are made with the slice being removed from the next series of drifts. All ore will be trammed through the lowest drift. The ore and the roof are both hard and stand well. The ore is delivered from the mine bins to the smelter by a wire-rope tramway, built in two sections and having a 1½-in. cable for loaded and 1¼-in. for returning buckets, with a 1-in. traction rope. The buckets hold 1500 lb. and as the grade is heavy great care is necessary in controlling the speed. Ultimately it is hoped to operate at 500 ft. per min. The length is about three miles.



MAMMOTH SMELTERY, KENNETT, CAL.

The Smeltery

The Balaklala smeltery, at Coram, on the Southern Pacific railroad, was described in the Journal of March 6, 1909. Briefly, it consists of four MacDougal roasters, three blast furnaces, one reverberatory and two converter stands. Up to January but a small portion of the plant had been put in commission, only one furnace being in operation most of the time. The ore treated in 1908 amounted to 15,960 tons, from the Balaklala mine, having an average content of 2.53 per cent. copper, 0.016 oz. gold and 0.71 oz. silver.

The Balaklala smeltery also receives the ore from the Shasta King mine of the Trinity Copper Company, adjoining this property on the north. The Shasta King is opened up by tunnels several hundred feet below the level of the Balaklala, and on the opposite side of Squaw creek. The ore is hoisted up an incline track 850 ft. long, and with nearly 45 deg. slope, to bins beside the mine ore bins of the Balaklala, from which it is delivered to the smeltery over the Balaklala tramway. At the time of my visit 200 tons per day were being treated. The Balaklala report shows that 7286 tons of this ore treated in 1908 averaged 2.78 per cent. copper, 0.032 oz. gold and 1.02 oz. silver per ton, which is about $1.10 better than the Balaklala average for the same period.

Mammoth Copper Mining Company

The Mammoth Copper Mining Company is a subsidiary company of the United States Smelting, Refining and Mining Company. Its mining property, over 1000 acres, lies about three miles northeast of the Balaklala. The workings from which ore has been mined extend vertically to a depth of about 190 ft. from the surface. The ore now being mined does not come from below a gossan outcrop of prominence, and there is little secondary enrichment. It averages about 4½ per cent. copper, 80c. gold and 2 oz. silver, or 2c. in precious metals for each pound of copper. It contains up to 12 per

cent. insoluble, about 40 per cent. sulphur, and an average of 4 per cent. zinc.

The ore is mined by a slicing and caving system. An interesting method of firing the caving holes by electricity, using a current in parallel, has been developed so that 400 holes may be fired together satisfactorily; though at present the roof is caved twice a week and a smaller number of holes required. Formerly this was done by hand, and 70 to 80 men used. Four hundred men are employed in the mine and a product of three tons per man per day obtained. The mine is operated through tunnels, all of the ore being delivered to the lowest, from which it is hauled over an electric road about one mile to the head of a gravity tram. This tram is 4500 ft. long, with a drop of 1500 ft. The ore is delivered to a standard-gage railroad, over which it is hauled two miles to the smeltery bins. Fines amounting to about 100 tons per day, and carrying over 40 per cent. sulphur, are screened out and shipped to the Peyton Chemical Company, where they are used for acid making and the residue smelted.

Mammoth Smeltery

The Mammoth smeltery is situated at Kennett. A complete description has been given by the manager, A. S. Haskell.[13] There are five blast furnaces, each 180 in. long. Three are 50 in., one is 53, and one 56 in. wide, all having been increased from the original width of 42 in. The increase to 56 in. gave an additional capacity of nearly 20 per cent., somewhat below the percentage increase in width. There are 16 tuyeres on the front, and 18 on the back, each 3¾ in. in diameter. A cold blast with 42 oz. pressure is used, and coke equal to about 4 per cent. of the charge. Coke is bought from Washington, Utah, Australia, Scotland, Germany and rarely from Pennsylvania, the place depending on the market conditions.

The ore is too zinky to permit of smelting with hot blast and practically no coke, as was formerly done at the Mountain Copper Company plant. The furnaces formerly had brick tops which gave much trouble on account of zinc incrustations, but water-jacketed tops have now been adopted and the difficulty has disappeared. The furnaces are run with a 9-ft. ore column and rather hot top. One furnace was being rebuilt at the time of my visit; the other four were handling 1000 tons of raw sulphide ore per day, two running on raw ore alone, making low-grade matte, and two running on raw ore and low-grade matte, making a converter matte.

The first matte runs from 20 per cent. to 25 per cent. copper and the second from 35 per cent. to 40 per cent. The slag carries 42 to 46 per cent. FeO, 35 to 40 per cent. SiO_2, and 8 to 12 per cent. CaO. There are two converter stands. The fluedust and fines are briquetted, no reverberatory being used. The ore received at the smeltery includes coarse ore, and some fines, from the company's mines, silicious gold ore from Quartz Hill, some custom ores, and the Bully Hill matte. The custom ores sometimes include ores from Nevada and Utah. The company has a lease on the Quartz Hill, a big low-grade gold quartz mine, and has built a narrow-gage railroad connecting it with the Southern Pacific. Lime is bought from the Holt and Gregg lime quarry although the company has purchased lime lands of its own.

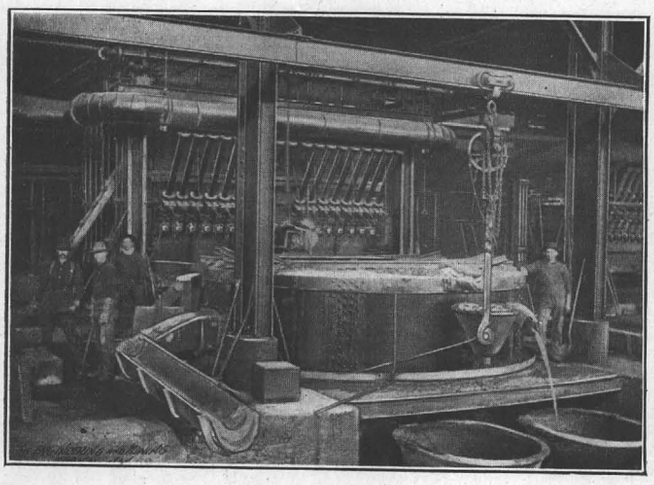
Bully Hill Copper Mining and Smelting Company

The property of the Bully Hill Copper Mining and Smelting Company is situated in the porphyry area east of the Sacramento river, and about 14 miles east of the Mammoth. It comprises over 200 acres, and includes the Bully Hill, Rising Star and Copper City mines. In January there was little doing at the last property. These orebodies being nearly vertical offer less opportunity for exploitation by drilling than do the flat bodies west of the Sacramento, but there are fair reserves in the former two properties.

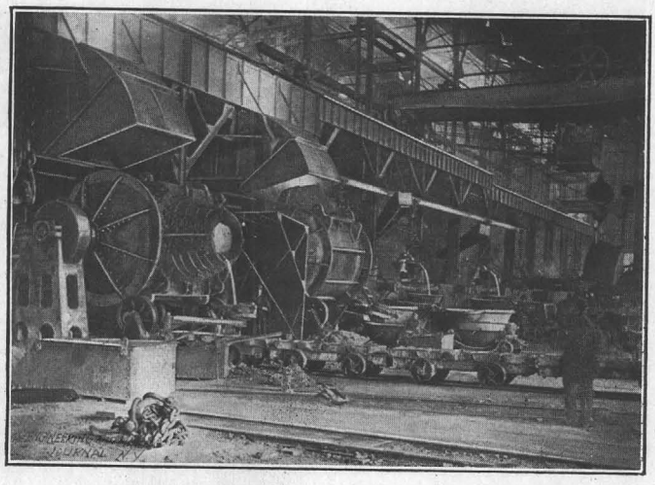
The gulches below these properties were productive placers in the '50s and later a stamp mill was erected in which the surface ores were treated. J. R. DeLamar bought the property in 1899 and equipped it with a smelting plant. Later he turned it over to the General Electric people. By them it was developed until the ore in sight justified the construction of a railroad 15 miles long, connecting with the Southern Pacific. During the construction, for a period of two years, the property was practically closed down.

The Bully Hill mine has a shaft down to a depth of 970 ft., and the Rising Star to 800 ft. below the surface. Both are equipped with electrical hoists having a capacity of 1000 tons per day. The pump at the Bully Hill, a quintuplex with brass parts, pumping through a lead-lined iron pipe, was operating in January from two to four hours per shift, or about nine hours per day, equivalent to 20 gal. per min. In summer there is little water to pump. Copper is precipitated from the mine water here, and also at some other mines of the district.

The orebodies appear to be lens shaped, and arranged somewhat like the steps of a step ladder. At the surface there is not a large amount of gossan, and this is much more silicious than at the Iron Mountain. Secondary enrichment, however, has resulted in higher-grade ores than west of the Sacramento, and copper, gold and silver ore aggregating $100 per ton is sometimes encountered. At the lowest level of the Bully Hill, 970 ft. down, is a stope 20 ft. wide showing much chalcocite and high in silver. The



NO. 4 FURNACE, MAMMOTH SMELTERY, KENNETT, CAL.



CONVERTER POURING COPPER; PART OF MAMMOTH SMELTERY

[13] "Copper Smelting at Mammoth Plant," *Mines and Minerals*, March, 1908, p. 392.

appearance of the ore, with the excess of zinc, lead and dark copper sulphides, is widely different from that west of the Sacramento.

By prospecting along the shear zone, new orebodies, which do not reach the surface, are encountered. These zones are much crushed and the mine is timbered with 10x10-in. square sets which are promptly filled with waste. Samples are taken at close intervals and much sorting is done, the rock too low to pay being left underground. The mine openings are irregular. As a result of the heavy ground and the handling of the ore the mining costs must be large. The Bully Hill was producing somewhat less, and the Rising Star somewhat more, than two tons per man employed underground, but more development was being done at the Bully Hill. On account of the long period of inactivity, conditions underground are undoubtedly worse at present than they will be later.

Ore Handling and Smelting

At the Bully Hill the ore is hoisted to the 320-ft. level and trammed through a tunnel 1000 ft. long to bins from which, and from the Rising Star, it is hauled over a narrow-gage road to the smelter bins. The Copper City mine is on the new broad-gage railroad. The fines are screened out and go to two MacDougal roasters, each handling 30 tons per day. They are provided with oil jets which are used occasionally from one half to one hour when roasting ore from the Bully Hill mine. That from the Rising Star contains more sulphur. The roasted fines and the flue dust go to a reverberatory 16x35 ft. A five-ton charge, mixed with lime when necessary, is delivered from two hoppers every two hours. Three oil jets connected with ½-in. oil, and ½-in. steam pipes supply fuel.

It is found that the sides of the furnace are cut out more rapidly by the slag when oil fuel is used than was the case with coal. The gases from the reverberatory go to a U-type stove in which the air for the blast furnace is heated. The blast furnace is 42x200 in. with 15 tuyeres on each side. To permit varying the air supply these are made 5 in. in diameter and bushed down. Formerly a 3½-in. opening was used, but this has been increased to 4 in. The blast pressure is 35 oz. and the hight of the ore column 8 ft. The furnace smelts about 350 tons of ore per day.

In January hand feeding had temporarily replaced the dumping of cars directly into the furnace. As a result it was necessary to run down and bar off crusts only once in three or four shifts, in place of barring down once each shift as in the past. The ore contains much zinc and at times the crusts have nearly closed the furnace, while with the new method they are small. The furnace top is an air-cooled jacket.

The ore carries an average of 20 per cent. sulphur, 23 per cent. silica and 4 per cent. copper. Manager Keating states that charges have been run containing as high as 27 per cent. BaO and 12 per cent. Al_2O_3 or 16 per cent. Zn. Iron gossan bought from the Mountain Copper Company is occasionally added. A common slag carries 36 per cent. SiO_2, 21 per cent. FeO, 9 per cent. CaO, 8 per cent. BaO, 12 per cent. Al_2O_3, and 8 per cent. Zn. The matte, which carries about 37 per cent. copper, goes to the Mammoth smeltery for converting. The management is certainly entitled to credit for solving such a difficult smelting problem as this ore furnishes.

Costs

The cost of living in Shasta county is lower than in many mining camps of the West, and underground labor is generally paid about 25c. per day less than in Montana and Colorado camps. The mines have the advantage of comparatively cheap power, and in many cases of mining through tunnels. Coke is not the best and is more expensive than in some districts, but it forms an unusually small percentage of the charge.

The Balaklala is the only one of these properties publishing costs, and this company has not yet reached a point where conditions are normal. For the short time in operation in 1908 the figures are $2.424 for mining, $0.304 for tramming, and $2.924 for smelting. They expect to mine at a cost of $2 per ton, to reduce to matte for $2.50 per ton of ore smelted, and to convert at 0.75c. per pound of copper. Accepting these figures, and adding 15c. for delivering the ore from mine to smelter, if the Balaklala ore yields 50 lb. of copper to the ton, we have a cost of 4.3c. per lb. of copper for mining and ore transportation, and 5.75c. for smelting and converting, or a total of 10.05c. per lb. of copper converted. To this must be added the cost of freight, refining and marketing. This can hardly be less than 2c. per lb. Crediting the copper with the value of the precious metals in the ore, about 1.75c. per lb. of copper, the cost of Balaklala copper will approximate 10.25c. per pound.

At the Mammoth the mining cost, including exploration, development and administration, is $1.65, and transportation of ore to the smelter costs 20c., or a total of $1.85 per ton. With a recovery of 80 lb. of copper per ton, this gives a cost of 2.3c. per lb., or a decrease of 2c. per lb., as compared with Balaklala, on mining and transportation alone. As the ore carries precious metals exceeding 2c. per lb. of copper, as compared with 1.75c. for Balaklala, an additional credit of 0.25c. per lb. is obtainable here; so that assuming other costs to be the same as Balaklala's, Mammoth copper would cost 8c. per lb. With its excellent management of longer experience, its ore of higher grade, its leased gold quartz mine and the connection with other large enterprises, Mammoth doubtless does better than this.

Bully Hill, with its complex ores and smaller production, must have higher costs, but these are perhaps offset by the higher content of gold and silver in the ore. The Mountain Copper Company, with the manufacture of acid and fertilizer, has become an industrial concern, no longer dependent upon the price of copper for its profits.

The Oak Creek section of the Yampa coalfield, on the Moffat road, in Colorado, has now four shipping mines: the Oak Hills company, fully equipped, preparatory to a 2000-ton per diem production; the James seam of the Prentice company, and the MacKinlay mine adjoining, both extensively opened but not yet fully equipped as to surface improvements; and the Juniper company, F. A. Craise, manager, also undergoing extensive underground development. This Routt county coal is being supplied to the Moffat road for locomotives, and is also for sale in Denver for domestic use, coming into competition with northern and southern coals, an important feature in the fuel supply of the inhabitants of Denver, and the State generally.

High prices for charcoal iron about 40 years ago are shown in an extract from the books of Jefferson furnace in the Hanging Rock district of Ohio, given by the Cleveland *Iron Trade Review*. These prices for 16 years were as follows:

Year.	Low.	High.	Year.	Low.	High.
1860....	$27.00	$32.00	1868...	$54.00	$57.00
1861....	24.00	32.00	1869...	54.00	61.00
1862....	27.00	31.50	1870...	52.00	56.00
1863....	31.00	52.00	1871...	50.00	58.00
1864....	52.00	75.00	1872...	58.00	60.00
1865....	57.00	85.00	1873...	57.00	60.00
1866....	61.50	68.00	1874...	53.00	61.00
1867....	57.00	64.00	1875...	.....	50.00

It must be remembered that these prices were in currency, in a period when gold was at a premium varying from 25 to over 100 per cent.

An article by Henry E. Birkenbine in the Cleveland *Iron Trade Review* calls attention to the fact, which few people now recall, that for over 30 years—1839 to 1873—iron was produced in the southern part of Illinois. At that time two blast furnaces were active in Hardin county, Ill., producing pig iron from local ores smelted with charcoal, and the ruins of these plants are still in existence. The ores used were carbonates and brown hematites which were found in a coal-bearing area.

The Treatment of Steel in Electric Furnaces

Superiority of Electric Furnaces Largely Due to Freedom of Product from Oxide, Suspended Slag and Perhaps Hydrogen and Nitrogen

BY HENRY M. HOWE*

In an admirable article in the *Revue de Metallurgie*,[1] C. Clausel de Coussergues describes and discusses at great length and in a most interesting way the treatment of steel in electric furnaces. In taking his paper as a peg whereon to hang a sermon my purpose is not so much to compare the various electric furnaces as to consider with him the bearing of the phenomena noted in these furnaces on our general ideas about the purification of iron, i.e., the removal of carbon, phosphorus, and sulphur, whether in the bessemer converter or the open hearth or electric furnace. In beginning, it may be well to point out that the processes carried out in these electric furnaces are not really electric processes. Electricity is used in them solely as a source of heat, and the purification is brought about by the same old means to the use of which in the puddling, bessemer, open-hearth, and blast-furnace processes we have so long been accustomed. That is to say, carbon, silicon, and phosphorus are removed chiefly by oxidizing them to carbonic oxide, silica, and phosphoric acid, by means of iron oxide either formed in the process itself with atmospheric oxygen, as in both the bessemer and open-hearth processes, or added in the form of iron ore as in the open-hearth and puddling processes. The sulphur is removed in part as sulphide of manganese, which distributes itself between metal and slag, quite as in the puddling, basic bessemer, and basic open-hearth processes, and partly as sulphide of calcium which passes apparently wholly into the slag, quite as in the blast furnace.

But though electricity is here used solely as a source of heat, it has the great advantage over other sources of heat that it can supply its heat without simultaneously introducing oxygen. In the bessemer process the blast which generates the heat acts essentially through introducing vast quantities of oxygen. The flame which supplies the heat to the puddling and open-hearth processes brings with it much oxygen, and even when it is called reducing it is in fact violently oxidizing to iron and most of the non-ferrous elements which it contains. In the last analysis this freedom from oxygen seems to be the chief if not the only thing that gives the electric furnaces their advantage over others, as we shall see later.

The obstacle to the wide use of electric furnaces in iron metallurgy is the great cost of the electricity itself. It is true that these furnaces do their work of heating and melting much more cheaply than the crucible furnace does, but still they do it much less cheaply than the blast furnace, the cupola furnace, the bessemer converter, or the open-hearth furnace, and this will be the case in general until the exhaustion of our coalfields shall have greatly increased the cost of coal. In cases where power is to be had at a small cost, for instance, near the coke ovens of great metallurgical works, it may indeed be possible to heat and melt with electricity more cheaply than with coal; but even in these cases it will probably be more profitable to use the power as a basis for some other industry, and to continue to use the blast furnace, cupola, converter, and open-hearth furnace for decades if not for generations to come.

That so costly a thing as electricity should compete with so cheap and efficient a thing as the iron blast furnace for the smelting of iron ores seems hardly to be on the cards. It might have been possible 50 years ago, before coke could be carried so cheaply to almost every place where it is needed; but it is hard to think of conditions such as to make it cheaper today to use current than coke. In places so remote and inaccessible that coke cannot be brought to them, one fears that this very inaccessibility and costliness of inward freight must imply such corresponding costliness of outward freight that the iron smelted from ore by means of electricity cannot be exported with profit.

Thus the natural work of the electric furnace is to replace the crucible furnace and to supplement the work of the converter and open-hearth furnace.

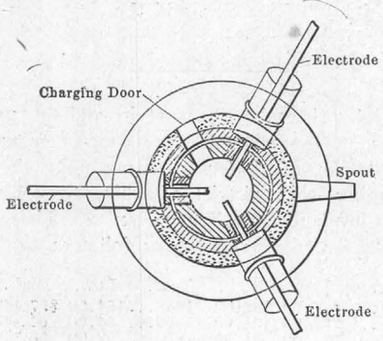


FIG. 1

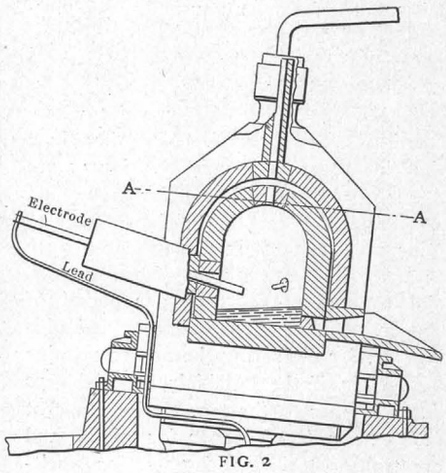


FIG. 2

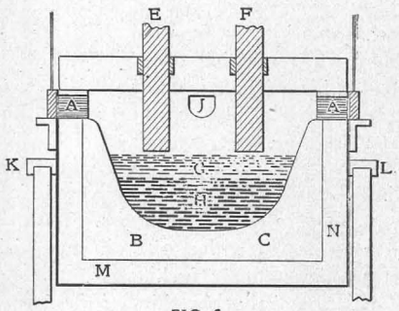


FIG. 3

The Engineering & Mining Journal, N. Y.

FIG. 1. TRANSVERSE SECTION A-A

FIG. 2. STASSANO FURNACE

FIG. 3. HEROULT DOUBLE ARC FURNACE

A A, working doors. *B C*, magnesite bottom. *E*, entering electrode. *F*, exit electrode. *G*, molten slag. *H*, molten metal. *J*, pouring spout. *K L*, trunnions. *M N*, outer brickwork.

What the Electric Furnaces Are

Electric furnaces may be regarded as large internally heated crucibles, or, if I may use the hibernianism, as closed open-hearth furnaces with the flame replaced

*Professor of metallurgy in Columbia University.

[1]VI, June, 1909, p. 589.

G.S.A. Berkeley
Aug. '39.

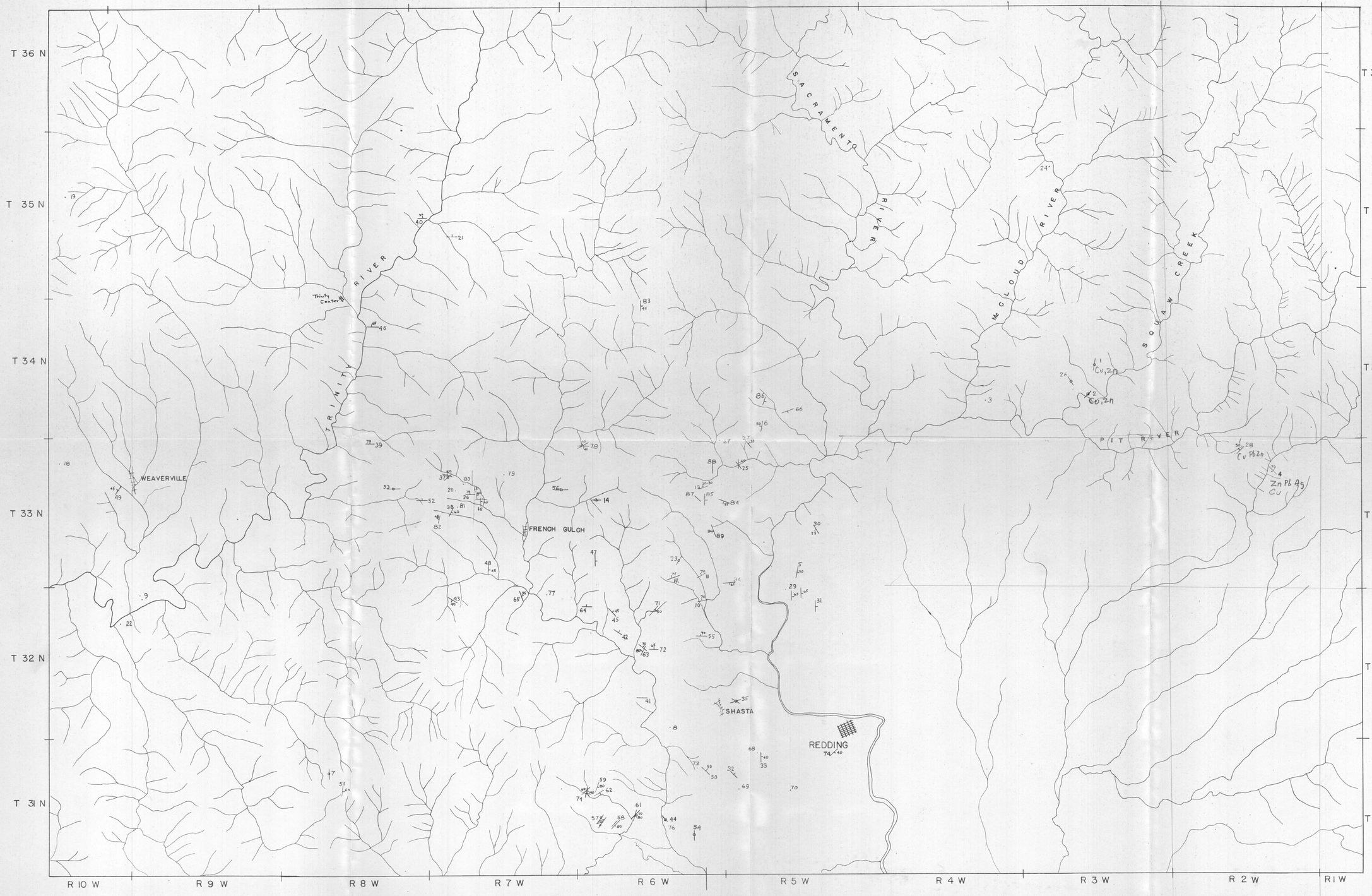
AGE OF THE DEKKAS-BULLY HILL VOLCANICS OF THE KLAMATH MOUNTAINS

BY HARRY E. WHEELER *

The Dekkas andesite and Bully Hill rhyolite of supposed Triassic age overlie the Permian Nosoni formation in the southern Klamath Mountains and are overlain by the Middle? Triassic Pitt shale.

The discovery of an unconformity between the volcanic and Pitt sequences involving, in places, the complete removal of the Bully Hill rhyolite, together with the development of thick basal Pitt conglomerates, and the absence of lava above the unconformity, suggests a post-Bully Hill and pre-Pitt erosion interval of appreciable duration. In addition, the remarkable similarity of these relationships to those in the Humboldt Range of northwestern Nevada and in the northern Sierra Nevada, where the volcanics are of known Permian age, forces the conclusion that these Klamath Mountain effusives and pyroclastics should also be assigned to the Permian.

MINES OF THE REDDING AND WEAVERVILLE QUADRANGLES



1 BULLY HILL Cu, Zn
2 COPPER CITY Cu, Zn
3 HEROULT Fe
4 AFTERTHOUGHT Cu, Zn
5 TEXAS CONSOLIDATED Au
6 MAMMOTH Cu, Zn
7 BULLY CHOOP Au
8 MT. SHASTA Au
9 UNION HILL
10 MINNESOTA Cu
11 LITTLE NELLY Cu
12 IRON MOUNTAIN Cu
13 BALLAKLALA Cu
14 GLADSTONE Au
15 MILKMAID Au
16 WASHINGTON Au
17 BRUNSWICK Au
18 LA GRANGE (PLACER)
19 GLOBE Au
20 NIAGARA Au
21 FIVE PINES Au
22 Au
23 HORNET Pyrite
24 HIRZ MTN. Fe
25 AKERS GROUP Cu
26 ARPS GROUP Cu
27 FRIDAY-LOWDEN Cu
28 WOODROW WILSON Cu (SUGARLOAF) Pb, Zn
29 CENTRAL Au
30 GOLD BAR Au
31 REID (WALKER) Au
32 BOSWELL (GOLDEN CHARIOT) Au
33 BUENA VISTA Au
34 MENZEL Au
35 MTN. QUEEN Au
36 FRANKLIN Au
37 SYBIL Au
38 SUMMIT Cu
39 PAYMASTER Au
40 LA CLAIR Au
41 KANAKA Au
42 ISOBEL & QUEEN Au
43 GREENHORN Cu
44 GREAT WESTERN Au
45 GANIM Au
46 FAIRVIEW Au
47 EVENING STAR Au
48 DOUBLE HEADER Au
49 DEMOCRAT GROUP Au
50 CROWN POINT & MIDNIGHT Au
51 CLEVELAND Au
52 CALMICH Au
53 BROWN BEAR Au
54 BROKEN HILLS Au
55 BENSON Au
56 AMERICAN Au
57 SILVER FALLS & CHICAGO Ag
58 WHITE STAR GROUP Au, Ag
59 MANZANITA GROUP Au
60 CONTINENTAL Ag
61 CLIMAX Au, Ag
62 BIG DIKE Ag
63 WEST END Au
64 INDEX GROUP Au
65 EL DORADO Au
66 BACKBONE (GOLINSKY) Cu
67 UNCLE SAM Au
68 BLACK DIAMOND Cu
69 RICHSTRIKE Au
70 HORSTMAN Au
71 DESMOND Au
72 PHOENIX Au
73 HALL BROS. Au
74 BALLOU Au
75 BLUE GRAVEL Au
76 POTOSI Au
77 MERRY MTN. Au
78 BJORK Au
79 HIGHLAND Au
80 NIAGARA SUMMIT Au
81 TOM GREEN Au
82 MINERS GROUP Au
83 CATES Au
84 SPREAD EAGLE Cu
85 KEYSTONE Cu
86 SUTRO Cu
87 STOWELL Cu
88 SHASTA KING Cu
89 KING COPPER GROUP Cu

1" = 2 mi.

Shasta
&
Trinity Cos.