報告第五號經濟地質誌第三册

郭紹儀
田奇瓗
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湖南益陽板溪銻鑛報告

民國十七年十二月

湖南建設廳地質調查所印行

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湖南益陽板溪銻鑛報告目錄

第四章　採鑛

第五章　煉鑛

益陽板溪銻鑛報告

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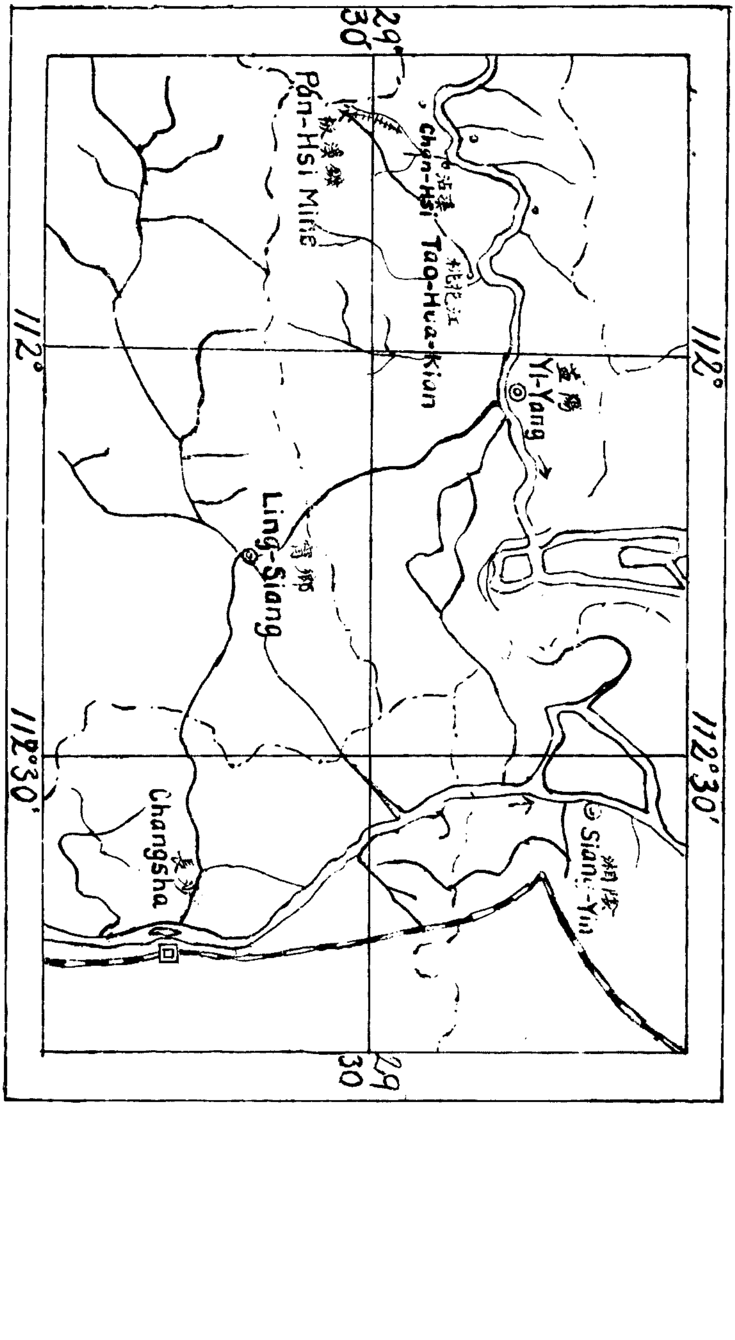
第一章 緒論

位置及交通

板溪在益陽縣極西偏南、離城百三十五里、西隣滄溪鎮、與安化大福坪接壤、距流入資水之桃花江七十五里、總公司設在長沙、自鑛山至望三洲二十里、築有輕便鐵道、望三洲距沾溪四十餘里、由沾溪經益陽以達長沙、計三百五十里、長沙益陽間二百四十里之交通、除冬乾水淺外、小汽輪每日暢行、此本鑛山進物出貨一定之途徑也、若通常行人往來、則由長沙過益陽經桃花江直達板溪、較爲便利、茲將本鑛山與長沙間之水陸交通情形、繪圖(第一圖)如左、

沿革

本鑛於前清光緒中葉、經土人發見後、由湖南巡撫陳寶箴委員官辦、定名爲中路久通鑛務公司、採鑛區域、在臭石壙一帶、以地勢偏僻、民智閉塞、且獲砂既少、成色又低、致虧損不貲、無法繼續、光緒二十六年、由梁煥奎兄弟以賤價承頂、改爲商辦、命名久通、增區開採、逐漸改良、數年之間、稍著成效、迨長沙華昌公司成立、梁氏將久通作股併入、出砂概歸華昌冶煉、原華昌煉銻係用哈倫許密德氏 (Herren-



第一圖 益陽板溪銻礦位置圖

Fig 1 Map showing the location of the Pan-Hsi Mine

Scale 1:850,000

schmidt) 所發明之蒸溜法、煉本山低等之砂、最爲適宜、斯時銻業漸形發達、銷場日益推廣、本鑛工程、已有東西前中四廠、及歐戰發生、銻用擴大、銷路既廣、價格又昂、獲利之多、不待言矣、乃聘諶洮溪君主持鑛務、將各廠次第改用西法、設置機械鍋鑪、講求通風排水、鑛工計千餘人、產額月達千噸、進物出貨、頗極一時之盛、惟以山路崎嶇、運輸艱難、乃於民國六年、募集公債、修築自板溪至桃花江七十餘里之輕便鐵道、閱時兩載、始完成板望一段、計長二十里左右、然尚係人力推車、上行甚緩、所備車頭車箱軌條夾板螺釘等件、殆已等於閒物、蓋自歐戰告終、銻價跌落、華昌受茲影響、虧累甚巨、久通爲所牽制、竟於民國九年停止工作矣、自是百凡廢弛、規模設備、不堪聞問、至民國十三年、久通舊股東與華昌債權團結合、組織維益久通公司、租借久通礦區、就山設爐、提煉存砂、並從事採冶、訂期共一十五年、主持工程者爲劉世傑君、所有工程進行、仍本從前計劃、一經整飭、頓復舊觀、去年正月、產銻砂千一百餘噸、純銻八十餘噸、而銻養尚未計入、惟以砂質低劣、成本不輕、殊難獲利耳、自工會成立後、工人增加、開支浩大、而產額反形減少、共匪流毒之影響於生產事業、如此重大、曷勝浩嘆、幸六月起、產額日增、漸復原狀、十月產銻砂千四百餘噸、銻養純銻各九十餘噸、若銻價增高、售銷暢旺、則本山事業、仍大有可爲、乃今年入春以來、銻價未見起色、勉力支持、猶難獲利、故於四月重新整頓、縮小範圍、裁汰人員、退減工人、意在撙節開支、減低成本、以維目前狀況、而望將來發展、法至善也、綜觀本礦前後三十餘年、慘澹經營、規

模已具、今日之命脉、全繫乎銻產之市價、與其銷路之推廣、夫銻之爲物、用途頗廣、於軍用國防、尤爲重要材料、徒以吾國近年、外患頻仍、內訌迭起、生產事業、未嘗發達、原貨專供外洋、價格由人操縱、以致此等裕國利民之事業、尙有廢棄停頓之隱憂、洵可慨也、今者北伐成功、集中建設、鑛業發展、方興未艾、本鑛蘊藏豐富、計劃已成、且現在所採掘者、距地彌深、成分彌佳、將來愈往下掘、成分可望愈佳、必大有貢獻於實業前途、非徒爲地方民衆闢一無窮利源已也、著者於斯、欣然以喜、謹拭目以觀其卓效焉、

氣候

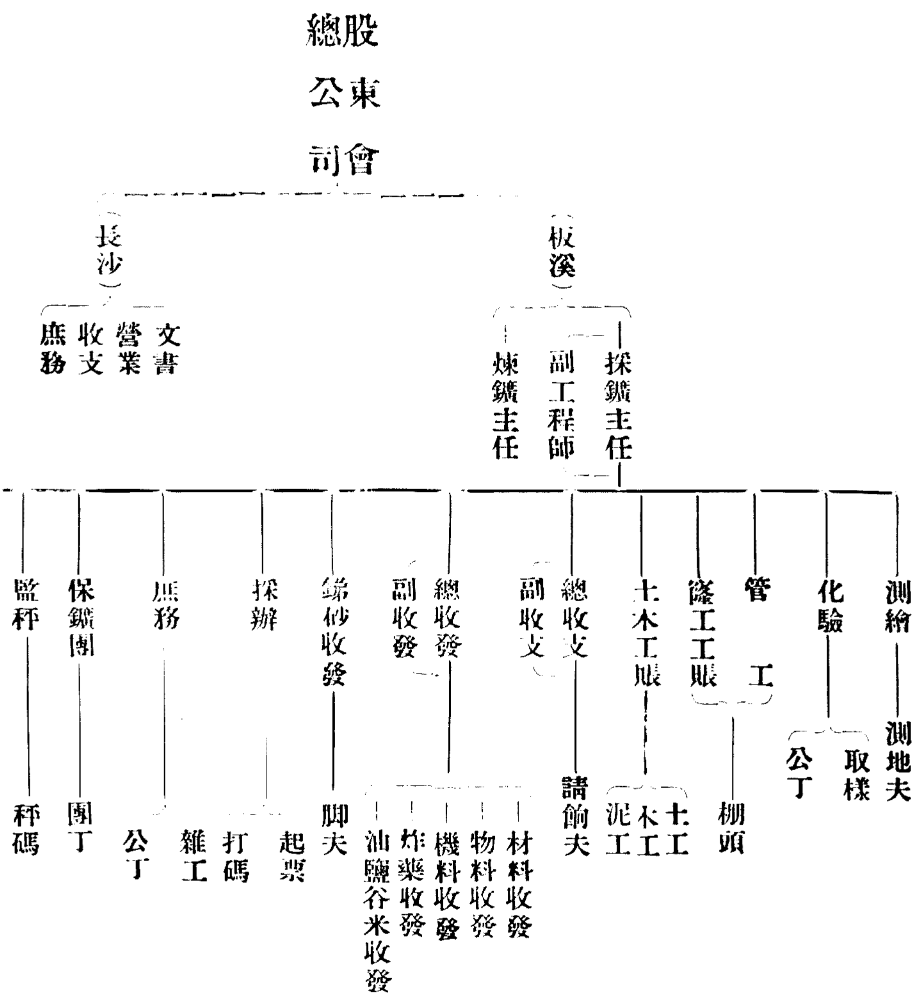
本鑛四面峯巒高聳、蒼翠欲滴、惜邱壑顯然、絕少幽秀之處、雨水調暢、氣候溫和、冬雖早寒、而夏無溽暑、通常在華氏七八十度之間、四時皆可工作、

鑛區

本礦礦區面積、計六方里左右、東界虛谷菴、南連佘家壠、西抵棕石坑、北至吒口石、但現在採礦地點、僅黑灣子萬家山臭石壠等處、

組織

公司向設總理經理工程師路鐵主任各一人、民國七年改設總理總務主任工程主任各一人、最近分採鑛煉鑛二部、各設主任一人、營業部設在長沙總公司內、玆更將其組織系統、列表如次、


股東會
總公司
長沙
板溪
文書
營業
收支
庶務
採鑛主任
副工程師
煉鑛主任
測繪
化驗
管工
窿工工賬
土木工賬
總收支
副收支
總收發
副收發
銻砂收發
採辦
庶務
保鑛團
監秤
測地夫
取樣
公丁
棚頭
土工
木工
泥工
請餉夫
材料收發
物料收發
機料收發
炸藥收發
油鹽谷米收發
脚夫
起票
打碼
雜工
公丁
團丁
秤碼

- 文書
- 交際
- 稽查
- 入山道轉運處
- 望三洲轉運處
- 沾溪轉運處
- 桃花江轉運處
- 益陽轉運處

第二章　地質

一　地形

本區內地形險峻、巒峯重疊、交通極稱不便、造山之岩、屬板岩千枚岩及千枚狀頁岩等、均質地堅強、且大部傾角不大、故溪谷分割之處、多呈孤峯峭壁、蔚爲奇觀、峯之高者達八百公尺以上、低者亦在五六百公尺之間、山脉大致呈東東北——西西南向、與岩層走向略相符合、益陽安化兩邑在本境大都依此山嶺分界、嶺北屬益陽割境之板溪、嶺南則屬安化割境之大福坪、境內地勢高聳、首推此嶺、由是以往南北、則逐步低微、故附近溪流、均循此嶺而分其源、即在嶺南者南流、嶺北者則北流焉、以是山脊亦

均呈南北向、溪谷以板溪爲最大、此溪發源於滄溪嶺、大致東北北流、經沾溪而入資江、長凡六十餘里、其上游雖不能通行舟楫、然自望三洲以至沾溪、水漲時可通小舟、卽水涸時、載重數百斤之竹筏及木排、間亦可暢行無阻、現久通公司沿此溪谷建設輕便鐵道、只修至望三洲爲止、故自望三洲至沾溪間之運輸、莫不有賴於此水也、總覽境內地貌峯巒挺拔、溝澗巉深、其尙未離幼年時期可知也、

二 構造

本區內地質構造、趨重縐摺、斷層殊不多見、且祇限於局部、與全體構造無關、姑不具論、縐摺屬於複縐摺一類、其在本區南北兩端、摺縐緊逼、中部則頗和緩、軸向見於北端及中部者、均呈東西向、見於南端者、則呈東東北——西西南向(見附圖第一版板溪銻鑛地質圖)茲就觀察所及逐步分述於後、在板溪車站東北約三里入谷口處所見黑白相間之板岩傾向南十度東、傾角四十度左右、由是沿谷西南行、傾角漸次減小、將及鐵路分义處、傾向如前、傾角則爲二十五度至三十度左右、前行二百餘步、傾向折爲北十度西、傾角約二十度至二十五度、是可知其間爲一向斜層、由此前行至入車站口處、傾向未變、傾角則逐次減小至六七度左右、在入山道附近、傾向折爲畧近正北、繼復折爲畧近正南、在煉廠附近則見黃色千枚狀砂質頁岩、直覆於黑白相間之板岩之上、傾向如前、繼見黑色板狀頁岩內夾黃色砂質頁岩、其初傾向同前、繼則折而爲北、此段岩層來回拗折、傾角均不大、約由六度至十度之間、但由

是上溯至入砂道東南傾向折而爲南十五度東、傾角二十五度至三十度左右、至通東西道谷口處則見灰白色及灰綠色千枚岩、傾向折爲北十度西、傾角四十度至五十度、繼復折爲南八度東、傾角約二十度、由是沿谷上溯、傾向無變動、惟傾角逐漸增大至三十餘度、繼則折爲北十五度西、傾角三十度、至東西道附近、傾角增至六十餘度、過此即近直立、繼復折爲南十五度東、傾角亦在六七十度之間、是可知此段岩層來復摺縐、較前爲緊逼也、最可注意者、即主要鑛脈、均發見於質地較爲鬆弱之千枚狀頁岩中、其走向與縐摺軸向亦相去不遠、至鑛脈生成之時期、與本區造山地動、是否同時、抑或有先後之分、雖難遽下斷語、然鑛脈之生成、與鑛區東北穿天塅附近所見之偉晶花崗岩、當有相當之淵源、查湘省中北部造山地動、據勘查所及、實與各處偉大花崗岩體之侵入有關、其時期或不出白堊紀末期及第三紀初期、本區造山地動、諒亦不致例外、由是以論本鑛鑛脈、既有關於火成岩之活動、則其生成時期、必緊隨造山地動之後也、

三　地層

本區內及其鄰近地層、據已見及者、有下列各層、茲逐層由下而上、分述於後、

(一)板岩　本岩質堅密、多呈條紋黑白相間之狀、查其始原成層甚薄、惟後或因地動劇烈影響、遂相互膠合而成厚層狀、本岩內常見石英細脈、貫穿其間、厚度雖未詳悉、然至少當在一百五十公尺以上、

且大部傾斜和緩、故溪流分割之處、多呈懸崖絕壁、蔚爲奇觀、

(二)千枚狀砂質頁岩　本岩色黃、內常夾含有輝銻顆粒之石英細脈、其風化後崩碎之岩塊、在久通公司新築後山坡脊上、隨處皆可拾見、本岩厚度約三十公尺、質地較板岩爲弱、故其構成之山脊、均較斜緩、

(三)板狀頁岩　本岩性質、頗與(二)類似、色亦黑白相間、惟大部較爲柔弱、且內常夾黃色砂質、風化後易沿層面及節理碎爲細塊、本岩厚度約二十餘公尺、由入砂道所採取之主要鑛脈、卽於此中發見、其與鑛脈接觸處、多呈翠綠色、表面膩滑、類似滑石、此外石英細脈、亦間見及、

(四)千枚岩及板岩　本岩成層甚厚、質亦堅強、故在境內多成高山峻嶺、顏色極其複雜、或黃或灰綠或灰白或灰藍、但以前二者爲最顯著、由東西道採掘之主要鑛脈、卽見於此種岩石之內、其與鑛脈接觸處、亦與前者相同、變爲類似翠綠色之滑石、本岩總厚、至少約在四百公尺及五百公尺之間、

(五)矽化板岩　本岩見於滄溪嶺南麓、色作灰白或灰黑、質地細緻、內常見石英細脈呈網狀穿入、其下部夾有炭質頁岩一薄層、總厚約在五十公尺及六十公尺之間、

(六)石英砂岩　本岩多作灰白色、中部夾有略帶稜角之燧石小卵石、非注意不易見、及厚度約六十公尺、

（七）板狀頁岩　色黑富含炭質、土人常以此作燒石灰之燃料、厚度約八十公尺左右、

（八）石灰岩　色深灰、質殊不純、多呈薄層狀、厚度未悉、

此役調查、專重鑛產、以致石灰岩以上之地層、未能再事追溯、一窺全豹、誠屬恨事、上述各岩層、就層次及岩性而論、與湘鄉岳陽及臨湘各處所見之奧陶紀下部地層、頗多類似之點、故暫統歸之於奧陶紀、惟以未得化石、確否尚待異日考證耳、本系地層在益陽境內分佈頗廣、自縣治經桃花江至板溪鑛山、所見盡是、在穿天坳附近所見之花崗岩及偉晶花崗岩、卽係侵入於本系地層內、該地在鑛山東北、相距約三十里、爲境內僅見之火成岩也、

第三章　鑛床

一　分佈

本區內地層分佈及地質構造、具見前章、至鑛床據已發見者而言、均呈脈狀、貫於千枚岩及千枚狀砂質頁岩中、而分佈於黑灣子萬家山臭石壠及虛谷菴近附一帶、但現在採鑛地點、僅黑灣子萬家山及臭石壠數處、虛谷菴附近、據云前十餘年公司曾從事採探、結果尙佳、祗以深處崇山峻嶺中、運輸困難、遂停工作、至此處鑛脈是否與黑灣子等處鑛脈相連續、抑係另一鑛脈、尙難斷定、然據地勢觀察、實有連續之可能也、此外與本區接壤屬安化縣境之大福坪、岡囊日亦在石英脈中、發見輝銻鑛、惟後以銻

價大落、鑛砂質量、又均欠佳、遂至廢棄、總之本鑛在本區周圍、如詳加探尋、或可另發見重要鑛床也、

二 鑛物

本鑛床內鑛物之組合、頗爲簡單、所稱爲鑛石者、除輝銻鑛外、只有少數黃鐵鑛、餘如金辰砂等鑛、與本鑛伴生者、均無所見、所謂脈鑛物者、全係石英、輝銻鑛呈塊狀、聚集於石英脈中部者、作鉛灰色、光澤不甚顯耀、成分亦甚低劣、且結晶微細、形體不明、有時非用放大鏡觀察、不易見此塊狀鑛石爲無數之針銳狀結晶體簇聚而成、其晶軸似與脈壁垂直、其呈細脈穿入於石英中者、光澤顯耀、質亦較佳、含銻可達百分之六十以上、鑛工每以生銻目之、其晶體頗不易見、惟解理殊甚明顯、在磨光面上、因反光作用、可見排列整齊之聚片雙晶片、(Polysynthetic twin laminae) 此外亦間有呈粒狀結晶者、大都見於石英脈壁邊緣、而與石英每成交錯之狀、上述各種、均屬原生硫化鑛物、至次生養化鑛物、如見於新化錫鑛山者、迄未發見、黃鐵鑛每成遊離晶體、包含於石英中、顆粒不大、且不常見、在本鑛床內、殊非重要成分、石英概呈塊狀、通常作灰白色、大都浮集於鑛脈之上部及兩旁、單個晶體、不易見、及各鑛物結晶之先後、最先當屬黃鐵鑛、其次石英、再次輝銻鑛、以是遂有黃鐵鑛成遊離晶體包含於石英內、而石英又爲輝銻鑛橫截而過之現象也、抑更有進者、本鑛床內、凡鑛脈較寬之處、鑛質較劣、反之則較優、且採掘彌深、成分彌佳、是亦大可注意之事實也、

三　形態

本鑛床屬於脈形鑛床一類、分佈尙具規則、在本類鑛床內、實殊鮮見、現已發見之主脈、計有二條、略近平行、一走向北五十四度——八十六度東、傾向西北、傾角約四十五至七十五度、已知之長度達二千英尺、寬度由一至二十英尺不等、是爲西北脈、一走向北四十一度——六十四度東、傾向西北、傾角約六十至九十度、已知之長度達一千六百英尺、寬度由五英寸至五英尺不等、是爲東西脈、二脈相距約有一千五百英尺、西北脈雖較東西脈爲長大、但鑛砂成分則較遜、含銻不過百分之二十左右、東西脈鑛砂含銻則可達百分之二十五左右、現已闢成之主要洞道凡三、卽入山道入砂道及東西道是也、入砂道以取西北脈之砂、東西道以取東西脈之砂、而以入山道貫通之、坑道及鑛脈情形、見後第二圖平面圖及截面圖、又附圖第一版A——B剖面圖、

四　成因

本鑛鑛床之成因、論者每以充塡鑛床（Fissure filling deposit）擬之、觀翁文灝先生於其所著中國鑛產誌略一百九十八頁（北平中央地質調查所地質專報乙種第一號民八出版）有根據衛勒及司卡夫二氏調查關於益陽板鑛一段之記載內云、「銻鑛床多充塡於裂縫、脈寬平均不過一尺半、然最寬處有達五尺者、脈中爲石英及石英與頁岩碎片所成之塊、石英多近於底壁、而墊以泥質之層、銻鑛

即聚於此……」然據著者等調查所得之結果、實未可與新化錫礦山銻礦床相提並論、且事實上亦與衛司二氏多有出入之點、茲逐一述之如後、(一)本礦主要礦脈有二、上述所云脈寬平均不過一尺中、然最寬處有達五尺者、此如單指東西脈而言尚可、如就全體而言則與事實相差頗遠、因西北脈最寬處、有達二十英尺者、最狹處亦在一英尺以上、(二)上云脈中爲石英及石英與頁岩碎片所成之塊、石英多近於底壁、然據著者等之觀察、石英則多居於脈之兩側及頂部、而銻則多集於脈之中央及下部、至沿脈壁之石英中間或包含滑石狀千枚岩塊、或係由於石英沿圍岩壁之罅裂縱橫穿入所致、不能即視爲充塡之徵、(三)與礦脈接觸一帶之圍岩、多呈綠色、表面膩滑、有類滑石、似曾受炙變及逼壓之影響、與遠處圍岩、迥然有別、(四)本礦區及其隣近岩層內、石英細脈、殊爲常見、內中亦間有含輝銻顆粒者、據是以觀、本礦不能與錫礦山銻礦相比擬、而視爲全由充塡作用而成、可知要之其生成當與穿入細花崗岩及偉晶花崗岩有關、以意推之、或當此岩漿尚未完全凝結之候、即有銻硫鐵及石英等混合礦液之分出、此種礦液、每乘地殼虛弱處、以覓容納之所、查附近一帶地層、適以板溪一隅、摺縐爲最激劇、破裂自當較多、大部礦液、遂得乘虛貫聚其間、而成重要礦床、觀今日之主要礦脈聚集之處所、均居於縐摺較爲劇烈之部可知也、當其侵入時、必備其相當之溫度、而可使與其接觸之圍岩變爲滑石之狀、且因比重不同、石英多浮於上部、故其侵入時、遂得與圍岩先行接觸而凝結、觀今日石英多

居於鑛脉之兩側及頂部、而錦則多聚集於中部、且常成細脈穿入於石英中、與前述各端、亦無不相符合也、

五　鑛量

本鑛開採迄今已歷三十餘年、關於銻砂及純銻等項產額、尙無精確之統計、又加簿册散失、稽考無從、以是欲知各項產額正確總量、以爲估計鑛量之叅考、實不可得、不過本鑛在前淸時、尙屬試辦時期、規模不大、產額有限、但歷時十餘年之久、綜合計之、當亦不少、茲姑假定在此時間內每年銻砂平均產額、約爲四千噸、當有五六萬噸之譜、迨至民國初年、併入華昌公司後、開採兼用西法、規模頓形增大、其時復值歐戰期間、銻價大漲、且爲供給華昌銻砂之唯一鑛山、出砂之旺、自可想見、自民三以至民八六年間、依彌時銻業情况推測之、每年銻砂產額、至少當在一萬噸以上、茲姑作一萬噸計之、當有六萬噸、惟自歐戰解决、銻價跌落、華昌虧累過鉅、遂至倒閉、本鑛因連帶關係、亦於民九停辦、直至十三年、始復興工、據公司報告、是年銻砂無產、僅產純銻一百五十三噸、十四年產銻砂一百六十噸、純銻七百噸、可知此兩年間所煉之銻砂、均係往年所採之剩餘、十五年出砂六千七百四十七噸、白養五百三十一噸、純銻六百九十九噸、十六年出砂一萬零三百四十六噸、白養八百四十九噸、純銻八百三十四噸、十七年每月可產砂千餘噸、純銻及白養各百噸、總計是年可產砂一萬二千餘噸、純銻及白養各千餘噸、故本

鑛自開採迄今、出砂總額、約計至少當有十四萬噸之譜、如照現在煉純銻一噸、約需銻砂六・二一噸情形計算、當已得純銻約二萬二千噸之譜、

本鑛鑛脈、計分東西及西北二脈、開採巷道、計分入山入砂及東西三道、已如上述、現各道開採、深者已達百公尺、淺者亦在七十公尺以上、查東西脉原長一千六百英尺、西北脉原長二千英尺、現假定可供採砂之長度、東西脉爲四百五十公尺、西北脉爲五百公尺、可供採砂之平均寬度、前者爲〇・六公尺、後者爲三公尺、可供採砂之深度、均假定仍有一百五十公尺、平均比重爲三・五、則東西脉之儲量、當仍有

3・5×450×0・6×150=141.750噸

西北脉之儲量、當仍有

3・5×500×3×150=787・500噸

總計東西及西北二脉、仍可採取銻砂之總量、當有九十二萬九千二百五十噸、由此冶煉純銻、照一與六・二一之比計算、當可得純銻一十四萬九千八百噸之譜、合計已採之銻砂十四萬噸、本鑛銻砂總儲量、當有一百零七萬噸之譜、可得純銻總量當有十七萬二千噸之譜云、

第四章　採鑛

鑛井

本山採鑛工程、從前純用土法、分東西前中四廠、自民國五年採用西法、首將前中二廠、闢爲入砂入山二洞道、(Tunnel) 及通達直井利達斜井 (Shaft) 等處、其計劃入砂道爲採取前中廠黑灣子山腹鑛砂之捷徑、入山道用以貫通前中東西四廠、爲全鑛之咽喉、總風水運爲一道、其地勢在本山爲最低、(較入砂道低百英尺) 直井專供將來採取地腹砂之總出路、位於入砂入山二道之間、斜井爲全鑛天然通風管、位於阿婆坑之巔、高出入山道五百二十英尺、其佈置窿路方法、(第二圖) 每平進相距一百英尺、開一橫巷、下一擦邊、(即Raise或Winze) 至高低相差五十英尺、開一平巷、爲小一層、相差一百英尺、開一大平巷、爲大一層、餘仿此、兩層之間、借擦邊聯絡上下、以便通風排水運砂卸土、民國六年秋、復開闢西入砂道、專供採取萬家山阿婆坑山腹鑛砂、爲東西二廠水路運輸總道、其地勢較入砂道高一百二十英尺、今名東西道、與入砂入山同爲本山三洞道、道內平巷分三大層、每層相距一百英尺、每大層又分爲二小層、相距五十英尺、現以氣壓鑽機延長入山道、經入砂道而達東西道、使三道連通一氣、以利鑛砂之搬運、其工程已通入砂道、距東西道僅二百公尺矣、

採法

本鑛開採方式、中西參用、多係蠶食留柱等法、對於較軟岩石、用鋼鏨鋼錘鶴嘴鋤鷹嘴鋤等器具、以人

力打成炮眼、裝以炸藥、轟開岩石、使成隧道、堅硬者用鑽岩機鑽成炮眼、然後轟炸、每日工作八小時、每人可鑽一孔至二孔、所用炸藥、分洋藥土硝兩種、洋藥係由德美購來現成製造品、用銅帽油引配合、土硝則用硝石百分之七十五、炭末百分之十五、及硫磺百分之十組合而成、每放一炮、可獲砂數十斤至百斤不等、現在採鑛塌入山道大三層十處、小四層十處、東西道十八處、入砂道二處、合計四十處、每日共約出砂三十餘噸、入山道佔三分之二、入砂道僅三 四噸、其餘則東西道所出也、鑛質以東西道所出、比較爲佳、茲將十六年每月所用炸藥引線數量及其價值、附列於左、以供參攷、

品名／月份	洋藥（數支）	價值（數元）	引線（數丈）
1	10,100	505	1,395
2	9,640	482	1,246
3	11,000	550	1,449
4	6,730	336	913
5	8,050	402	1,021
6	11,000	550	1,327
7	12,550	627	1,318
8	12,250	612	1,647
9	15,950	797	1,813
10	13,870	693	1,638
11	17,420	871	2,346
12	14,850	742	2,259
合計	143,310	7,167	18,402

運搬

價值（數元）	土引（數支）	價值（數元）	土硝（數斤）	價值（數元）	銅帽（數顆）	價值（數元）
10	35,000	90	320	603	10,050	209
11	39,000	119	425	581	9,690	187
9	33,000	73	260	660	11,000	217
3	11,000	28	100	404	6,730	137
5	19,000	22	80	474	7,900	153
3	11,000	14	50	663	11,050	199
3	11,000	17	60	774	12,900	198
6	20,000	42	150	738	12,300	248
3	9,000	25	90	952	15,870	272
5	19,000	53	190	850	14,170	250
7	25,500	67	240	1,125	18,750	352
1	4,000	6	20	1,014	17,400	339
66	236,500	116	1,985	8,868	147,810	2,761

本鑛洞道總路及各層平巷、均設二十四英寸軌間十六磅軌條輕便鐵道、以濟人力、惟各採鑛地點各處當頭所出砂硤、先由人工用兜箕扁担挑至各平巷總路、上桶推出、洞外亦有鐵路、故運砂卸硤、頗行便利、所用鑛桶、雖有形狀大小之不同、要其原理則概爲本身卸物是也、其名稱一爲荷葉桶、可容砂一噸、用諸地面、一爲大車桶、可容噸半、一爲小車桶、可容半噸、用諸各層及總路、據閆侯三道連通後、將於通達井安設吊車、所有鑛砂、概由入山道運出云、

支柱

本鑛隧路、概用杉木支撐、視壓力之大小、而定撐柱之粗細、對於傾瀉流沙之處、非杉木所能支住者。則用六寸見方或八寸見方松木、以爲之撐、撐式有三皮四皮溜樹中點八方等名、三皮用於頂堅之平巷、四皮用於擦邊、溜樹中點、不過用於岩石碎瀉之處、以爲三皮四皮之補助、八方撐用於總分巷各分路口、抵制猛烈壓力、茲將十六年每月所用杉木支數列表如左、（平均每支合洋六角左右）

月份 \ 品名	杉木（數支）
1	3,166
2	3,563
3	4,597
4	2,691
5	3,097
6	3,458
7	3,544
8	4,171
9	4,128
10	4,057
11	3,800
12	5,410
合計	45,682

通風

本鑛採用天然通風法、新鮮空氣、係由利達斜井導入、局部間設風箱、用人力手搖打風、以補天然通風之不足、

排水

本鑛排水機力人力並用、大二層設有雙心抽水機兩部、一層三層之水、均導由此處排出、其他則多用孔明車、以人工車水、

燈火

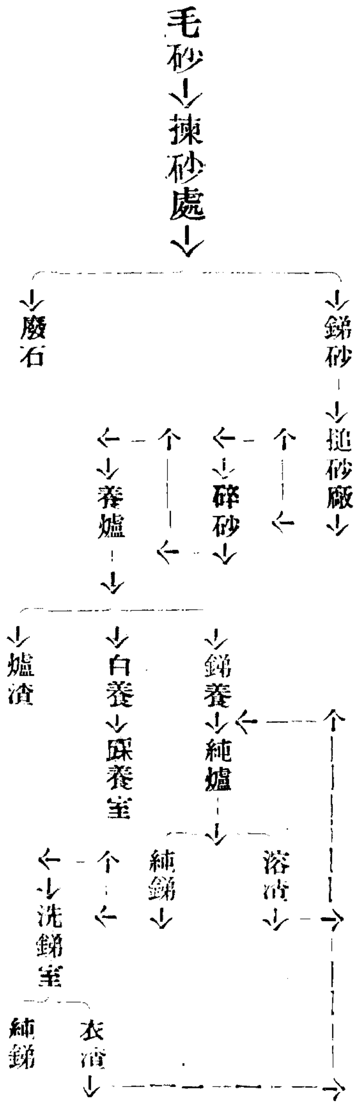
隧內燈火、用洋鐵皮明燈、以茶油發光、左表爲十六年每月使用茶油數量及其價洋、卡擺燈（即水熱電燈）間亦用之、刻正製造乾電蓋將兼用手電也、

月份 / 品名	茶油（數斤）	價值（數元）
1	5,470	1,094
2	5,295	1,205
3	4,540	1,135
4	4,460	1,249
5	4,010	1,123
6	3,892	1,089
7	3,962	1,109
8	3,873	1,084
9	5,290	1,428
10	3,995	1,079
11	4,810	1,299
12	4,733	1,278
合計	54,330	14,172

第五章　煉鑛

煉鑛程序

鑛砂由窿內取出、先在窿外揀選後、挑至煉廠旁之搥砂廠、由搥砂工搥成一至二英寸徑之碎塊、送至爐頂平台、和以白炭及焦煤、入養爐煉成銻養、爐渣完全廢棄、所得之銻養、潔白純粹而爲輕鬆粉末者、即入踩養室、打包上市、其色雜不純而含塊粒者、和以曹達及白炭、入純爐煉純銻、茲更將冶煉程序、列表如次、



一　銻養之冶煉

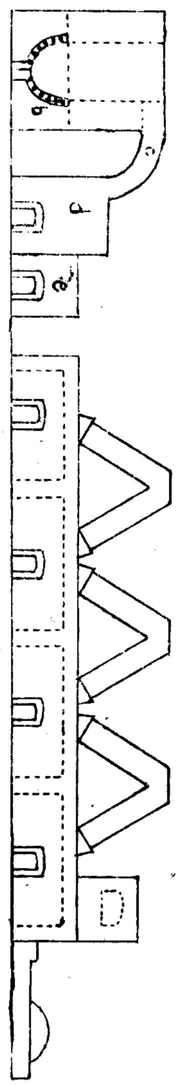
銻養分銻養三、銻養四兩種、前者揮發、後者固定、性質不同、冶煉之方法亦異、本鑛成分平均含銻百分之二十二三、因適用於哈倫許密德氏蒸餾煉銻法、故煉成者爲銻養三、茲將其煉爐及煉法、分別述之

如左、

煉爐　煉廠內設煉爐八座、當本年六月著者等調査本鑛時、只六座應用、其他二座、正値修理、擬完竣後卽開工、故得乘機將其內外尺寸過量、繪圖(第三圖)如左、

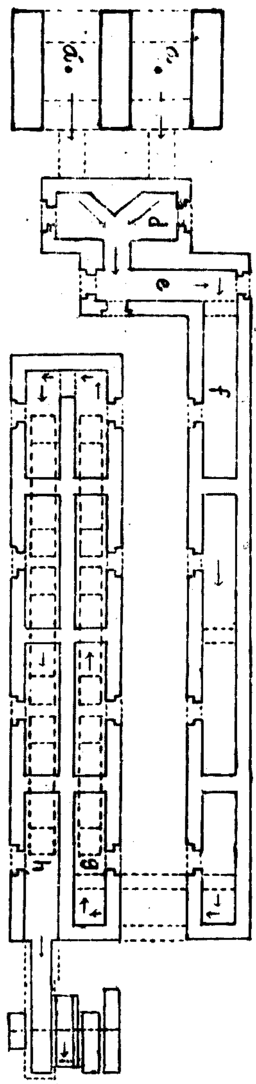
如圖煉爐每座、係由熔爐兩口、凝積室五間、風扇一架、組合而成、又凝積室最後兩間、上面裝置人字形冷凝管八個、熔爐A或A'、爲一耐火磚造成之正方柱身、爐底鐵柱B、爲數十二、排列如圖所示、爐頂當中小孔、爲物料加入之處、靠頂前面曲管C、爲引導瓦斯入冷凝系統之路、凝積室末端之風扇I、一經電力發動機撥轉後、則熔爐內之瓦斯、卽被吸而入冷凝系統、經由風扇、受壓力而至地下烟路、以達最後之木製凝積室、同時熔爐外之空氣、乘勢由爐底流入、使養化作用、進行不已、

煉法　煉爐每座、於二十四小時內可煉銻砂五噸、分十六次加入爐內、每次取碎砂約七百磅、和白炭百分之八、及焦煤百分之六、由工人在爐頂平台攪勻後、用鐵鏟從二熔爐頂上小孔、分配裝入、因燃料中所含炭質、需要養氣、故爐中大氣、不能連續作劇烈之養化作用、所成之銻養、乃爲銻養三而非銻養四、銻養三受熱揮發、連同爐內所產生之養化硫及養化炭等氣體、由曲管C入冷凝系統、次第經過凝積室D E及F、其進行狀態、爲一蜿蜒起伏之路線、當瓦斯經過此等凝積室時、其中銻養三、受冷凝固、隨時聚集、猶含雜質百分之二十五左右、大抵爲爐中鑛砂之微粒、及燃料之灰燼、其餘瓦斯、仍本其蜿



第三圖

Fig.3 Scale 1:160

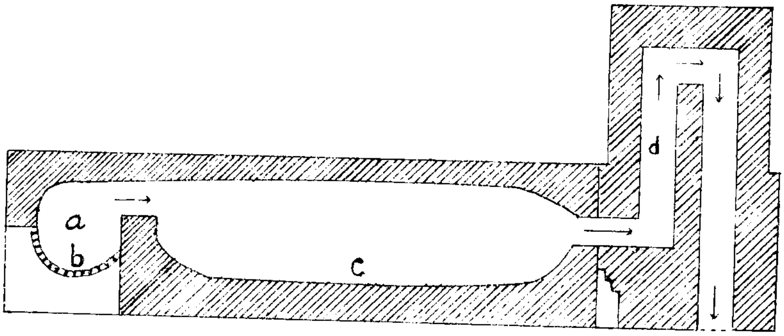


蜒上下之路程相繼入人字形冷凝管及凝積室G及H、此等處所聚集之銻養三、甚爲純碎、各凝積室均開設小門、用銻養三密切封閉、可按時啓闢、以取銻養三、自是瓦斯乃經由風扇I、受壓力入地下烟路、而達木製凝積室、以收取其中銻養三之最後部分、計自物料入爐、約經一點三十分鐘、養化凝積、即可次第完成、第二次物料、又可加入、故每二十四小時內、可下物料十六次、依每次七百磅計算、每日可煉砂五噸、由各凝積室以及烟路等處、平均可收取銻養一・一五噸、（根據養爐報告平均銻砂每百噸可煉銻養二―三噸） 其色白質純、爲輕鬆粉末、成分在百分之九十八以上、直接送入踩養室、打包上市、所稱爲白養者、約佔半噸、又依煉爐六座計算、每日共可煉砂三十噸、得銻養六・九噸、白養佔三噸、而每噸銻養約須煉費三十六元云、

二　純銻之提煉

由上觀之、每日所煉成之銻養六・九噸、除白養三噸外、其餘二・九噸、色既不白、且塊粒夾雜、祇能作提煉純銻之用、純銻煉爐、與銻養煉爐、建在同一煉廠內、共有四座、現只兩座應用、左圖（第四圖）即其一也、

煉爐依反射爐之結構而造成、內襯火磚、外圍鐵板、火門係花格鐵柵、填砌火磚、烟路由上行折向下行、而入地下烟道、與銻養煉爐、同入烟囪出氣、如圖A爲火箱(Eire--box) B爲爐橋、共三十根、C爲爐缸、



第四圖

Fig. 4 Scale 1:60

(Hearth) D 爲烟路、兩旁各開鐵門二、寬十八英寸、高十四英寸、爲物料加入熔銻取出之用、爐中空氣、係從爐橋下自然流入、

煉法　煉爐每座、於二十四小時內可煉銻養二噸、分二次加入、每次取銻養三約一噸、和白炭百分之二十及曹達百分之四、由工人在爐側攙勻後、用鐵鏟裝入、白炭爲還原劑、曹達爲熔劑、燃料用煙煤及松柴、火焰入爐、卽從弧形爐頂、向下反射、物料受熱熔解、白炭與銻養中之養氣化合而成二養化炭氣、銻養還原而熔成質純銻、沉積下層、曹達與銻養中之廢質(Gangue)造成熔渣(Slag)浮於上面、一以防阻銻養三之揮發、並保護熔銻免致復行養化、一以融去其所夾雜硫化銻及其他金屬硫化物、使熔銻純淸、同時二養化炭氣、連同少量揮發銻養、由烟路逸出、自物料入爐、約經十

二小時、還原作用、即可完成、遂由工人開放爐門、先用長柄鐵瓢舀出熔渣、然後將熔銻舀出、傾入鐵製模型、使之凝固、但熔銻未舀之前、須取曹達及白養各原物料之百分之十、謂之衣料、加入熔銻上面、俾純銻結晶遲慢、而生鳳尾草狀之花樣、以顯其成分之純粹、純銻凝結後、送入洗銻室、敲去衣渣、裝箱上市、成分在百分之九十九·二以上、熔渣及衣渣、仍須入爐提煉、以取其餘銻、所得純銻、約爲〇·七噸、(根據純爐報告平均銻養每百噸可提純銻七十噸)計每爐於二十四小時內可煉銻養二噸、得純銻一·四噸、煉爐二座、共可銻煉養四噸、得純銻二·八噸、而每噸純銻由銻養煉成、約須煉費三十元云、

綜觀上述各節、銻砂五噸、煉銻養一·一五噸、除耗失不計外、因銻養百分含八三·三五分、故一·一五噸銻養含銻〇·九五八噸、以銻砂五噸除之、再以一百乘之、即得銻砂含銻之百分數爲一九·一六、但銻養一噸僅煉純銻〇·七噸、是則一噸純銻、須一·四三噸銻養、即須六·二一噸銻砂、因之銻砂含銻之百分數變爲一六·一二、此百分之三·〇四(即一九·一六減一六·一二)銻、完全係提煉純銻時所耗失、若再加以銻養冶煉時之耗失、則其耗失總計當達百分之六七、(即每百噸銻砂耗失純銻六七噸)故著者謂本鑛成分、平均含銻百分之二十二三、苟能改良煉法、減少耗失、至多銻砂五·五噸、即可煉純銻一噸也、

第六章　運輸

本公司設入山道望三洲沾溪桃花江益陽五轉運處、入山道爲全山進物出貨之總樞紐、運物至山廠各處、及各出廠貨、均須挑力、每噸須費二角、入山道距望三洲二十里、有二十四英寸軌間二十四磅軌條輕便鐵道、用人力推車、大車桶每車可裝貨噸半、荷葉桶可裝貨一噸、進物則以煤米爲多、每噸需費一元、由望至沾溪四十餘里、春夏水漲、可用小船、秋冬水涸、則用竹簰、每噸需費一元七角、由沾運長沙、帆船甚多、四時可通、每噸需費三元六角、即由省由益運往山廠物料食品等項、亦可按時至沾、絕無滯礙、但如在益改用小輪拖省、則每噸需費一元四角、而沾益間之運費、每噸需一元二角、故總共純銻或白養運省、每噸需費五元五角至六元五角、

第七章　工人

本鑛自開辦以來、對於開巷打砂揀砂搥砂等工作、概係包工制、對於運輸及機械工人、則多半係點工制、工作時間、每日八小時至十小時不等、茲將本年四月改組後、工人數目、及每人每月所得工資、列表如次、

種類	人數	每月所得工資（圓）
採鑛工人	三六〇	九・六——一二
抽水工人	二四〇	一〇・八——一二

運輸工人	二二〇	九・六—一二
揀砂工人	二五	一八・〇—二一
搥砂工人	四二	一五・〇—一八
煉鑛工人	一一二	一八・〇
豚養工人	四	一八・〇
洗銻工人	三	九・〇
裝箱工人	二	一二・〇
推車工人	六五	二四・〇—二七
機械工人	二九	一二・〇—六〇
泥工	一四	一〇・八
土工	八〇	九・六
木工	四〇	一〇・八
鐵工	三	一五・〇
篾工	三	九・六

白養打包、係用脚踩、純銻去衣、係以錘敲、上表所列踩養及洗銻工人、其工作指此、

第八章　設備

本鑛煉廠及修理房所用原動力、均爲電力、而電機房各種機器、則係用蒸汽發動、茲將各處機件、列表如左、

地點	種類	個數	備考
鍋爐房	一百五十馬力立式赫因水管鍋爐	二	祇用一個平均每日燒烟煤四噸左右
同右	進水打水機	二	
同右	修藍機	一	
電機房	發電機	一	五百四十五安培六十啓羅瓦德一百一十弗打每分鐘約轉六百次
同右	空氣壓縮機	一	可供八鑽
修理房	車床	二	一長十五尺一長六尺
同右	鑽床	一	
同右	刨床	一	
同右	手搖打磨機	一	

同	右打孔機	一	
同	右電力發動機	一	
同	右老虎鉗	八	
煉廠	電力發動機	二	

第九章　產額及經費

產額

本鑛出產、從前盡屬銻砂、當民國九年停辦之時、表冊記載、散失殆盡、因之歷年產額、無所稽攷、然其總額約爲十二萬噸、自民國十三年、就山設爐冶煉白養純銻、銻砂不復售出矣、現在每日可產砂三十餘噸、煉白養三噸、純銻二・八噸、第四第五兩章、曾分述之、是則年出白養純銻、各在千噸上下、茲將自民國十三年起、至十六年止、各年產額及成本、列表如左、

年份	銻產噸數			採砂經費(元)	銻產每噸成本(元)		
	銻砂	白養	純銻		銻砂	白養	純銻
十三年	無	無	一五三				
十四年	一六〇	無	七〇〇	未詳	未詳		未詳

十五年	六・七四七	五三一	六九九	二二三・四二二	三三	一八〇	二八七
十六年	一〇・三四六	八四九	八三四	三九〇・七一二	三七	一九七	三一〇

備考　民國十三年十月、開爐提煉存砂、出產全屬純銻、故是年表內各項、無從塡註、十四年十月、始採新砂、煉品仍爲純銻、十五年所採銻砂、悉供冶煉白養純銻之用、十六年出砂、除供提煉外、存砂千餘噸、白養及純銻成本係按照第五章內所述其每噸所需砂量及煉費計算而得、

經費

經費最多者、爲工資及材料、次爲轉運處煉廠及特別費、又次爲雜支薪水及保鑛團、茲將民國十六年下半年每月經費列表如左、以資參攷、

摘要／月份	7（單位元）	8
職員薪水	706	717
工資	25,979	26,427
職工會	341	336
保鑛團	750	394
煉廠	1,033	971
轉運處	3,402	3,683
材料	10,620	12,126
機件	910	519
拖費	329	352
旅費	148	99
雜支	826	773
消耗	1,320	218
醫藥	130	76
撫卹	0	0
津貼薪金	502	12
特別費	467	220
合計	47,463	46,923

9	10	11	12	合計
798	798	798	798	4,615
29,719	33,585	32,692	33,013	181,415
331	328	328	328	1,992
463	463	837	900	3,807
1,204	1,249	1,355	1,652	7,464
3,616	5,354	3,411	4,682	24,148
13,685	14,485	13,048	16,013	79,977
510	502	485	520	3,446
517	452	270	360	2,280
83	70	13	124	537
639	849	754	1,163	5,004
537	499	138	563	3,275
6	8	14	3	237
30	0	0	5	35
103	0	0	398	1,015
2,620	720	1,232	798	6,057
54,861	59,3[illegible]2	55,375	61,320	325,304

按經費十五年僅三十三萬數千元、十六年受時局影響、成立工會、工人既加、開支自大、遂增至六十餘萬元、雖產額亦隨之增多、然終不足以成比例、觀是年銻砂每噸成本、較十五年高四元、可知其得失、幸自本年四月改組、竭力整頓、此後出砂一噸、可望不滿三十元云、

第十章 銷路及市價

我國工業、方在萌芽、銻之銷場、多在外國、尤以美國爲最多、故欲明銻市情形、不可不知美國市價、茲將民國元年至十六年間紐約每年平均純銻市價、列表如次、

年次	每磅市價（單位美金分）	年次	每磅市價（單位美金分）
民國元年	七•七六〇	民國二年	七•五二〇
民國三年	八•七六三	民國四年	三〇•二八〇
民國五年	二五•三七〇	民國六年	二〇•六九〇
民國七年	一二•五八一	民國八年	八•一九〇
民國九年	八•四八五	民國十年	四•九五七
民國十一年	五•四七一	民國十二年	七•八九七
民國十三年	一〇•八三六	民國十四年	一七•四九四
民國十五年	一五•九八八	民國十六年	一二•三九三

至長沙市價之漲落、大都隨外國市場需要量之多寡爲轉移、然亦恆有本地商人、乘機操縱、以致銻價自行漲落、但不能持久耳、茲將民國十五十六十七三年、長沙每月平均純銻市價、列表如次、

月別＼年別	十五年	十六年	十七年
一月	$650	$360	$285
二月	750	370	290
三月	700	350	280
四月	680	350	270
五月	650	350	310
六月	650	350	280
七月	670	350	274
八月	660	320	290
九月	620	285	296
十月	500	295	285
十一月	460	280	268
十二月	450	285	260

第十一章　結論

一，連合貿易

本鑛蘊藏尙豐、設備漸全、前途希望、未可限量、祇以吾國工業不振、經濟落後、銻之銷塲、全恃外洋、致售價漲落、每受外人操縱、歷年損失、數已不貲、近復有一般奸商、仰外人鼻息、買空賣空、從中把持、勒抑銻價、遂造成今日銷塲疲滯價額日落之現象、使一般營銻者、均有岌岌不可終日之勢、夫銻之一物、在世界上吾湘幾占獨有之利、今不惟不能盡量發展、以左右世界之市場、且反受外人挾制、而呈疲滯不振之狀、良可慨也、現省政府對於買空賣空之奸商、雖已有澈底取締之嚴令、尙須希望各鑛當局者、能仰體斯意、放大眼光、切實聯絡、公開貿易、俾一切奸商、無所覬覦、庶幾有豸、如能進一步共同在省組織一連合貿易所、將各鑛所有產品、均交該所直接貿易、當更可收周轉相維之效、是則不能不有望於各鑛

當局者鞭猛省、好自爲之也、

二，改良煉廠

本鑛最大特點、即就鑛設廠、倣照從前華昌公司煉銻之法、自行冶煉純銻及白養、此種設計、不惟貨物裝運起卸、省時省財、而採冶兩方亦得斟酌盈虛、通籌並顧、不至一則停滯坐損、一則作輟靡常、此在吾湘今日經營各鑛中、最足資效法之處也、惟煉廠設備至今日尚多遷就、冶煉方法亦欠精密、以致純銻產品成分只能達百分之九十九・二以上、不能與英國科克遜公司（Cookson Co.）產品競爭於市場之上（該公司純銻產品成分能達百分之九十九・九）此亦爲吾國銻業受制之一大原因、又加煉時耗失甚多、據煉鑛章中計算、由銻養提煉純銻、耗失已達百分之三以上、如就銻砂冶煉純銻而言、則其損失總計當在百分之六以上、（即由銻砂冶煉純銻每百噸銻砂損失純銻約在六噸以上）匪惟可惜、且與本鑛前途關係甚巨、攷厥可供研究之處、約有數端、（一）大凡用哈倫許密德氏法以煉銻養三者、多於瓦斯未至烟囱之先、使之經過一塔、其中滿貯焦煤或陶器、上設水管、下建水池、俾瓦斯上升之際、其中最後部分銻養三、被水溶解、沉積池中、可以盡量收取、提煉純銻、本廠未見備此、僅以內襯火磚之木製凝積室代之、故烟囱排出之氣、每含銻養、白霧迷漫、嗅氣可辨、是則非獨有關經濟、而且影響衛生、不可不加以注意者也、（二）爐渣（Slag）之成分、關係於冶煉方面者至巨、治金者常以之更正其爐

料(Charge)之配合、及煉術之運用、必須一再化驗、至達所定限度而後已、且化驗每與冶煉相終始、不宜偏重、本廠冶煉銻養時所出之爐渣、爲量極多、未經化驗、完全棄置、其中成分如何、含銻若干、既不可得而知、則支配爐料與斟酌煉術、未必能恰如分際、盡善盡美矣、耗失之大、或職是故、亦不可不加以注意者也(三)柱狀熔爐(Shaft furnace)上面、多係鐘式頂蓋、開閉自如、爐料入爐時、爐中瓦斯逸出有限、所以減少失耗而增加產額也、本廠銻養煉爐、頂各二口、每日爐料入爐、凡十六次、當此之時、頂口洞開、爐中含銻養成分最富之瓦斯、乘勢冲出、不可向邇、爲時頗不短、合全廠各爐觀之、此種耗失、豈在少數、亦不可不加以注意者也、夫欲業務發達、必先求出品精良、而後銷場方可推廣、尤必先求成本減低、而後產額方可增加、是以本鑛關於煉廠設備及冶煉兩項、不能不亟起直追、設法改良、以圖補救於萬一也、

三，添設吊車

本鑛開採、多用西法、在吾湘銻鑛中、亦係一大特色、現巷道共計凡三、長者達二千英尺、短者亦在一千六百英尺以上、深均達三百英尺、惟尙無吊車之設、各道在各處所出鑛砂、仍須人力挑至各平巷總道、方能上桶、沿鐵軌推出、不惟不便、且亦不甚經濟、聞公司方面、對此亦甚注意、擬於三道貫通後、於入山及入砂二道間、加開吊井、添設吊車、以爲各道進出之總樞、著者等惟有祝其從速觀成而已、

GEOLOGICAL SURVEY OF HUNAN

C. P. LIU, Director.

BULLETIN 5. ECONOMIC GEOLOGY 3.

REPORT ON THE PAN-HSI ANTIMONY MINE, YI-YANG, HUNAN

BY

C.C.TIEN, S.Y.KUO and H.C.WANG

CHANGSHA, HUNAN

1928

Report on the Pan-Hsi Antimony Mine,

Yi-Yang, Hunan

(Summary)

TABLE OF CONTENTS

Report on the Pan-Hsi Antimony Mine.

Yi-Yang, Hunan.

(Summary)

By C. C. Tien, S. Y. Kuo, & H. C. Wang

LOCATION AND HISTORY

The Pan-Hsi Antimony Mine, (板溪銻鑛) which is one of the most important mines of its kind in Hunan, is situated 135 li south-west of the city of Yi-Yang Hsien (益陽縣). It is 75 li distant from Tao-Hua-Kiang (桃花江), a tributary of the Tze River (資江), and 20 li from Wan-San-Chou (望三洲) connected by its own light rail-way, wherefrom there is a distance of over 40 li to Chan-Hsi (沾溪). From Chan-Hsi by way of Yi-Yang to Changsha, it is about 350 li, of which nearly one third is communicated by Chinese junks while the other part from Yi-Yang to Changsha is navigable by steam boats throughout a greater part of the year, except during low water season usually in winter. Hence the mine is very inconveniently located so far as transportation facilities are concerned.

The mine was first operated in the end of Ching dynasty by the Hunan Provincial Mining Board without good results. In 1900, the 26th year of Kuang-Hsu, Mr. H. K. Liang took it over and organized a company by the name of Chiutung, (久通) operating improvingly to some extent, till the establishment of the well known Huachang (華昌) Company when Mr. Liang, being the representative of Chiu-tung, took part in it with all of Chiutung as the share-capital of Huachang. In the course of the Great World War, as antimony was greatly needed and the Company was very prosperous, modern mining practice was introduced in place of old methods and a light railway between the mine and Wan-San-Chou was built. The Company then advanced in the pursuit of anything more desirable than before. Nevertheless, in 1920, the mine stopped operation because Huachang was bankrupted due to the great, sudden drop of antimony price immediately after the close of the Great War, resulting in a heavy loss of money. It was in 1924 that the share holders of Chiutung together with the creditors of Huachang re-opened the mine, establishing a new company by the name of Weiyi-Chiutung (維益久通). Furnaces were then built and the work of mining and smelting went on continuously and successfully.

TOPOGRAPHY AND GEOLOGY

As shown by a glance at the map (Plate 1), the Pan-Hsi antimony field exhibits a very rugged surface with innumerable hills and ridges projecting above deep valleys. The hills mostly rise up to a height of about 700-800 meters and often show precipitous peaks and cliffs. Among the valleys in the mining region, however, the largest and deepest is Pan-Hsi which runs out from Tsang-Hsi-Ling (滄溪嶺) and thence extends in a general direction of NNE to meet with Chan-Hsi, about 60 li NNE of the mine. It is along this valley that a light railway was built by the Company from the mine to Wan-San-Chou, about 20 li long. The great features of the landscape have a general trend of NEE-SWW, following the strike of sedimentary rocks.

In the mining region, the bedrock is built exclusively of sedimentary rocks, probably Ordovician in age. As shown in the Pan Hsi vicinity they are chiefly represented by slate, phyllitic sandy shale and phyllite, folded along the chief tectonic axis of NEE-SWW into a series of anticlines and cynclines the slopes of which dip some 6°-70°.

The sequence of the strata as far as we have observed in the mining region and its neighbourhood can be given in descending order as follows:

8. Dark gray or light gray, impure limestone, mostly thinbedded. Thickness unknown.

7. Slaty, carbonaceous shale, about 80 m. thick.

6. Grayish white quartzose sandstone, carrying in the middle part small and not well-rounded flint or chert pebbles. About 60 m. thick.

5. Siliceous slate, intercalated in the middle part with a thin layer of carbonaceous shale, about 50-30 m. thick.

4. Slate and phyllite, about 400-500 m. thick. Nearly in the middle part of these rocks occurs the well-known vein Tung-Hsi-Mei (東西脉) which now produces the best ore in the mining region.

3. Slaty shale, usually showing white and black bands in alternation and frequently containing yellowish sandy shale, about 30 m. thick. The main ore vein, i. e. Hsi-Pei-Mei, (西北脈) occurs in it.

2. Yellowish, phyllitic sandy shale, about 30 m. thick, The small quartz veins occasionally carrying stibnite grains are not unfrequently found in it.

1. Massive, hard slate, occasionally cut through by small quartz veins and generally showing an alternation of white and black bands. Thickness estimated at least to be more than 150 m. even its lower limit unobserved.

Near Chuan-Tien-Ou, (穿天坳) about 30 li NE of the mine, we found the same beds, slate and phyllite, intruded by a big mass of granite or pegmatite granite. It is the only occurrence of igneous rock as far as we have observed in the surrounding region of the mine.

ORE DEPOSIT

Distribution: - The distribution of the antimony deposits in the mining region may be divided into the following groups or ridges:

1). Hei-Wang-Tze (黑灣子) ridge.

2). Wan-Chia-Shan (萬家山) ridge with its extension Su-

Shih-Lung (臭石壠).

3). Hsu-Ku-An (虛谷菴) ridge.

At present, the mining places are all confined to the first two ridges.

Mineral Association; - The ore minerals belong, as far as we have found, exclusively to the primary sulphides of antimony, viz. stibnite, the secondary oxides as valentinite or cervantite which are not unfrequently found in the Ch'ang-Lung-Hua antimony mining field of Hsi-Kuan-Shan, Hsin-Hua, being entirely absent here. Stibnite chiefly occurs either as very small acicular crystals or as medium grained masses interlocked with quartz. Besides, it also sometimes occurs as veinlets cutting through the quartz. The latter is the only gangue mineral, generally occurring as white to grayish white densive masses; its crystals have so far not been found. Except some pyrites that occur as small grains scattered in the quartz, indeed no other associated minerals such as gold and cinnabar have so far been observed.

Occurrence and Origin: - The ore deposits, as already mentioned, all occur in the form of well-defined veins and are practically confined to the folding part of the slaty or phyllitic shales and phyllites (Plate 1, Sec. A-B in Chinese text). Up to the present time, two main ore veins called Hsi-Pei-Mei and Tung-Hsi-Mei respectively, have so far been discovered. Hsi-Pei-Mei is about 2,000 feet long by 1-20 feet wide, trending N 54°-85° E with a general dip toward NW at an angle of 45°-75°. Tung-Hsi-Mei is about 1,600 feet long by O. 5-5 feet wide, running N 41°-61° E with a general dip also toward NW but at an angle ranging from 60° to 90°. The distance between the two veins is about 1,500 feet apart. Up to the present time, they both in many places have been mined downward to a depth of 300 feet and have produced as a total not less than 22,000 tons of antimony, equal to about 140,000 tons of raw ore. In general, the ore mined form Tung-Hsi-Mei is rather better in quality than that from Hsi-Pei-Mei (In average, the former contains about 25%, and the latter about 20%, of antimony).

At last, some facts regarding the origin of the deposits may be noted as follows:

1. The country rocks such as phyllites or phyllitic shales near the contact with the ore veins often show the appearance of talc.

2. The ore stibnite also occasionally occurs as small grains scattered in the small quartz veins which cut through the said country rocks sometimes in form of veinlets.

3. The ore stibnite generally occupies the inner and lower part, while the gangue quartz occupies the outer and upper part, of the veins.

In view of these named respects, apparently the antimony deposits of the Pan-Hsi mining field can not be taken only as fissure filling as what A. S. Wheler and others have referred to. However, it seems very likely that the deposits in question would be connected to the granite or pegmatite granite activity occurring at Chuan-Tien-Ou, which took place probably accompanying the tectonic movements of the Latar Cretaceous or the Early Tertairy.

Ore Reserve:- According to the calculation on page 15, Chinese text the total quantity of ore in the two main veins amounts to about 172,000 tons of antimony, equal to about 1,070,000 tons of raw ore. Of the figure 172,000, only about 22,000 tons of the pure metal, equal to about 140,000 tons of ore, have been removed, leaving a quantity of about 150,000 tons of metal for future exploition.

MINING.

The mine has thus far altogether three tunnels, named Tung-Hsi-Tao, (東西道) Ju-Sha-Tao (入砂道) and Ju-Shan-Tao (入山道), and two shafts of which one is vertical called Tung-Ta (通達) and the other inclined called Li-Ta (利達) respectively (Fig 2 in Chinese text). Tung-Hsi-Tao, laid out for exploiting the ores of Wan-Chia-Shan (萬家山)

and A-Po-Kong, (阿婆坑) is located 120 feet higher than Ju-Sha-Tao which is the short cut for extracting the ores of Hei-Wang-Tzo(黑灣子). Ju-Shan-Tao is now being driven by compressed air drills for the purpose of connecting Ju-Sha-Tao to Tung-Hsi-Tao and will be finished in a short time. It is of prime importance to the whole mine in regard to ventilation, pumping, and underground transportation. Hence its position is very low, being about 100 feet lower than Ju-Sha-Tao. Between Ju-Sha-Tao and Ju-Shan-Tao there lies the vertical shaft that will be the main outlet of ores after connections of the tunnels shall have been made. The inclined shaft is located at the summit of A-Po-Kong, about 300 feet higher than Tung-Hsi-Tao, serving as a ventilation winze. Below Ju-Sha-Tao there are three levels called 1st, 2nd, and 3rd level at depths of 100, 200, and 300 feet respectively. Midway between Ju-Sha-Tao and the first level and between the levels themselves sub-levels have been driven which are connected to the levels by inclined raises and winzes. There are four sub-levels altogether up to the present.

The ore is mined by open stoping. Drilling is entirely done by hand, Timbers are little used, most of them being fir wood. In 1927, the total cost of timber amounted to about $27,000. Two kinds of explosives, imported and native, are used there, the latter consisting of 75% potassium nitrate, 15% charcoal, and 10% sulphur, but used only in a very small amount. In 1927, more than $18,000 were paid for the imported explosive and about $170 for the native one; hence the annual consumption of the former is over ten times that of the latter. One or two drill holes which is about the work done by a miner in an eight-hour shift, is fired or are fired at the same time, producing 80 to 100 catties of raw ore. As a rule, ores coming from Tung-Hsi-Tao are better in grade than those from Ju-Sha-Tao and Ju-Shan-Tao, though Ju-Shan-Tao yeilds the greatest production. In all the levels and tunnels a 16-lb rail track was laid or built. The ore mined in the stopes is loaded by shovelling into baskets which are carried on shoulders to the tunnels where it is transfered into cars and then pushed out. Daily production of raw ore reaches 30 to 40 tons at present.

Ventilation is conducted by natural draft, Li-Ta shaft serving as the up or down cast of the whole mine. Underground reservoirs were constructed in the 2nd level wherefrom water is pumped to the surface by two steam pumps.

Formerly underground workings were lighted by electricity, but on account of the frequency of breaking lamps through the carelessness of the miners a kind of native oil called "Cha-Yu" is now used instead.

SMELTING

So far as the metallurgical process is concerned, there are two successive steps, i.e., the preparation of volatile antimony trioxide and the extraction of antimony from the trioxide.

In the first step, antimony trioxide is prepared by Herrenschmidt process. The plant (see fig. 3 in Chinese text) employed for this process comprises two furnaces in which the oxidizing roasting is carried on, five collecting chambers, one fan, and finally a series of wooden collecting chambers.

The furnace A or A' is a square shaft of fire brick with a step grate of 12 iron bars B, arranged as shown, and with an opening on the top, for receiving charges and another one on the front, near the top, to which is fitted a pipe C for conducting the gases to the condensing and collecting system.

The condensing apparatus consists of two transverse chambers D and E and three longitudinal chambers F, G, and H of which the last two are set over with eight inverted, v-shaped tubes, as illustrated in the figure. At the end of these chambers is a fan I, which is rotated by an electric motor so as to draw the gases through the system and force them through the underground flue into the last collect'ng chambers. Moreover the air takes the chance to enter the furnace much easily as soon as the fan is set in motion.

As for the operation, the ore coming from the mine is transported to a shed beside the plant, in which it is hammered to from 1 inch to 2 inches in size from which the dust and fine particles are separated by shifting. These are all done by laborers. The broken ore is then carried to the charging platform of the furnace, and an amount of 700 pounds of it is charged at one time into the furnaces A and A', mixed with 8 percent charcoal and 6 percent coke.

The atmosphere in the furnace is not excessively oxidizing, due to the carbon in the fuel, hence the antimony sulphide is oxidized to trioxide, Sb_2O_3, and not to tetroxide, Sb_2O_4. The trioxide volatilizes and passes out of the furnace together with the gases from the fuel through the pipe C to the condensing and collecting chambers D, E, and F in an up and down way. The oxide which is collected in these chambers, as the temperature falls, is generally contaminated with about 25 percent of impurities, chiefly dust from the ore and ashes from the fuel in the furnace. From these chambers the gases traverse successively the inverted v-shaped tubes and chambers G and H still in an up and down manner, in which the oxide is condensed and deposited in a pure form. Finally the gases enter the fan I and are forced through the underground flue into the series of wooden chambers wherein the last portion of the oxide is collected.

About one hour and half after the first charge has been made, oxidation, condensation, and deposition are successively completed and another chargee is made. Hence in 24 hours, 16 charges can be made, that is, 5 tons of raw ore can be roasted in two furnaces. The antimony trioxide thus obtained in the collecting chambers and flue amounts to 1.15 tons of which 0.5 ton is pure and called the "white oxide". There are 12 furnaces in operation, so that 6.9 tons of antimony trioxide can be obtained from 30 tons of raw ore per 24 hours and 3 tons of the oxide is relatively pure which can be sold separately without further treatment.

In the second step, the other part, 3.9 tons, of the oxide which is not so pure should be smelted and reduced for the extraction of metallic antimony. The plant (see fig. 4 in Chinese text) consists of a reverberatory furnace with natural draft, A being the fire box, B the grate of 30 iron bars, C the hearth, and D the flue.

At one time about one ton of antimony oxide is charged into the furnace, mixed with 20 percent charcoal and 4 percent sodium carbonate, charcoal being the reducing agent and soda the flux. The fuel used is bituminous coal and pine wood. As soon as the flame enters the furnace, it reflects from the arched roof to the charge which then becomes melted. The charcoal reduces the oxide to metallic antimony in a molten condition settling to the bottom with the evolution of carbon dioxide while the soda fluxes the gangue to form a very fusible slag floating on top, which not only protects the molten antimony from being reoxidized and refines it by dissolving any sulphides of antimony and of foreign metals left in the oxide, but also prevents the volatilization of the oxides. In the meantime carbon dioxide passes out of the furnace together with a small amount of volatilized oxide.

About 12 hours after charging, reduction is completed and the workmen open the doors, skim off the slag, and put a proper amount (about 10 percent of the original weight) of fresh soda and white oxide onto the melting antimony before it is poured into iron molds. Since the antimony is covered with a coating of soda and oxide, the time is quite enough for it to crystallize slowly that it presents a characteristic fern-like pattern, which is called the "star". A distinct and well formed "star" is generally considered to be an indication of the purity of the metal.

As an average, 0.7 ton of metallic antimony can be extracted out of one ton of oxide. Since two charges can be made in 24 hours, the metal produced in one furnace is therefore 1.4 tons. There are two furnaces in operation, so that the total daily production is 2.8 tons of metallic antimony extracted from 4 tons of oxide. The metal thus produced is called commercially "Antimony Regulus".

As 5 tons of ore gives 1.15 tons of oxide (Sb_2O_3), the ore contains 19.16 percent antimony, if loss is neglected. On the other hand 1 ton of oxide gives only 0.7 ton of metallic antimony, so the percentage of the latter in the ore should be reduced to 16. 12. It is evident that the 3.04 (19.16 – 16.12) percent of the metal is entirely lost during the second step. If the loss during the first step of roasting is also taken into consideration, the total loss would reach probably 6 or 7 percent, that is, 6 or 7 tons of metallic antimony are lost for every 100 tons of raw ore smelted. Hence we dare say that 1 ton of metallic antimony can be produced from at most 5.5 tons of raw ore, if the metallurgical process is well manipulated.

MECHANICAL EQUIPMENT

The mine is equipped with a boiler house, a power house, a smelting plant and a work shop. The boiler plant consists of two 150-h.p. Heine water tube boilers of which only one is kept running all the time, bituminous coal serving as the fuel. The monthly consumption of coal in 1927 averaged about 120 tons. The power house is equipped with an air compressor and an electric generator; the former supplies power to the compressed air drills used in the drifting of Ju-Shan-Tao and the latter supllies electricity to the motors in the semlting plant and work shop and for lighting as well. In the smelting plant were built sixteen shaft furnaces for oxidizing roasting with only twelve running at one time and four reverberatory furnaces for reducing smelting with only two running at one time. Both kinds of furnaces were constructed with natural draft and their operations in general have already been briefly described in the former section. The work shop is equipped with a set of mechanical appliances such as lathe, drilling machine, planer, grinder, drill-press, etc., most of them being driven by electric motors.

TRANSPORTATION

There are five loading stations at Ju-Shan-Tao, Wan-San-Chou, Chan-Hsi, Tao-Hua-Kiang, and Yi-Yang respectively for the transportation of mine products and supplies. Among them Ju-Shan-Tao is the center of distribution for the products from, and supplies to, the different parts of the mine; materials being carried by coolies at a cost of about $0.20 per ton. From Ju-Shan-Tao to Wan-San-Chou was built a 24-lb rail track on which wagons are pushed by men at a cost of about $1.00 per ton. On the return trips coal and general supplies are brought back. When the load reaches Wan-San-Chou, it is tipped from the track, shovelled into baskets and carried down the river bank by coolies to Chinese junks in order to sail for Chan-Hsi; bamboo or timber rafts are used instead of junks during low waters. The transportation cost from Wan-San-Chou to Chan-Hsi amounts to $1.70 per ton. Between Chan-Hsi and Changsha junks are available throughout the whole year which are usually dragged by steam boats. The portage for this part averages $3.60 per ton. If steam boats are available at Yi-Yang, transportation from Chan-Hsi to Changsha costs only $2.60 per ton. Thus it can be shown that the total cost of transportation from the mine to Changsha ranges from $5.50 to 6.50 per ton.

MANAGEMENT

As mentioned above, Weiyi-Chiutung Company was organized by the partners of Chiutung and the creditors of Huachang. The head office is at Changsha where sales are carried on. At Pan-Hsi the general office consists of only two departments, i. e., mining and smelting. There is a head officer in each of these department — that of the mining department in charge of general affairs as well. Up to this time stoping, drifting and ore-preparation are all done by contract work while in the smelting plant and other works the day's pay system is adopted. The table below shows the number of laborers in the different works and their monthly wages paid at present time.

Kinds of works	No. of laborers	Monthly wages
Underground Mining...........	360	$ 9.60 - 21.00
Pumping.........................	240	10.80 - 12.00
Ore-preparation.................	25	18.00 - 21.00
Smelting..........................	158	15.00 - 18.00
Transportation....................	285	9.60 - 27.00
Power house, workshop, etc.	29	12.00 - 60.00
All others.........................	145	9.00 - 15.00

PRODUCTION AND OPERATING EXPENSE

The production of the mine, before 1920, was all raw ore, after which the company had ever stopped operation until 1924. In the mean time all the records about production were lost. In 1924 work was resumed and the smelting plant was built. Raw ore could then be converted into white oxide and antimony regulus, and was no longer for sale. At present more than 30 tons of raw ore can be produced daily, from which 3 tons of white oxide and 2.8 tons of regulus may be extracted, thus the annual production of each of them reaching about 1,000 tons The following table shows the yearly productions from 1925 to 1927 of raw ore, white oxide, and regulus, and the cost per ton of each of them produced.

Table of Annual Production and their Cost per ton

1925 — 1927

Year	Raw Ore, tons	White Oxide tons	Regulus tons	Cost per ton		
				Raw Ore	White Oxide	Regulus
1925	——	——	700	——	——	——
1926	6,747	531	699	$33.00	$180.00	$287.00
1927	10,346	849	834	37.00	197.00	310.00

For reference, the distribution of the operating expenses during the second half year of 1927 is also shown in the following table.

Distribution of Operating Expenses
during second half year of
1927

	July	August	Sept.	Oct.	Nov.	Dec.	Total
Salaries........	$ 706	717	798	798	798	798	4,615
Wages....	25,979	26,427	29,719	33,585	32,692	33,013	181,415
Supplies........	10,620	12,126	13,685	14,485	13,048	16,013	79,977
Transportation	3,731	4,035	4,133	5,806	3,681	5,042	26,428
Smelting......	1,033	971	1,204	1,249	1,355	1,652	7,464
Mech. Eng.	910	519	510	502	485	520	3,446
Miscellaneous							
Total	47,463	46,923	54,861	59,362	55,375	61,320	325,354

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