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GEOLOGY AND MANGANESE DEPOSITS OF NORTHEASTERN TENNESSEE.

P.B.King, H.W.Ferguson, L.C.Craig, Jno.Rodgers.
Tenn.Division of Geology Bull.52,1944.

Bumpass Cove 4 mi.WNW of Efwin (7 mi.by road), 15 mi.SW of Johnson City (19 mi.by rd.). Cove a synclinal valley, creek flows east to Nolichucky River. 4 mi.long by 1 mi.max.

History: Fe mined Civil War & before.1892 English co.bult 150-ton blast furnace. Various owners until 1903,Embree iron co.mined iron,1904-9. Fe mining NG,1909;1912 rich ox.Zn ores found,company started mining them, 1913. Pb conc.started 1918.Mn found shortly after 1900;1934-8,Mn hand mined UG.1938,started open cut mining,E Baptist Hollow.

1913-1942,211,043 short tons Zn conc.average 40% Zn.

GEOLOGY AND MINERAL DEPOSITS OF BUMPASS COVE, UNICOI & WASHINGTON COS.,T.

John Rodgers. Tenn.Div.Geol.Bull.54, 1948.

Weathering of Shady Dolomite: By solution,end product a yellow to brown clay,mainly waxy,structureless.

Structure: Gentle trough,axis along Creek,pitches gently NE. SE part of trough thrust-faulted. S flank of trough showx minor folds in dolo. Two of these near No.14;traced by subsurface data NE past Fowler,and may berepresented by a sharp flexure near center of Jackson mine. Main Zn sulphides lies near these folds.

Sulphides: ZnS,PbS,py.disseminated in Shady Dolo. Possibly commercial deposits restricted to a belt from Jackson to Dry Branch. This belt follows axes of two folded mentioned. Erratic distribution;where rock brecciated and carries sparry dolo.,an accompaniment of the brecciation.

Oxide Ores: Calamine and cerussite restricted to limited portions of the residual clay,forming distinct OBs with fairly sharp contacts against barren clay;these OBs sporadic,irregular. Given OBs contain calamine only or cerussite only (Peach Orchard),can be mined separately;but bodiez of both kinds of ore occur also. Most Zn OBs lie plastered against the sides or tops of ls.pinnacles or in hollows or pockets between them. Locally the weathered crust of the dolomite has enough calamine to make ore; here smithssonite may accompany. Pb Obs occur a little higher in the clay & do not hug the pinnaclez;but they also are mainly in the lower part of the residual clay blanket,

Assays of oxidized ore were a ways made on washed samples Actual Zn content before washing might run 10-15%.P.35:"The finer particles(of calamine and cerussite) are som imtimately mixed with the clay that they are not recovred by the milling methods, but are washed out with the clay into tailing ponds."

Zinc OBs in belt from No.10 mine to Peach Orchard and Lick Log.In E part of this belt mines were Fe with Zn as impurity,but from Fowler SW, primari;y Zn;Peach Orchard most productive mine. Some Pb in Jacksom and W Fowler,but most comes from P.O.

Oxide OBs restricted to clay underlying remnants of the lower terraces in the valley;terrcaes represent periods of aggradtion,not cuttin

While oxide belt corresponds in part(central part of oxide belt) with sulphide belt and its associated folding,and while similar structural control higher up in dolo.,now removed by erosion is probable,oxidation did not take place in situ. Pb,Zn now largely separated,Zn travelled farther;Zn oxides against barren pinnacles. Hence circulating water not only ~~dixxxxxxd~~ oxidized the sulphs but it dossolved them and carried them downwards,redepositing them near water table. Calamine boxwork in clay resembles that in weathered dolo crust;much of the Zn was deposited in weathered crust;as wezthering of latter proceeded OBs closely parallel to retreating surface of dolomite were built up in the clay adjacent to the dolo. Under present erosion cycle water table has fallen continuously;oxidized bodies stranded above it have been repeatedly dissolved and redposited at lower levels. Hence rich Peach Orchard deposits result from concentration,into a small body of clay,of the zinc and lead from great volumes of sulphide-dolo now eroded.

Fowler #14

Mn Belt: Polly Hollow to and past Lick Log. Hence at SW end of cove Mn belt intersects Zn belt;

West Ore Bank gave over half production. Mn ore higher in clay than Pb, Zn.

Production:Zn conc.,ave.40%, 1913 thru 1946:213,276 short tons. Pb conc.,ave.60%, 1917 thru 1946: 29,652 short tons. Mn conc..metallurgical,long tons,ave.38%,Mn 1935 thru 1944:25,718. Chemical grade,ave. 74.5% MnO2,3858 short tons.

2400 churn drill holes. I secured data on over 1500.

p.49: Zinc slimes aggregate only 15,000T ave.13% Zn.

p.50:Where drill records indivate available Zn ore,most of it latter removed;exception high-iron bodies.However,fine friable ore NG for log washer.Big Moccasin a case of this;mine abandoned before all ore outlined by drilling had been mined.p.51:"..a considerable body of such ore probably remains in that area. Elsewhere in the cove,however,most of the clay containing appreciable quantities of finely disseminated zinc silicate also contained hard lumps and the greater part of it was mined for the hard lumps,the finely divided particles being washed into the tailing ponds."

Size of Zn OBs mined has steadily decreased. 1st period of Zn mining, 1913-1922,big Fowler,No.14 and Peach Orchard mined.1922-1926,outlying OBs in same areas mined.1927-1931,new mines,smaller Obs.After 1931,older mine reopened but only small,hitherto overlooked OBs mined. 1942,1943,still smaller pockets mined;Lick Log shaft bodies not previously mined because of mining difficulties. 1942,prospectingshowed Zn,Pb Obs under valley flo floor beyween P.O.and Lick Log shaft;further work here warranted.

Zn Conc

Peach Orchard Loading

P.O. loading production

1913	907
14	4874
15	8633
16	20273
17	30438
18	17959
19	19098
20	14558
21	10303
22	7842
23	16816
24	9337
25	14520
26	5706
27	48
28	2018
29	4439
30	4685
31	3746
32	1574
33	1099
34	3361
35	2021
36	715
37	2445
38	273
39	428
40	985
41	996
42	891
43	890
44	—
45	399
46	960

15
3

<u>No.14 and Extension:</u> Ox.Zn ore mined from opencuts,bgginning 1914;at s same time deeper ore found by drilling,3 adits driven;1914-18 and again, 1922-1924 ore mined by a complicated system of UG wkgs.1926,1927,drilling found ox.ore SW of workings;new shafts sunk older wkgs.to NE extended~~ed~~ Operated 1928-1933. Included Dry Branch.(My area VI is here).

<u>Simmons Branch</u>:(May areas II,III).UG mining,1929-1931.Drilling was in 1927-1929.

<u>Big Moccasin:</u> Drilled 1929,1930.See above.

<u>Peach Orchard:</u> Opened 1916,soon became leading producer.Abandoned 1926 as worked out. 1935-1941,P.p.again main producer Zn,Pb.Some of this work done UG,but much of it in opencuts. L942 further pockets found by drilling later mined by hand;1943, some of overburden stripped by power equipment.

ZINC DEPOSITS OF EAST TENNESSEE. Mark H.Secrist.Tenn.Div.Geol.Bul.31,1924

Zinc province lies in Great Valley of E.Tenn.,part of Appalachian Basin. Zn,Pb ores in Velley confined to Knox dolomite,e-ord with two exceptions: Embreeville where much oxidized zinc and lead ore washed from residual clay of Cambrian Shady ls (middle Camb.);Evanston,small non-commercial ZnS in dolomite bed of Rome foramtion(next above Shady ls.).

Knox deposits at horizons from near top to near bottom;nearly all are localized by brecciated horizons.

Shady Ls.:Overlies the basal Cambrian metamorphics. Limited extent to a few basins:Shady Valley, Johnson Co.(type locality) and Bumpass Cove. Most ls.gray,bluish-gray,weather dull geay or black.Dolomite irregularly intercalated. Underlies Watauga shale, but latter eroded away at Bumpass.

Pb,Zn found in this formation only at Bumpass Cove,where erosion has reduced the thickness to 500',from 1000'. Oxid.Pb,Zn,Fe ores scattered thru heavy soil overburden;some sulphides found in the bedrock.

Knox Dolomite: Most massive calc.rock & most wide-spread.3000-4000' of blue,gray,whitish ls.,dolo.,FG,massive. Dolo really Mg-ls. Lower part has many white and sandy layers;chert thruout but chert horizons more abundant near base. Dolo weathers rapidly,usually covered by mantle of red clay thru which is scattered the insoluble chert. Knox highly deformed,s.t.closely folded,overturned;thrusted .Both intense folding and faulting brecciated certain horizons in the dolo.to localize ore.

Structure: Folds and faults all"parallel to one another and to the northwestern shore of the ancient continent"(NE)p.23. All stages of foldin from simple open to compressed or overturned.Most are symmetrical but have a rather long SE slope. Relatively few areas however in which NW dips prevail.

Reverse fault most common. More faults in Tenn.than in Va. Central part of Valley folds so obscured by faults that strata form a series of narrow overlapping blocks of beds dipping SE. See Section. B.Willis, Nechanics of Appalachian Structure,USGS 13th AR,1891-1892, 227-228,these faults wonderfully persistent,all dip SE,parallel among themselves and to the outline of the Archean continent. " they are intimately associated with folcs, and whenerver a fault fades out it is in the northwestern side of an anticline and in the direction of anticlinal pitch."

~~the effect~~ "The mechanical effort is beyond comprehension,but the effect on the rocks is inappreciable. The strata beside a great fault are but rarely brecciated,squeezed or rendered schistose.The shearing planes are sharp and clean,the movement of overthrust was concentrated as by a knife/cut,and the passing layers ground little grist one from another. Great vertical pressure and very slow movement probably conduced this result,but however explained,the fact is conspicuous that Appalachian thrusts are not associated with alteration of the faulted strata.

"The strata sheared by these faults include all known horizons of the province from the lowest Cambrian to the Carboniferous,but nowhere do they bring up crystalline rocks older than the Cambrian."

Ore: ZnS,PbS,py.,ccpy. Associated gangue minerals: dolomite,calcite,qtz., chert barite(rare) fluorite(rare).

ZnS mostly light-brown. As dissm.grains,irreg.,masses,stringers in CR. Locally with varying PbS,py.,ccpy. Tenn.ZnS notably massive,no cryst. forms,but shows perfect dodecahedral cleavage.

Smithsonite: $ZnCO_3$. 52 % Zn when pure. Called carbonate or drybone . Where deep clay mantle as in the mines of the Embree Iron Co. ,Bumpass Cove, smithsonite the only Zn ore mined.

As brownish or yellowish porous masses,earthy look.

Hydrozincite: $ZnCO_3.2Zn.(OH)_2$. 60% metallic Zn. Soft,white to gray. Zinc bloom. Not generally recognized;associated with smithsonite.

Calamine.-H_2ZnSiO_5. With smithsonite,which it closely resembles. Granular massive and honeycomb forms. S.t.as stalactites.

Buckfat.-Mixture of smithsonite,calamine,clay. Applied at Embreeville to the very lean ore. Soft,plastic.

Cerussite $PbCO_3$. Largest quantity in E Tenn. in Embree mines. Distributed thru clay overburden and the disintegrated ls. as formless masses or clusters and crystal aggregates. Called white lead ore.

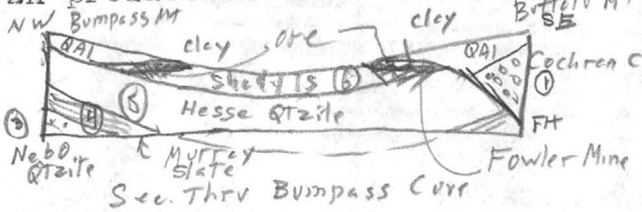
Embreeville & Graselli mines only oxide producers;there oxide ores as lumps and crystalline aggregates of mixed ore and clay,scattered thru the overburden but more abundant just above the unaltered rock. Most productive areas are pockets or basins between pinnacles.

Clay mostly ferruginous,dark brown to deep red;Bumpass Cove ores originally smelted for iron.

Embreeville District

Along Nolichucky R. Embreeville at NE limit of Bumpass Cove,a topogr. & structural depression between Bumpass Mt.on NW and Buffalo Mt.on SE. Cove extends 4 mi.SW,where the 2 enclosing mts.join. 1836 iron forge at Embreeville. 1890 English Co.bought ppty now Embree Iron Co. Failed,as did Embree Iron,successor. Zn ore recognized during the iron smelting,but not exploited. Constant Zn production since 1919;concentrator.

General Geology:



Sec. Thru Bumpass Cove

Shady ls.,the ore-bearer,consists of FG,cryst.& massive,dark-blue heavy-bedded ls & dolo,weathers dull-gray to black. Some beds mottled gray, blue,or white;seamed with calcite. Chert common. Quite magnesian.

Operations confined to mining the oxide ores,smithsonite,calamine,cerussite,as residual masses in clay or as an intricate netwoork of veinlets in partly disintegrated ls. The ox.ores are crystalline,rarely being massive;

due to their high lustre & tendency to form large aggregates are easily seen in the clay.

The ore masses were formed on top of the ls. in clay pockets between pinnacles. The accumulation of ore protected the underlying ls. while the pinnacles eroded most rapidly, and were reduced to clay which is barren. Hence ore in a matrix of clay separated by areas of barren clay. Where no xid., unaltered ls shows ZnS, py. some PbS as small veinlets or as finely dissem. particles. Locally sulphides are more abundant than this.

Basin a symmetrical syncline as shown in Section. Ideal locus for concentration of sulphides by descending surface waters.

Fowler Mine: 2.5 mi. SW of Embreeville near base of NW slope of Buffalo Mt. Mine 1600' along strike (N60E), 600 ft. wide. Zverage depth 55'. Upper limit of open cut terminated at junction of Shady ls. and Cochran cgl.

Ore in clay overburden mined by open cut. Ore in solution channels within the pinnacles mined by short tunnels and winzes, but only a part recovered. Complex occurrence of ore in the less altered ls. has presented tough~~t~~ mining problems.

No. 14 Mine.- 1/2 mi. SW of Fowler. Abandoned 1920. 500 ft. adit N30W found small pockets of smithsonite & calamine where disintegration of the ls., but most of ls. unaltered & conrains some ZnS and considerable py as small veinlets and disseminations. No Pb in any form.

No. 14 Open Cut.-600ft. SW of mouth of No. 14 adit. Mining exposed pinnacles of partly disintegrated ls. carrying veinlets and clusters of oxid. ores of Pb, Zn and ZnS.

Peach Orchard Mine.-Only mine working, 1921-22. Near base of SE slope of Bumpass Mt., and within 1/2 mi. of SW end of Cove. OB confined to a local structural basin in Shady ls. Strike N50E, basin 800' long that way; 500 ft. wide. Prevailing dip gentle SE but within OB slumping has dislocated the bedding.

Main level established by driving two adits, on from SW end of OB, other from NE end thru the clay and disintegrated ls. to the NW limits of the basin. Ore overhead stoped allowing roof to cave. Similar system, 2nd leve from 80 ft. countershaft.

Smithsonite, calamine, cerussite in pockets and veinlets in the disintegrated ls. & clay; where less alteration, ZnS, PbS. Oxidized ore only mined. Sorted, concentrated in 100-ton mill. Crushed, log washers to remove clay; g ground in rolls, roasted in rotary kilns to produce a slight magnetism of the Fe, thru magnetic separaores. Final Zn Pb concentration by tables. Conc. ave. 42% Zn, 62% Pb.

Both oxide and sulphide ores not uniformly distrib. but are in local masses of limited extent. Embree Iron Co. hasbeen drilling systematically to locate bodies of sulphide ore.

~~XXXXXXXXXXX~~.-

NW - SE Section passing NE of Maynardville, Union Co. Tenn
Secrist - Zinc Deposits of Eastern Tennessee. Tenn. Div. Geol.
Bull. 31, 1924, Fig. 3A (Keith)

MANGANESE DEPOSITS OF EAST TENNESSEE. S.O.Reichert. Div.Geol.Bull.50, 1942.

Most important type of deposit is the disseminated, pockety type in the residual clays,deep, overlying the Shady ls. near its contact with the Erwin~~e~~ qtzite.This type has accounted for more prospects and production than all others combined.

Typical mode of occurrence- irregularly dissem.pockets and streaks of lump psilomelane,pyrolusite,wad in a blanket-like deposit of residual clay overlying the Shady ls.and Erwin qtzite.This type shown by the only 2 current operatsions, Embree Iron Co. and the E.Tennessee Man Corp. near Neva.

Ore in this type under a shallow overbirden of barren clay,qtzite float and an iron-rich capping.Under this is a tough plastic clay called "ocher" or "buckfat".Latter may contain scattered pockets and streaks of Mn ore but these very sporadic;one pocket does not lead to another. Too blind prospecting,too expensive for peace-time Mn.

Many Mn deposits occur along remnants of terraces above the present valley floor. These benches parts of old valley floor formed during pauses in denudation,between periods of active stream incision that followed intermittent uplift.

Mn deposits like placers:they are areas of shallow mineralization areally related to favorable topgraphy:scattered over several different rock formations but always found in favorable structural and physiographic basins or their remnahts. But they are not detrital,like placers.

Mn float all over E Tenn.,but few commercial deposits;means that several periods of 2ndary enrichment by ground waters xxxxxx migrating down dip into favorable structural basins needed to make ore. Hence best places to drill are in Johnson,Carter & Unicoi Cos.along contact of Shady dolo.and Erwin qtzite where structure is a shallow syncline or gently-dippibg monocline. Within this zone best places are terraces at base of Erwin qtzite ridge.Steep slopes NG.Low rolling hills within this geologic and topographic zone,when coveredby thick soil on which is abundant float:OK.

Psilomelane:9MnO2.1MnO.H2O,Most imp.Bluish black to grayish black amorphous.Pure,H 6. 50-52% Mn.Not a definite mineral:colloid.

Pyrolusite: MnO2.Crystalline or geanular-massive;as crusts on psilomelane or separate lumps.Soft,friable,H 2,soils fingers. Minor imp.

Wad:indefinite moxture of Mnox,water etc. Hard to tell from Mn- clay. Crushes to black earthy powder,not minutely crys.like sooty pyrolusite. Slimes too much in washing. 30-42% Mn;Mn-clay has only 5-10%.

Bumpass Cove District

Main Mn producer in Tenn.1939 its output made Tenn.leading producer of metallurgical grade Mn.

Embree Iron Mines Co.-Mined iron intermittently,1890-1910.Hydraulic giants sluiced ore to log washers. Found that in some iron pits on NW side of cove Mn ore underlay the iron ore;on S side of cove ox.Zn ore underlies the Fe ore;in still other areas iron ore capping overlies barren ground. Finding of Zn deposits,1914,Pb deposits,1916 lead to long & prosperous Zn-Pb mining that has continued to date.

Geology.- Bunpass Cove a syncline,faulted along SE flank,normal succession along NW flank. Mn mines occur near the unfaulbed Shady dolo-Erwin qtzite contact;contact zone deeply weathered,bedrock ave.50' below surface. Mantle here tough plastic brownish clay,buckfat or ocher. Mn deposits occur along this ocher alignment. Mn deposits also are localized along broad topo terrace betweeb 2100 and 220' contours,at ft. of Erwin qtzite ridge. Is topographic expression of deeply weathered zone along the contact.

Ore mainly psilomelane,minor pyrolusite,Much soft Mn-wad but mostly lost in log-washing. No Mn in Shady dolo or Erwin qtzite.All OBs in buckfat mantle overlying the contact. Mn as streaks,lenses,pockets in the tough residual clay;depths to 60' (to bedrock). Ore-bearing clay somewhat like a blanket,paralleling present topo.

Mining Methods.-1934-1938,UG,network of drives and Xcuts.Too limited and expensive. Drilling program started,with gasoline-powered Keystone drill,6" bit & bailer. Bailer sample of mud and cuttings taken for every 4' depth drilled.This sludge quartered,washed by hand in bucket,mud being dispersed by abundance of water. Remaining granules inspected;if many Mn grains,sample partially dried sent to chem.lab.

Drilling complete in an area ,data plotted on topo map;elevation of ore holes shown. Shows Mn blanket roughly parallels surface topo. This suggested stripping overburden with scraper & shovel,mining ore with shovel.

Terrace Mining started in East Baptist Hollow mine,1938.2 acres OB/ Bench ht.16'.Stripping started at top of slope,angledozer stripped off layer after layer,progressing in benches downhill. Ore so pockety clean stri ping impossible;much barren clay had to be removed with the 3/4 yd. shovel. Shovel started mining on topmost terrace.When mining had progessed to a depth of 15' on a bench,shovel dropped to next lower bench and another 15-ft.layer mined.

West Baptist Hollow mine,mined by UG rabbot workings,though to have a large reserve of shovel ore.

Detailed descriptions of milling.

ZINC ORE RESERVES OF

APPALACHIAN MINING & SMELTING CO.

Edward Wisser

November 23, 1953

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ILLUSTRATIONS

In Text

In Flap at End of Text

SUMMARY STATEMENT

Appalachian Mining & Smelting Co. is putting in operation a Waelz plant to treat oxidized zinc ores at Bumpass Cove, Tennessee. Possible participation in the venture by National Zinc has been discussed by representatives of the two companies. While the economic set-up in terms of metallurgy, government contracts etc. has been analysed by National Zinc, estimates of ore reserves and proable mining costs were lacking. The writer was commissioned to make such estimates.

Ore reserves indicated by churn drilling total 856,000 tons, of which 80,000 tons or more have been mined. Estimated of grade are difficult because samples were washed before assaying. Under plausible assumptions, a factor has been calculated to apply to the washed samples to obtain the assay of ore in place. Applying this factor, the average grade for the 856,000 tons is 10,8% Zn, far lower than had been assumed.

Cost estimates show that at 12¢ zinc none of the ore reserves blocks could be won at a profit. At 16¢ zinc ore blocks higher in grade than the rest and aggregating 255,000 tons could be mined; these blocks plus the tailings pond would give an operation~~s~~ with 7½ years life, an annual profit of $145,000 and a yield of 69,000 tons zinc oxide.

Chances for finding hew higher-grade ore bodies look slim. Short of a zinc price much higher than that of today Bumpass Cove looks unattractive, and prospects for Appalachian's venture none too bright.

ZINC ORE RESERVES OF APPALACHIAN MINING AND SMELTING COMPANY

EMBREEVILLE, TENNESSEE

INTRODUCTION

Appalachian Mining and Smelting Co. is about to put in operation, at Bumpass Cove, near Embreeville, Tenn., a Waelz plant for treatment of oxidized zinc ores. On July 20, 1953, Mr. W. H. Leverett, President, National Zinc Co., met at their request with representatives of Appalachian to explore the possibility of participation in the venture by National Zinc. The meeting was at Johnson City, Tenn.; on the same day Mr. Leverett inspected the Waelz plant, in course of construction.

Appalachian felt that National Zinc, with long experience in zinc production and associated with organizations familiar with open-pit mining, could contribute "know-how" so valuable that it would be worth Appalachian's while to capitalize it and cut National Zinc in on the deal without purchase of stock.

The proposed role of National Zinc would be largely that of mining ore and delivering it to the Waelz plant, the success of which Appalachian then considered assured. Mr. Leverett's inspection, however, showed radical errors in plant design which will result in high-cost, low-recovery operation. The plant was scheduled to start, I believe, in August or September, 1953; but when I left the property early in November trial runs of operating units were breaking parts and burning out motors right and left. While Mr. Leverett believes the plant can be considerably improved at moderate cost, it seems plain that Appalachian needs outside help in metallurgy at least as much as it does in mining.

A memorandum by Mr. Leverett dated August 17, 1953 analyses the economics of the Appalachian venture. His conclusions concerning chances for success at present zinc prices were pessimistic, but he felt that to arrive at a decision regarding possible participation in the venture by National Zinc information on the extent and grade of available ore reserves was desireable. I was asked to inspect the property and its records, to estimate tonnage and grade of ore, and to calculate the probable mining cost. The present report attempts to supply this information.

Six days were spent on the property (between October 28 and November 3, 1953). Mr. George Warren, manager, struggling with grief in the Waelz plant, could devote very little time to me; Mr. Barney Wiggins could give me only an hour or so toward the end of my visit. I was forced to tackle the mass of ill-assorted data practically on my own.

In spite of this handicap it is felt that the essential information was secured. Logs of over 1500 drill holes were inspected and copies of necessary maps and reports made. Publications of the Tennessee Division of Geology listed in the Bibliography proved helpful in the interpretation of this mass of data.

LOCATION. COMMUNICATIONS. HOLDINGS.

Bumpass Cove, the valley in which the operations of Appalachian Mining and Smelting Co. are situated, lies toward the extreme eastern tip of Tennesee, about 18 miles by road southwest of Johnson City, the principal town and supply center of the region. Erwin, a lesser supply center, lies 7 miles by road to the east. Jonesboro, on the Southern Railway, lies about 8 miles by road northeast of Bumpass Cove.

Embreeville, on the paved highway system, is at the mouth of Bumpass Cove, where Bumpass Cove Creek joins the Nolichucky River. It is planned by Washington County to pave the mile or so of gravelled road connecting the center of mining operations with Embreeville.

Appalachian Mining and Smelting Co. owns mineral and for the most part surface rights to 5000 acres in the Bumpass Cove tract, and mineral rights in the 8000 acre Clark's Creek*Painter's Creek tract to the west. The accompanying general plan shows the explored portion of the Bumpass Cove tract, comprising a little less than 2000 of the 5000 acres involved. The western tract is entirely unexplored.

GEOLOGY OF BUMPASS COVE

The area is part of the complexly folded and faulted Appalachian mountain system, but the structure of the Cove is relatively simple: topographically it is a valley about 4 miles long and 1 mile wide; geologically it is a "valley" also, being a syncline or trough formed by the downward flexing of the Paleozoic rock formations along a northeast axis marked by the course of Bumpass Cove creek(see general plan). The trough is faulted and broken along its southeastern border and near its southwest end; but in general the strata on either side of the trough axis dip toward the axis: beds northwest of Bumpass Cove Creek dip southeast toward the creek; Beds southeast of the creek dip northwest.

Cambrian Shady dolomite (see general plan) once filled the core of the trough and was underlain by sandstone, shale and quartzite of the Erwin formation. The Shady dolomite, being easily eroded, has been largely removed to form the present Bumpass Cove valley, while the Erwin rocks, much more resistant, form the ridges bounding the valley. The trough plunges gently northeast; its outline on the present surface is that of a half ellipse, with the Erwin-Shady dolomite contact following the northwest side of Bumpass Cove valley, curving around the southwest end and continuing northeast along the southeast slopes of Bumpass Cove. This is well shown on the general plan.

Erosion of the Shady dolomite was mainly by solution: relatively insoluble constituents, alumina, silica, iron-etc. remained behind to form a thick body of residual clay in which iron oxide, zinc silicate, lead carbonate and manganese dioxide ore bodies are found. (See general plan). The surface of Shady dolomite on which the residual clay rests is exceedingly jagged, the dolomite sticking up through the clay as "pinnacles". (Photos 2-6)

ORE DEPOSITS OF BUMPASS COVE

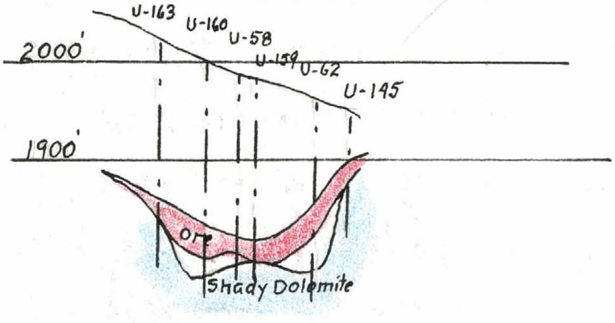
Ore deposits in the Cove area fall into two categories: (1) iron manganese, lead and zinc ores of secondary origin, in the residual clay derived from Shady dolomite: (2) primary zinc sulphide ores, with minor lead sulphide, in unweathered Shady dolomite.

Sulphide Ore: Disseminated sphalerite, galena and pyrite are widely distributed through the Shady dolomite, but deposits of possible commercial importance are restricted to a belt commencing at the Dry Branch zinc mine on the southwest, passing through the No. 14 and Fowler zinc mines, and ending on the east at the Jackson iron mine (see general plan). The sulphide belt corresponds to a long, narrow zone of minor folding. The folding, together possibly with some faulting brecciated the dolomite, forming open spaces which permitted deposition of sphalerite in quantities approaching the commercial. (Bibliography, No. 4).

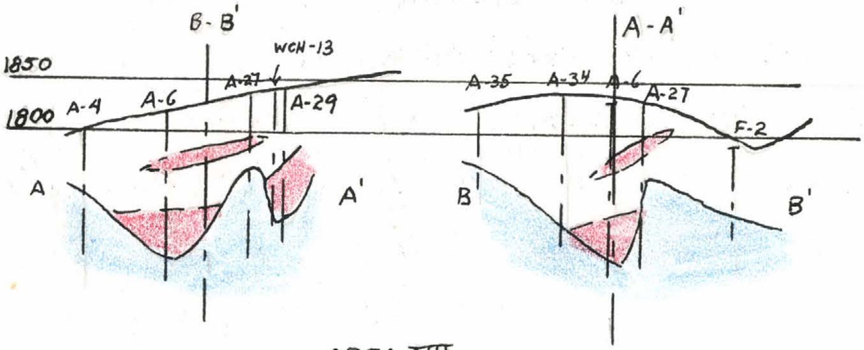
Since sulphides are limited to the Shady dolomite, surface sulphide showings are restricted to outcrops of that rock. The writer saw fairly strong sulphide mineralization just west of the Jackson mine and in a pinnacle within the Fowler open pit(Photo3). Most of the sulphides however are buried beneath the residual clay. Nearly all of the 2400 churn-drill holes were designed to explore for secondary zinc, lead and manganese bodies in the clay; as a rule these holes were stopped when they encountered dolomite. Sporadic attempts were made during several drilling periods to find and delimit sulphide ore bodies, but the work lacked system and met with small success. In the No. 14 mine area only were results consistent enough to block out an ore body, containing about 277,000 tons of sulphide ore averaging 4.0% Zn. The ore body lies nearly horizontal and averages 36' in thickness; but parts of it are over 50 ft. thick.(See general plan).

East of No. 14 mine and west of the Fowler mine are areas where drilling showed considerable sulphide mineralization but where no definite ore bodies ~~have~~ are proved to exist.

New Jersey Zinc Co. during its recent tenure of the property conducted diamond drilling for sulphides but avoided areas where sulphides are known to exist, following some theory unknown to me. Thus four holes were drilled north of the Lower Peedee iron mine;; nine holes west of the Jackson iron mine; twelve holes in the Simmons Branch area; three holes northeast of the Peach Orchard open pit; one hole south of that cut. I inspected the logs: no zinc sulphide showings sampled over 1% zinc. The holes averaged 300 ft. in depth, many bottoming in Erwin quartzite.

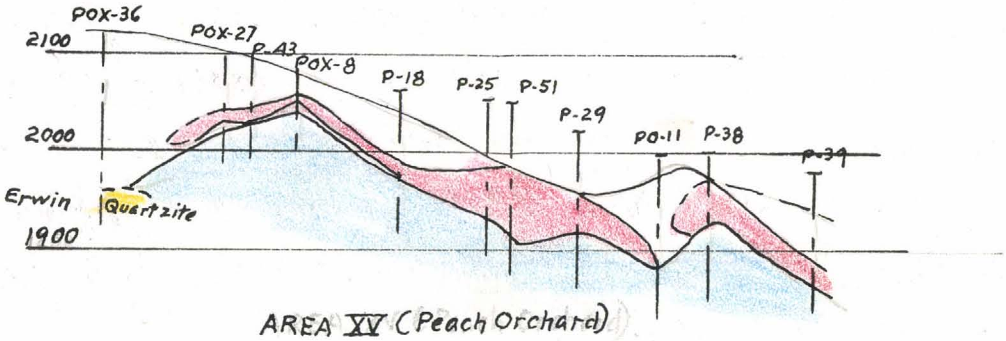


AREA II



AREA VII

Sections at right angles to each other



AREA XV (Peach Orchard)

REPRESENTATIVE VERTICAL SECTIONS SHOWING OXIDIZED ORE OCCURRENCE

Scale: 1" = 200'

Obviously 300,000 or 400,000 tons of 4% zince ore will not make a mine; 1,000,000 tons might. It is quite possible that the million tons exist; chances look especially good in the large potential ore area surrounding the Fowler mine. Against this notion however is the fact that sulphides are limited to the Shady dolomite, which has been very largely eroded along the favorable sulphide belt. Many drill holes passed directly from residual clay into the Erwin quartzite orginally underlying the Shady dolomite.

Oxidized Zinc Ore: Secondary zinc ores within the residual clay blanket account for the entire district production of 213,276 short tons of 40% zinc concentrates. (1913 through 1946)

The chief zinc mineral is the silicate, calamine; the carbonate, smithsonite is much less abundant. Lead carbonate, cerussite, occurs also in the clay and both zinc and lead deposits form distinct ore bodies with fairly sharp contacts against barren clay; but the ore bodies, are unpredictable, sporadic and irregular in outline. Most zinc ore bodies lie plastered against the sides or tops of dolomite pinnacles or in hollows between them, as shown on the sections facing page 6. Locally the weathered crust of the dolomite contains enough calamine to make ore, and it is in this crust that most of the smithsonite occurs.

Lead carbonate ore bodies occur as a rule a littel higher in the clay; they seldom hug the pinnacles. Hence lead ore may often be mined separately from zinc ore. In places however lead and zinc overlap, the same ore body containing both lead and zinc. (Above description from Bibliography, No. 4).

Bodies of oxidized zinc ore are restricted to a well-defined belt extending from No. 10 iron mine on the northeast to Peach Orchard and Lick Log on the southwest(see general plan). Northeast of the Fowler mine zinc occurred merely as an impurity in the iron ore mined. The Fowler mine itself was originally worked for iron but became the first important zinc producer. Southwest of that mine zinc ore alone was produced.

According to Rodgers(Bibliography, no. 4) the sphalerite from which the oxidized zinc minerals were derived didnot merely oxidize in place. The pinnacles against which the calamine is plastered are in most cases barren of sphalerite; while in the sulphide ore galena and sphalerite occur together, lead and zinc are largely separated in the oxidized ores, the zinc having travelled further downward in the residual clay. It follows that circulating waters dissolved zinc and lead from their sulphides and carrying them downward, deposited them near the water table.

The calamine in the clay is crustified, with a boxwork structure, and resembles calamine in weathered crusts of dolomite pinnacles. Rodgers reasons from this that much of the zinc was originally deposited in this weathered crust. As weathering proceeded and soluble dolomite was dissolved out from around the calamine crusts, ore bodies parallel to the retreating surface of the dolomite were built up in the adjacent clay. This accounts for the localization of the ore bodies against dolomite shown in the sections facing page 6.

The oxide ore bodies were deposited at or near the then water table, but the latter is continuously being lowered by erosion of the land. Oxidized ore bodies stranded for the moment above the water table have been repeatedly dissolved and redeposited at lower horizons; hence the rich Peach Orchard deposits result from concentration, into a relatively small body of clay, of zinc and lead from great volumes of sulphide-bearing dolomite now eroded.

Reason for localization of oxidized ore bodies within the belt described are probably two:(1) The same zone of minor folding that broke the dolomite and favored present sulphide mineralization extended upward in the Shady dolomite and localized deposition of the sulphides at horizons now eroded; these sulphide bodies were the source of the present oxide ores. (2). The oxide ore bodies are restricted to clay underlying remnants of an old terrace visible in places along the flanks of Bumpass Cove and representing a period when the water table was considerably higher than at present and when aggradation i.e. valley filling by sediments, and not down-cutting, was operative. Periods of aggradation favor the kind of slow solution of dolomite and ore minerals, production of residual clay and redeposition of metals in oxidized form that formed the Bumpass Cove deposits.

Manganese Deposits: The manganese belt lies along the northwest edge of the residual clay area, not far from the contact of the clay with the underlying Erwin quartzite. As shown on the general plan, the belt extends from the Polly Hollow mine on the northeast, (originally an iron mine), past the West Ore Bank mine, responsible for over half the total manganese production of 25,718 long tons of 38% metallurgical grade manganese(1917 through 1946). The manganese belt is known to extend to a point west of the Peach Orchard and Lick Log areas.

Psilomelane, pyrolusite and wad occur in irregularly distributed pockets and streaks in a blanket-like deposit in the residual clay underlying an old terrace at the base of the ridge formed by Erwin quartzite. The maganiferous blanket parallel roughly the present southeast slope. (Above description from Bibliography, No. 2).

Tennessee Manganese Co., Inc., controlled by T.K. Li, the tungsten tycoon, has the manganese belt under lease from Appalachian Mining and Smelting Co. and is presently engaged in constructing a log washer and sink-and-float plant. Only lump psilomelane can be treated in the plant as designed; but the company may install a flotation mill to recover pyrolusite as well.

Tennessee Manganese is working vigorously to get started and this lease may prove a substantial asset for Appalachian Mining and Smelting.

Iron Deposits: The limonite deposits in the northeast portion of Bumpass Cove, mining of which commenced over 100 years ago are not germane to the present investigation and will not be described.

RESERVES OF OXIDIZED ZINC ORE

The tabulated ore reserves shown on the general plan are derived from drilling records. "Ore" is usually defined as metal-bearing rock that may be mined at a profit under given conditions. In that sense much of the reserves listed does not constitute ore under present zinc prices; futher, some blocks have probably been mined out. The table simply presents data on tonnage and grade with no economic or historical implications; these are discussed later.

Estimated Mining Cost: The Waelz plant probably can handle about 150 tons of ore per day; mining costs are therefore estimated on that basis. Open-pit mining of the zinc ore bodies is assumed, preceded by stripping of overburden.. Average haul, pit to plant, is about one mile. Two five-ton trucks will be needed, probably followed later by a third. Stripping can be done mainly by caterpillar tractor ~~or~~ with bulldozer blade, mining by the same tractor with loader("High lift") on front end. A D6 tractor and loader costs about $15,000 and lasts about 10,000 hours, depreciation on this equipment being therefore about $1:50 per hour. Operating costs, fuel and lubricants total about $3.50 per hour, bringing total hourly cost to $5.00.

Two 5-ton trucks would cost about $10.000: Their life would also be about 10,000 hours, so that depreciation would be $1.00 per hour. Operating and fuel costs for the trucks would total about $4.00 per hour, and total cost would aggregate about $5.00 per hour.

The clay and ore would require practically no drilling and blasting; mining cost therefore would be nearly equivalent to the cost of operating the equipment, i.e. $10.00 per hour. Mining at the rate of 150 tons per day or about 20 tons per hour would therefore cost 50 cents per ton. Adding 40% for occasional blasting, grief and contingencies gives an estimated mining cost of 70 cents per ton.

Stripping with a bulldozer should cost about 20 cents per ton of overburden.

Grade of Ore: Average assays for the blocks shown are calculated from records, but as stated by Rodgers (Bibliography No.4, p.35), assays of oxidized ore were always made on washed samples. I have seen the same thing stated on several drill records. Former operators were interested only in the grade of material that had passed their log washer.

An old calculation gives the amount of clay washed out as 40%. The washings carried appreciable zinc, for the tailings pond produced by one epoch of log washing is said to assay 14% Zn. Assuming that washing carried away 20% of the original zinc in the ore, it may be shown that the recorded assay should be multiplied by 0.75 to give the assay before washing. Hence average grades shown in the table on the general plan should be multiplied by 0.75 to give the probable true assay value of the ore blocks.

Mr. Leverett states in his memorandum of August 17,1953, that Appalachian Mining and Smelting wished to commence mining ore in place instead of the tailings pond, said to assay 14% Z n, because the ore in place, higher in grade, would give a lower treatment cost per pound of zinc. The table on the general plan explodes that notion: applying the 0.75 factor, the highest-grade ore block, No. XIII, assays before washing 17.7% Zn. Since the tailings pond is said to have been sampled by the U.S. Bureau of Mines, its average assay, 14% Zn., is probably the true assay; hence little benefit will result from mining ore in place.

ECONOMIC ANALYSIS

General: To evaluate completely the Bumpass Cove oxidized zinc ore bodies in terms of probable profit or loss in mining them is beyond my sphere. Neverthe less, a little "shotgun" analysis serves to clarify the picture to the extent of demonstrating which if any of the blocks listed on the general plan might be commercial ore, and which cannot possibly be so.

Disregarding existent conditions of contracts with the U.S. Government and New Jersey Zinc, the economic picture might be roughly as follows with operations in the open market:

Treatment Cost per Ton of Ore Mined:

Waelz Plant (eliminating mining and drying slime and assuming crushing and feeding costs 50¢ per ton)..	$15.00
Freight to smelter(guess)................................	4.00
Smelting (per ton of original 15% ore).....................	10.22
	29.22

Mining Costs, Cut-off Grades and Actual Grades:

Block	Mining Cost	Cut-off grade in terms of assay, ore in place; 12¢ Zn. 72% recovery	Uncorrected grade	Corrected grade
I	$3.30	18.7%	15.2	11.4
II	3.60	19.0	15.0	11.2
III	3.34	18.9	12.6	9.5
IV	2.50	18.3	10.8	8.1
V	1.18	17.7	7.7	5.8
VI	2.10	18.1	19.7	14.8
VII	3.10	18.7	13.3	10.0
VIII	1.34	17.6	10.3	7.7
IX	0.70	17.3	14.1	10.6
X	1.42	17.8	10.3	7.7
XI	1.40	17.8	19.1	14.3
XII	3.90	19.1	20.6	15.5
XIII	3.10	18.7	23.6	17.7
XIV	3.90	19.1	18.2	13.7
XI	0.96	17.5	20.8	15.6

Assuming the 6.75 corrections factor applied to the calculated average grades to be correct, not one of these blocks could be mined at a profit with the price of zinc 2 cents higher than at present. Neglecting the corredtion factor, only blocks VI, IX, XII, XIII and XV would pay the expenses of mining, and of these only blocks XIII and XV would show any real profit.

The above calculations neglect mining dilution, which would lower the grade of ore at least 10% and probably more, thereby throwing out blocks VI, XI AND XII.

Thus the ore reserves as tabulated on the general plan do not make an attractive economic picture. Futhermore, some of the blocks are not there. Rodgers (Bibliography, No. 4) states that where drill records indicate available zinc, it will be found that most of it has been mined, an exception being those ore bodies high in iron (e.g. Blocks IX, X, XI, WHICH average about 26% iron). It is certain that Block I has been mined, and the extensive mine workings extending beneath Block VI suggests that this block no longer exists. For Blocks XII,XIV and XV, some allowance has been made for ore mined, but experience prompts me to suggest that such allowances are nearly always too small.

Incidentally, Appalachian believes the zinc tailings pond on which the Waelz plant is to start contains 85,000 tons averaging 15% zinc, but Rogers assigns it only 15,000 Tons.

It follows that the 856,000 Tons of ore shown on the general plan must be radically reduced regardless of whether shome of the blocks are ore or not ore.

Might there be a moderate-sized operation at higher zinc prices ? The more promising ore blocks are assembled below:

Block	Tons	Ave. % Zn (corrected).
IX	47500	10.6
XI	45000	14.3
XII	8300	15.5
XIII	10300	17.7
XIV	14100	13.7
XV[1]	130000	15.6
	255200	14.4

Average mining cost:$1.33/ton.
Total cost:$30.55/ton ore

14.4% x 72% = 10.4% recovered,= 208 lbs. Zn/ton

Price of Zn to break even = $\frac{\$30.55}{208}$ = 14.7 cents

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[1] Note: Tonnage indicated by drill holes below lowest underground working and probably still there.

The Waelz plant will treat about 45, 000 tons per year; if the tailings pond contains 85,000 tons, total reserves are 340,000 tons and the life of the enterprise would be 7.55 years. Operations during this life would produce about 69,000 tons of 60% zinc oxide.

Mr. Leverett points out in his memorandum of August 17, 1953., that under certain favorable circumstances Appalachian may be able to repay its loan from the government, unde the agreement whereby the government assumes cost of zinc production up to 17½ cents per pound. The company however owes $330,000 To Tennessee Zinc Stockholders and I believe they have incurred further indebtedness.

At a zinc price of 16¢ per lb., annual operating profit would be about $140,000 per year, a scant margin with which to pay off the debt and provide for contingencies.

CONCLUSIONS

Certainly higher-grade ore was mined than that shown for the reserves remaining. Perhaps undiscovered high-grade ore exists, but chances for this look slim. Rodgers notes that the size of zince ore bodies found and mined has steadily decreased; the Peach Orchard mine has been opened and reopened at least three times; each time the fruits of the work were less than those of the preceding operation. Rodgers believes the only chance for new ore lies in the small area between the Peach Orchard and the Lick Log. In view of the large areas shown on the general plan that have been intensively explored by drilling, I am inclined to agree with Rodgers.

To sum up, the Bumpass Cove oxidized zinc deposits would be attractive only under a zinc price nearly double the prevailing one (10¢ per lb.). Chances for developing a sulphide mine look none too good. Since ore in place averages probably less in grade than that in the tailings pond, the cost per pound of zinc cannot be lowered by shifting mining from the pond to the mines, so that prospects for the current operations look unfavorable.

E. W.

Berkeley, California
November 23, 1953

Edward Wisser

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Ibid Bu.. 52, 1944

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John Rodgers
Ibid Bull. 54, 1948

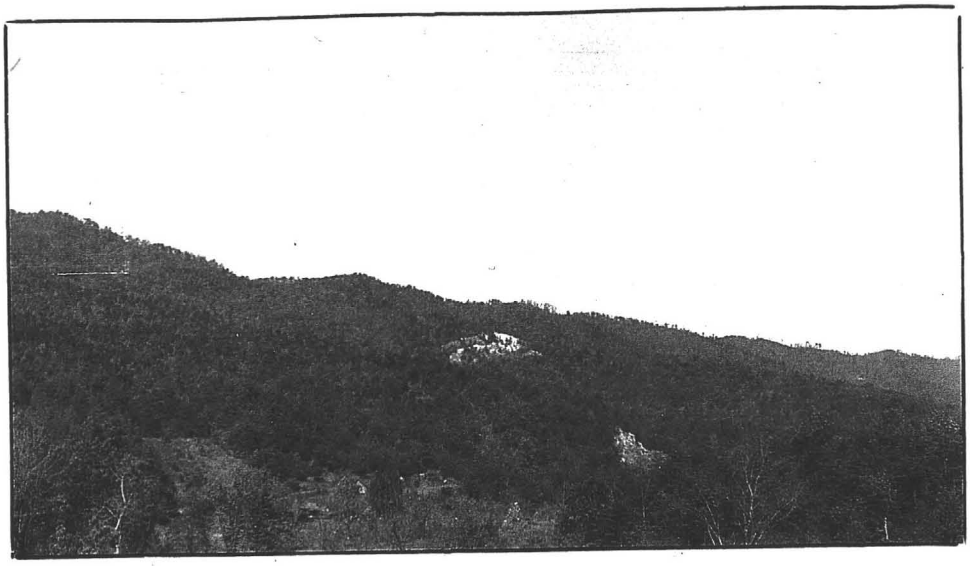

Photo 1: Northwest slope of Bumpass Cove, showing East Baptist Hollow manganese mine (near skyline).

Photo 2: Pinnacles of Shady dolomite, east edge of Fowler open pit.

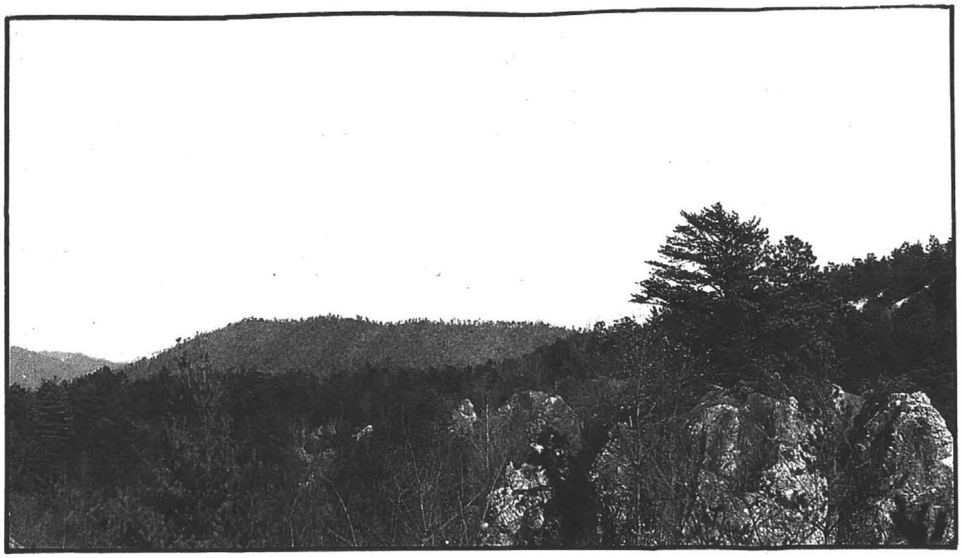

Photo 3: Dolomite pinnacle containing sulphides;Fowler open pit.

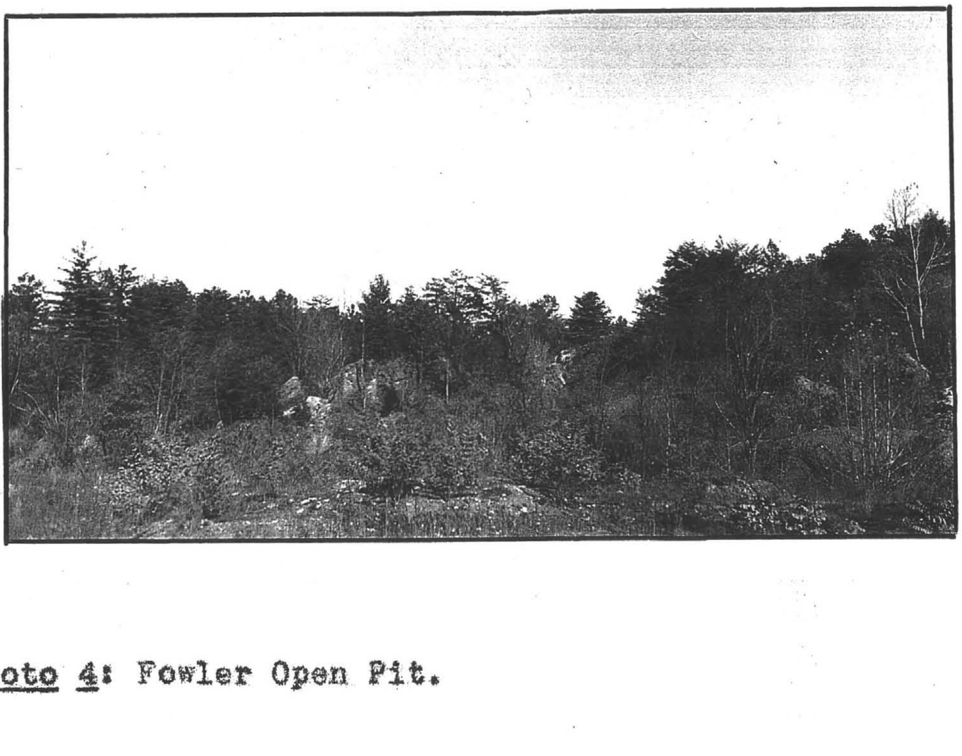

Photo 4: Fowler Open Pit.

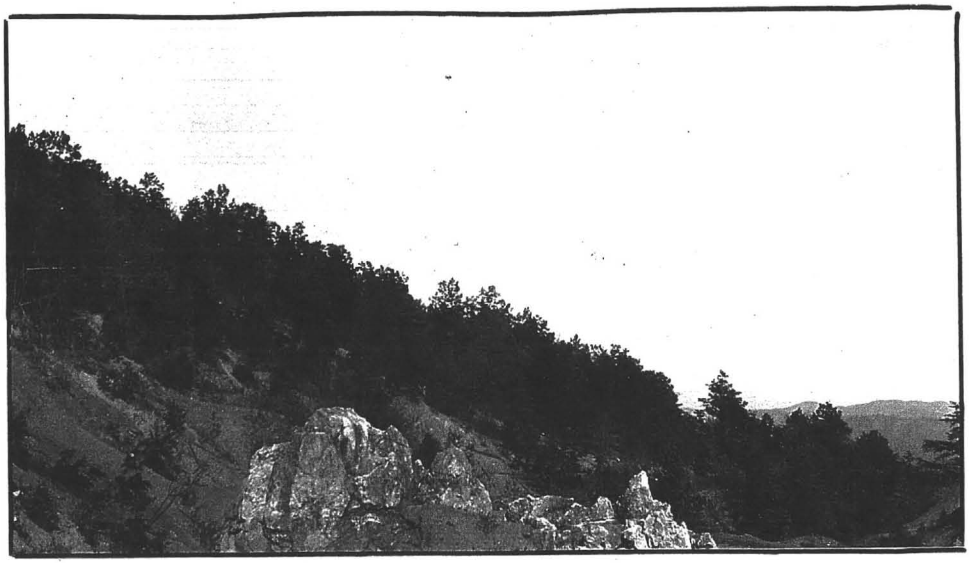

Photo 5: Peach Orchard Open Pit, looking east, showing part of main pinnacle.

Photo 6: Peach Orchard Open Pit, showing main pinnacle, stripping cut and remnant of overburden.

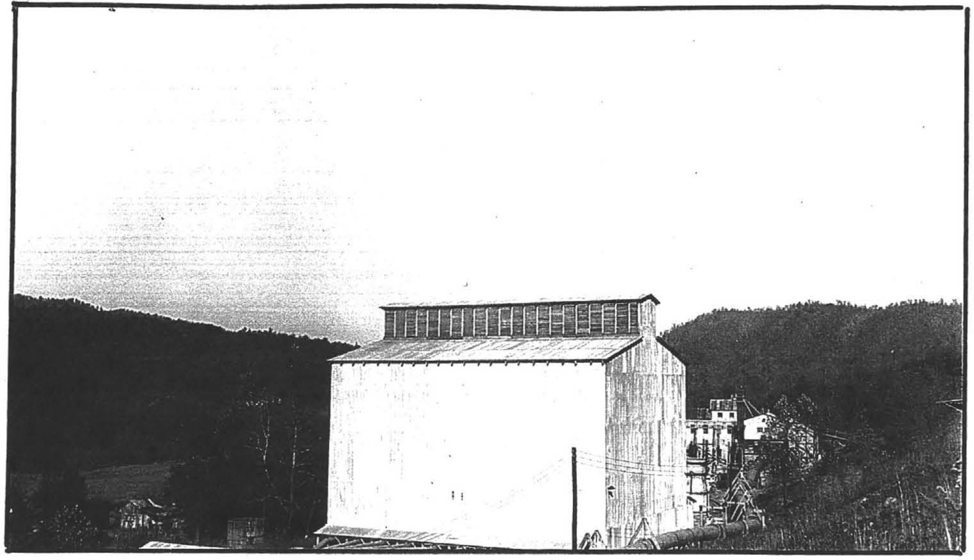

Photo 7: Waelz Plant.

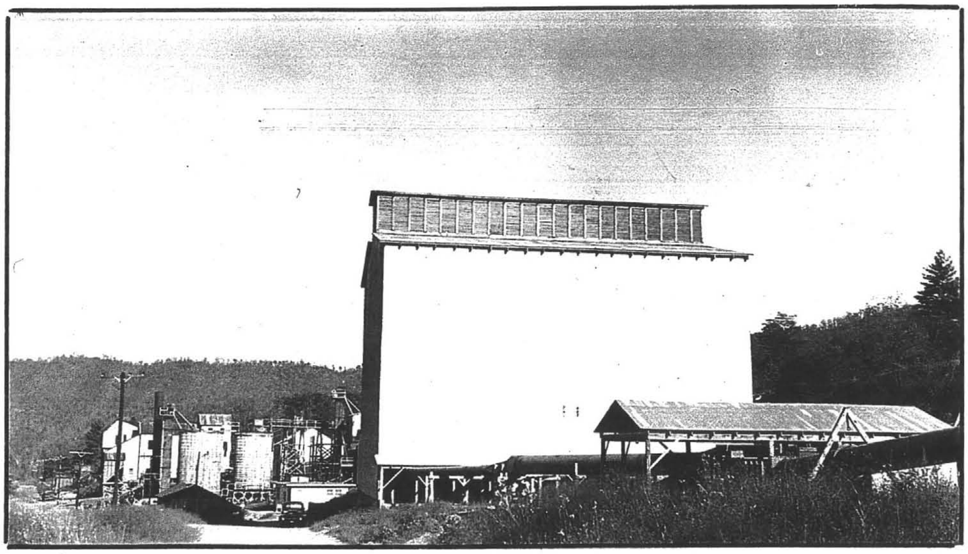

Photo 8: Waelz Plant.

APPALACHIAN MINING AND SMELTING CO.
EMBREEVILLE, TENN.
PLAN SHOWING RESERVES OF OXIDIZED ZINC ORE

Scale: 1" = 500'

LEGEND

ROCK FORMATIONS

Shady Dolomite (Cambrian):	▦
Residual Clay from Shady Dolomite:	☐
Erwin (Cambrian) Sandstone, Shale, quartzite:	⁘
OXIDIZED ZINC ORE BODY	▨ I

MINE WORKINGS

Open Pit:	
Portal of Adit:	
Shaft:	▣
Churn Drill Hole:	○ P-56
Area thoroughly explored by drilling:	

TABULATION OF ORE RESERVES

Block	Tons	Average Thickness	Ave. % Zn	Ave. Depth Overburden	Tons Stripping	Ratio, tons ore to Tons Stripping
I	5400	10.0	15.2	60	69000	1:13
II	41000	14.0	15.0	107	600000	1:14.5
III	20500	10.4	12.6	73	280000	1:13.7
IV	20400	11.7	10.8	69	180000	1:9
V	54500	15.6	7.7	32	130000	1:2.4
VI	44000	10.7	19.7	58	305000	1:7
VII	42000	—	13.3	100	500000	1:12
VIII	174000	19.0	10.3	50	560000	1:3.2
IX	47500	18.6	14.1	0	—	—
X	86000	28.0	10.3	63	306000	1:3.6
XI	45000	18.0	19.1	21	45000	1:1.0
XII	8300	8.3	20.6	61	135000	1:16
XIII	10300	10.7	23.6	45	129000	1:12
XIV	14100	10.1	18.2	58	274000	1:16
XV	158000	23.0	20.8		200000?	1:1.3?
Tailings Pond	85000		14.0	0		
Totals + Average	856000		14.4% Zn		3,713,000	1:4.3

Tonnage Factor, ore = 13 Cu. ft./Ton; for waste, 15 cu. ft./Ton. Slope of pit sides taken at 45°.

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APPALACHIAN MINING AND SMELTING CO.
EMBREEVILLE, TENN.
PLAN SHOWING RESERVES OF OXIDIZED ZINC ORE

Scale: 1" = 500'

LEGEND

ROCK FORMATIONS
- Shady Dolomite (Cambrian): ▦
- Residual Clay from Shady Dolomite: ▨
- Erwin (Cambrian) Sandstone, Shale, quartzite: ▤

OXIDIZED ZINC ORE BODY ● I
SULPHIDE " " ▨
MINE WORKINGS
- Open Pit:
- Portal of Adit:
- Shaft: ▪
- Churn Drill Hole: ○ P-56
- Area thoroughly explored by drilling: ▱

Potential Sulphide Ore Area: ▭

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TABULATION OF ORE RESERVES

Block	Tons	Average Thickness	Ave % Zn	Ave. Depth Overburden	Tons Stripping	Ratio, tons ore to Tons Stripping	Fe
I	5400	10.0	15.2	60	69000	1:13	0
II	41000	14.0	15.0	107	600000	1:14.5	Low
III	20500	10.4	12.6	73	280000	1:13.7	9
IV	20400	11.7	10.8	69	180000	1:9	8
V	54500	15.6	7.7	32	130000	1:2.4	8
VI	44000	10.7	19.7	58	305000	1:7	Low
VII	42000	—	13.3	100	500000	1:12	25
VIII	174000	19.0	10.3	50	560000	1:3.2	Low
> IX	47500	18.6	14.1	0	—	—	35
X	86000	28.0	10.3	63	306000	1:3.6	24
> XI	45000	18.0	19.1	21	45000	1:1.0	23 ?
> XII	8300	8.3	20.6	61	135000	1:16	
> XIII	10300	10.7	23.6	45	129000	1:12	
> XIV	14100	10.1	18.2	58	274000 ?	1:16	
> XV	158000	23.0	20.8		200000 ?	1:13 ?	
Tailings Pond	85000		14.0	0			
Totals & Average	856000		14.4 % Zn		3,713,000	1:4.3	

Tonnage Factor, ore = 13 cu. ft./Ton; for waste, 15 cu. ft./Ton. Slope of pit sides taken at 45°.

Mined out U.G.

#14 Sulphide Block

Tons	Ave. Thickness	Ave. % Zn.	Ave. Depth Overburden
277000	36'	4.0	67'

APPALACHIAN MINING AND SMELTING CO.
EMBREEVILLE, TENN.
PLAN SHOWING RESERVES OF OXIDIZED ZINC ORE

Scale: 1"=500'

LEGEND

ROCK FORMATIONS

Shady Dolomite (Cambrian):	▦
Residual Clay from Shady Dolomite:	🟫
Erwin (Cambrian) Sandstone, Shale, quartzite:	🟧
OXIDIZED ZINC ORE BODY	● I
SULPHIDE " " "	▨

MINE WORKINGS

Open Pit:	
Portal of Adit:	
Shaft:	▣
Churn Drill Hole:	○ P-56
Area thoroughly explored by drilling:	◇
POTENTIAL SULPHIDE ORE AREA:	◇

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TABULATION OF ORE RESERVES

Block	Tons	Average Thickness	Ave.% Zn	Ave. Depth Overburden	Tons Stripping	Ratio, tons ore to Tons Stripping
I	5400	10.0	15.2	60	69000	1:13
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V	54500	15.6	7.7	32	130000	1:2.4
VI	44000	10.7	19.7	58	305000	1:7
VII	42000	—	13.3	100	500000	1:12
VIII	174000	19.0	10.3	50	560000	1:3.2
IX	47500	18.6	14.1	0	—	—
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XII	8300	8.3	20.6	61	135000	1:16
XIII	10300	10.7	23.6	45	129000	1:12
XIV	14100	10.1	18.2	58	274000?	1:16
XV	158000	23.0	20.8		200000?	1:13?
Tailings Pond	85000		14.0	0		
Totals + Average	856000		14.4% Zn		3,713,000	1:4.3

Tonnage Factor, ore = 13 Cu.ft./Ton; for waste, 15 cu.ft./Ton. Slope of pit sides taken at 45°.

#14 Sulphide Block

Tons	Ave. Thickness	Ave.% Zn	Ave. Depth Overburden
277000	36'	4.0	67'