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湖南新化縣錫鑛山銻鑛調查記（節譯）

丁格蘭

一 位置

錫鑛山處湖南省之中心、近資江與漣水分水嶺之上部。自鑛地至湘潭以赴長沙有二路、（一）行十五公里陸路至冰水江村、由此沿資江以上湘江、約三百五十公里。（二）行二十三公里陸路至藍田石、乃沿漣水以入湘江、約二百公里。

二 地質

鑛地地質自下而上、為（一）石英砂岩、含輝銻鑛、厚五〇（以公尺計、下倣此）（二）石英狀硬板岩、厚二〇。（三）黃灰色薄層泥質石灰岩、厚一二〇。（四）暗灰色大塊密緻石灰岩、厚四〇。（五）富于化石而挾鮞狀赤鐵鑛、結核之灰岩、厚一。（六）大塊與薄層交互之暗灰色石灰岩、時含化石、厚二三〇。（七）白色砂岩及常夾煤層之暗色頁岩、厚二〇。（一）之石英砂岩、到處顯露、惟詳細觀察、似其下尚有暗灰色之砂岩及板岩、有時瀝青氣、其時代大概屬下部古生界、或亦能屬寒武紀以前。（七）之砂岩及頁岩之上、蓋以石灰岩、其上復有似屬中生界之紅色岩層。以上諸層已失其原有之地平地位、多為折皺及斷層所攪亂、且有兩折皺處直交方向而生穹地及盆地之構造。于銻鑛床之分佈有極大之關係。

三 鑛床

鑛床之分佈。 按之露頭範圍、其分佈情形可分四區。（一）錫鑛山區、凡歐家冲兎子塘老錫鑛山陶塘及南部之譚家冲與長龍界均屬之。（二）毛家泳區、祇獨立二小山。（三）七里江區、黃家壠及上連溪屬之。（四）江冲區、

附近三河流一帶之露頭屬之。

鑛床之性質。　原生鑛物有輝銻鑛、一半係稜柱狀或針銳狀結晶、一半則純粹結晶體。脈石僅石英。其他鑛物極少。次生養化銻鑛、以長龍界最爲常見。大抵係白色或黃色多孔成大塊或爲輝銻鑛之假形、其眞結晶未之見。

鑛床之構造。　鑛質在石英砂岩、四散分佈、漫無規則。岩石構造現迸裂及角礫狀、殆由折皺時橫壓力所致。鑛綫最富之點、多在十字折皺所成之穹形地之下。以各地之長距及剖面比較觀之、錫鑛山爲最富之鑛地、次爲七里江、次爲江冲。鑛脈之最大者厚〇・七五公尺、(總厚未詳)長逾五公尺、寬三・五公尺。脈中幾屬純輝銻鑛。此類大鑛脈、固不能常見。然多數之鑛、成不規則之鑛綫、亦厚自一〇至五〇生的、往往可有數層、總厚達數公尺。鑛層前後、間以數十生的厚之岩石。

鑛石之成分。　錫鑛山以前已煉純銻、至一九一五年爲止、約有一〇四、〇〇〇噸。惟此數尚不足代表銻在已採石中之總量。何以言之、(一)廢石中尚含多量之銻、(二)化煉時、由烟氣中飛逸者、亦不在少數。茲估計其所有損失僅百分之二十、則已採鑛石中所含銻之總量、應爲一二四、〇〇〇噸。再假定已採全數鑛石中所出選鑛之百分率爲百分之三十、(選鑛含銻百分之五十五)即得已採鑛石之總量、約七〇〇、〇〇〇噸。由此可以推算已採鑛石中銻之百分率約合百分之十八。但此亦非全體鑛床之眞實百分數、因其所採僅在富脈、而附帶岩石又必夾入不多也。然則其所賸貧鑛及已採富脈間之正確比例如何、就山脊全體蜂窠狀之現象觀察、前者不能比後者少於三分之一。是錫鑛山含鑛石英砂岩之銻成分、至少當爲百分之六。

四　鑛區及鑛量

含鍚石英砂岩面積、各區大小不同、茲列表如左。

區別	長公尺	寬公尺	面積平方公尺
錫鑛山區	二、一〇〇	三〇〇	四〇八、〇〇〇
毛家迯區	二〇	二〇	—
七里江區	一、八八〇	五三〇	六二三、〇〇〇
江冲區	八五〇	二五〇	四〇、〇〇〇

依上表則錫鑛山區之鑛層以二〇公尺計、（含鑛砂岩總厚在五〇公尺以上）比重以三計、應得鑛石總數如下、

$$3 \times 408\,000 \times 20 = 24,480,000\text{噸}$$

含鍚百分數假定爲六、則以前數推算應得淨鍚至少一、五〇〇、〇〇〇噸。（與含鍚百分五五之三、〇〇〇、〇〇〇噸鑛石數相當、）茲除去已經煉去之鍚約十萬噸、（即約等於二十萬噸之鑛石）則尚存未採淨鍚一、三〇〇、〇〇〇噸有餘。惟按之地層傾斜、鑛產似向東尚有數百公尺之延長、其深度當不過二百公尺。茲假定向東延長爲一、五〇〇公尺、寬二〇〇公尺、厚一〇公尺、含鍚百分之五、則可得鑛石總數三、〇〇〇、〇〇〇噸即得鍚一五〇、〇〇〇噸。江冲區調查未周。七里江區總量似不甚富。至毛家迯面積既小、鑛量自更有限也。

五　產額

茲將從前錫鑛山所採鑛石及所出生銻純銻分別列表如左。

	礦石噸	生銻噸	純銻	在鑛石與生銻及純銻中之金屬銻質量
一八九五至一九〇一年	?	?	?	七、三〇〇
一九〇二至一九〇九年	二二、九〇〇	三八、一〇〇	一	三九、三〇〇
一九一〇至一九一四年	一九、二〇〇	五〇、一〇〇	八、三〇〇	五七、六〇〇

依前表之約數、其金屬銻質總數已達一〇四二〇〇噸、迥然超出於世界銻產國之上。按一九一三年、全世界銻產總額爲二五六四九噸、中國居其一三八〇〇噸、約占總額百分之五四。顧中國銻產、以湖南爲中心、而湖南銻鑛實以錫鑛山爲最大。查是年湖南全省出銻一一五〇〇噸、即占全國產額百分之八三。錫鑛山出銻九、〇〇〇至一〇、〇〇〇噸、是又占湖南產額之百分八〇至九〇也。

附記　丁格蘭君調查錫鑛山、係在民國四年冬。報告成於次年春季、故所述鑛業情形、亦均指是時言。

甘肅地震考

翁文灝

一、緒言

中國舊籍於地震記載綦詳、然其用意並不在科學之研究、而僅以爲災祥之示徵。試讀五行之志、祥異之書、怪誕不經、輒越常理。如以地震記載等類齊觀、殆疑辭出牽附、未可盡信。顧有說者、地震現象爲多數人所共見聞、不易隱諱、亦不易臆造、一也。舊理想以地震爲重大災異、爲時所忌、決無人無故妄造、二也。地震記載所舉事實、大抵較其他祥異較爲翔實、間有不易解說之事、如地生白毛等類、亦間與外國古記不謀而合、卽或觀察偶誤、亦非同嚮壁虛構、三也。故中國古籍地震之記載、大致尚可徵信、確有研究之價值。

研究中國古時之地震最新最完備者、首爲法文中國地震表。Catalogue des tremblements de Terre signalés en Chine d'aprés les sources chinoises 上海黃司鐸編、J. Tobar 及 H. Gauthier 校補、民國二年出版。是書于古今圖書集成、正續通志、正續文獻通攷、春秋、二十四史、通鑑綱目、通鑑外記、及路史、均曾攷証。兼及外國學者 Biot Gaubil 大森房吉 S. H. Parker, J. Milne 諸氏關于中國地震諸作。其關於甘肅者、則參考及于順治重修靈台縣志、乾隆時修西和成縣秦州西寧甘州五志、道光鎭原縣志、光緒通渭縣志共八種。較之關於其他諸省者、收集府縣志書爲數較少。故其記錄甘肅地震、明清以前、尙爲完備、明清以來、反嫌缺略。近將宣統時修之甘肅新通志、于甘肅地震、收錄頗詳、與法文表兩相比較、新通志足以補法文表所未備者、計七十五條。其中震動劇烈毀屋傷人者、實居多數。法文表所載、而爲新通志所未及者、僅及九條。大抵稍有震動不甚重要。其餘時間雖有微異、大致多屬符合。乃以新通志爲主、年爲一條、按次列表。有未備者、參攷法文表以補之、共得二百四十

條。法文表爲最近考証中國地震最詳之作、新通志又爲甘省通志最新之編、兩相較補、于甘省古時地震、凡有記載可稽者、當已搜羅盡致。惟地震之生、或一年數次、或每次歷時數年、今按年列表、藉清眉目。二百四十條中、計其次數當在四百左右、而其震動之烈、尤爲中國各省中所僅見焉。

二、地震之頻度 Frequoncy

今如不問烈度大小、但以地震之次數計、則表列二百四十條中、照西歷紀元每世紀之分配如左表。

第一表

世紀	紀元前								紀元後																				共計
紀	八	七	六	五	四	三	二	一	一	二	三	四	五	六	七	八	九	十	十一	十二	十三	十四	十五	十六	十七	十八	十九	二十	
地震年數	二	○	○	○	○	○	三	三	二	五	九	一○	一一	九	三	五	六	二	五	七	一	二九	一二	二九	三五	一八	三一	四	240

除紀元前二世紀以前、記載不詳、姑置不計外、自紀元前二世紀以迄十九世紀、共二十一世紀中有地震之年、凡二百三十五年。即平均每世紀有地震者十一年有奇、亦即平均每十年中至少應有地震一次。若就記載較詳之十四至十九世紀言之、則每世紀平均有地震者二十五年有奇、即平均每四年至少應有地震一次、亦可云數矣。

觀上表二世紀至六世紀中、地震似較多、七世紀至十三世紀、似較爲平靜時代、至十四世紀以後、地震又復大盛。頗若地震現象、自盛而衰、復自衰而盛、具有循環之象。此類關係 Tobar 及 Gauthior 二氏、業經發見。二氏計算全國地震、第一期自紀元一年至六三三年、得四百一十三例。第二期自六三三年至一二六六年、僅得三百

七十五例。第三期自一二六六年至一八九九年、共得二九三五例。第三期得數較多、固由去今未遠、記載較詳之故、第一期地震較第二期爲多、則頗似由盛自衰出於自然。簡單言之、或有六百餘年盛衰迭更之週期、現時則已入較爲平靜之時代。二氏以此規律、驗之各省、則依律者十九省內得其十一。今以同計算法施之甘肅地震表、則約數如左。

第二表

第一期	第二期	第三期
四八	三三	一四六

其証明之程度、亦恰如 Tolar 及 Gauthier 二氏統計全國之所得。二氏嘗以之比於 Lockyer 日中黑子之週期、然地震是否爲週期現象、二氏究亦未能自信。且古代記載不能完全、其所記載者、震中所在、烈度所分、又未能概歸一律、難資比較。則上述盛衰循環之跡象、遽爲定論、要未易也。

舊籍地震記載之繁簡、與人事具有關係。都會之地、紀錄最詳、偏僻之區、輒多漏略。稽玫古籍者、類能言之、又有與時間相關者、例如第一表第十三世紀甘省地震最稀。實則時當南宋、東南半壁、喘息偏安、金元擾攘、疎于文事。甘省僻處西鄙、少通中原、縱有地震、亦缺紀錄。非果地盤之特爲靜謐也。茲復就朝代爲區分、列表如左。

第三表

朝代	周	秦	漢	三國	晉	南北朝	隋	唐	五代	北宋	南宋	元	明	清
西歷紀元	前一一二三至二四七	前二四六至二〇七	前二〇六至後二二〇	二二一至二六四	二六五至四一九	四二〇至五八〇	五八一至六一七	六一八至九〇六	九〇七至九五九	九六〇至一一二六	一一二七至一二六三	一二六四至一三六七	一三六八至一六四三	一六四四至一九一一
年數	八七六	四〇	四二六	四四	一五五	一七二	三七	二八九	五三	一六七	一三七	一〇四	二七六	二六九

地震年數	一	一〇	二三	四	一五	二五	三三	二	一〇	二	四	二五	六四	六九

上表秦隋南宋三國五代地震紀錄之少、尙可假定其與當時政局有關。然如兩晉南北朝地震之多、雖疆域之廣文化之盛享國之久、如漢唐二朝、猶有遜色、則誠不能不承認其實際之意義。意義云何、夫亦曰地震發生誠有其特多或特少之時代而已。然此多少迭更之關係、究竟有無一定週期、則殊無從確定。蓋理論上罔無此必要而事實上又難得左証也。觀乎元明清三代記載之數、突過前朝、愈見從前漏略之多。強爲根據、曲試猜度、其所得鮮矣。

元明清三朝地震紀錄既最完備、故復自十四世紀起、以十年爲度、計數如左。

第四表

世紀	十年期	朝代	地震年數
十四世紀	一	元	三
	二		四
	三		四
	四	順帝	七
	五		四
	六		三
	七	明太祖	〇
	八		三
	九		一
	十		〇
十五世紀	一	成祖	二
	二		〇
	三		〇
	四		〇
	五	英宗	二
	六		〇
	七	憲宗	一
	八		二
	九		二
	十	孝宗	三
十六世紀	一	武宗	二
	二		一
	三	世宗	三
	四		一
	五		四
	六		六
	七	穆宗	四
	八		二
	九	神宗	二
	十		四
十七世紀	一	熹宗	三
	二		三
	三	莊烈帝	五
	四		五
	五	清世祖	四
	六		四
	七		二
	八	聖祖	六
	九		二
	十		一

世紀	十年期	朝代	地震年數
十八世紀	一		三
	二	世宗	三
	三		二
	四	高宗	三
	五		二
	六		一
	七		三
	八		○
	九		一
	十		○
十九世紀	一	仁宗	一
	二		三
	三		一
	四		○
	五	宣宗	二
	六	文宗	三
	七	穆宗	二
	八		六
	九		七
	十		六

觀上表可見地震之頻繁或稀少、固變化極多、而實未必具有一定之規則。地震最多之時、依表所列十年中居其七。若按其詳數、猶不止此。例如清光緒五年至十九年間、據新通志所載、甘肅地震、殆不下三十餘次。其地盤之不穩固、可概見矣。復就朝代關係觀之、元順帝明莊烈帝清景帝之初年、適皆地震最多。持災異之說者、或將以此爲亂世失國之徵。然一姓之得失、庸何關於天道、全局之治亂、豈獨徵乎偏隅。況明之嘉靖、清之康熙、時代號稱治平、而震災之多、並不減於叔季、又何說耶。

黃司鐸原編法文地震表、依省府州縣按次排列。於研究地理上之分布、甚爲便利。惟根據所自、既未逐條註明、震動烈度、亦無確定標準。嚴格而論、不無遺憾。惟茲僅比較地震之頻度、援用橫表、於事滋便。更益以甘肅新通志之所載各數、爲表如左。

第五表

地方	地震次數	地方	地震次數
蘭州府(府治今皋蘭縣)	一三	平涼府(府治今平涼縣)	八
狄道州	一四	靜寧縣	三

河州(今導河縣)	七	隆德縣	一
靖遠縣	三	固原州(州治今固原縣)	六
紅水縣(新置)	一	西和縣	九
涇州(州治今涇川縣)	二	洮州廳(今臨潭縣)	五
鎮原	二二	岷州	三
靈台	五	階州(州治今武都縣)	八
鞏昌府(府治今隴西縣)	一九	文縣	六
安定縣(今名定西)	二	成縣	六
會寧縣	三	秦州(州治今天水縣)	六五
莊浪縣	一	秦安縣	一一
通渭縣	一三	清水縣	二
寧遠縣(今名武山)	六	禮縣	九
伏羌縣	四	徽縣	二
漳縣	一	兩當	一
慶陽府(府治安化縣今慶陽縣)	七	西寧府(府治今西寧縣)	一九
環縣	六	碾伯縣	一
合水	一	涼州府(府治今武威縣)	一一

正寧	一
寧夏府(府治今寧夏縣)	二七
靈武縣(故靈州)	七
中衛縣	三
平羅縣	一
鎮戎縣	一
永昌縣	一
鎮番縣	一
甘州府(府治今張掖縣)	一〇
山丹縣	二
肅州府(府治今酒泉縣)	四

按上表地震在十次以上者、爲蘭州、狄道、鎮原、鞏昌、通渭、秦州、秦安、寧夏、西寧、涼州等十處。在五次者爲河州、平涼、寧遠、西和、階州、文縣、成縣、禮縣、慶陽、環縣、靈武、甘州等十二處。要而言之、似天水秦安至狄道皋蘭爲一帶、約與所謂隴山山脈相當。是爲甘省地震最多之所。南乎此者爲西和、禮、成、階文諸州縣。北乎此者爲平涼、固原、鎮原、慶陽諸州縣。復北則爲寧夏附近。在西部則以西寧、涼州、甘州三地爲中心。此甘省地震頻繁各地分布之大略也。

三、地震之烈度

Montossus do Ballore 氏嘗主張研究一地地震之頻度、即可以爲是地地震性質 Sesmicity 之表徵。蓋古代記載於地震烈度、往往無所標準、不易比較。故爲研究世界之地震、有此簡便之假定。然震動最多之地、及最多之時、是否即爲震動最烈之地、及最烈之時。頻度與烈度、就大概而論、固互相關係、若詳爲分別、則原難強同、況震動之來、起原不必一地。輕微之震、記載不必盡詳。不問烈度如何、而一惟震動次數之是憑、所得結果、終恐難

符眞象。以是甘肅地震、嘗擬就烈度大小、加以別擇、庶於地震中心、(簡稱震中)在空間及時間之分布、或能得其概要。第舊籍記載、略而不詳、其烈度在 Rossi-Forel 或 Mercalli 等諸氏比較表中應居何級、大抵不易確定。強爲類別、可分五種。

甲、簡稱某地地震者、大抵震動不甚劇烈、多數人皆能覺察、至少應在 Rossi-Forel 表第四級以上。然在都會重要之地、注意較周、恐亦有較微之震、亦經記錄者。都會地震次數之多、此亦一因。

乙、記地震有聲者、其聲狀或如雷鳴、或如巨風、或如炮震、或不加他說。總計甘肅地震載明有聲者計三十七次。此外疏漏恐尚甚多。蓋記載者於鳴聲往往以爲無關重要、不甚措意。觀近時各地地震之報告、卽可証明此說。至鳴聲與烈度之關係、記鳴聲者多不言山崩地裂破屋傷人、而記破壞者亦不言有聲。似地震有聲之地、不必震動最烈。然因震動過烈、於鳴聲反不注意者、或亦有之。

丙、記地裂水泉涌出者、爲數甚多。大抵可爲震動較烈之徵。其烈度至少當在七級以上。然水泉涌出之地、往往並無破產傷人之事、且間有同時記水泉涌出之地、分布甚廣者。足証此類現象、離震中甚遠之地、亦能有之。不足以爲約定震中之表徵。

丁、記地震山崩者。中國籍所稱山崩、恐未必盡屬全山崩塌。凡巨石墜落、山崖傾頹、及沙土倒瀉、皆得謂之山崩。天然風化作用、往往足以致此、不必盡爲地震影響。故劇烈地震、固多能致山崩、而載明山崩者、不必盡爲重震。其僅言山崩而不言地震者、其原因自更難言。

戊、記地震敗城垣、壞屋室、死人畜、或損壞其他堅固建築物、如宗廟、宮室、倉庫等類者、其烈度大抵不外第九

十兩級大多數當屬第十級。且此類事實爲通俗所注意、無其事者不易臆造、有其事者亦不至漏載、故可作爲劇烈地震最確當及最完備之表徵。達此裂度之地大抵去震中必不甚遠、故準此表徵可以研究震中之分布。是類地震、茲統名之爲破壞震。

甘肅地震中合於破壞震之定義者、計得六十八條、其時間上之分布如左表。

第六表

世紀	八	七	六	五	四	三	二	一	一	二	三	四	五	六	七	八	九	十	十一	十二	十三	十四	十五	十六	十七	十八	十九	二十	共計
破壞震數	〇	〇	〇	〇	〇	〇	三	二	〇	四	〇	一	一	三	一	二	二	一	一	二	一	三	四	九	十四	五	九		六八

以上表與第一表相較、則見各世紀分布之不平均、大爲減小。第二至第六世紀、及第十四至十五世紀、地震次數較多者、烈度並不較大。第十六世紀以後、始見破壞震之數、視前倍增。當亦以近代紀錄較詳之故。自紀元前第二世紀至十九世紀止、二十一世紀中、有破壞震者六十八次、即平均每百年有破壞震三次。若自紀載較詳之十四世紀算起、則六世紀中共得四十四次、即平均每百年有破壞震七次。二十世紀以來、尚無大震、至民國九十年間、乃始見之、固其時矣。

復依第二表所用方法、僅以破壞震計入、則約數如下。

第七表

第一期　一〇　　第二期　九　　第三期　二三

一二兩期得數相去固亦僅矣。

復以朝代分別得數如下。

第八表

朝代	周	秦	漢	三國	晉	南北朝	隋	唐	五代	北宋	南宋	元	明	清
破壞震數	○	○	九	○	二	二	二	四	○	四	一	二	二一	二○

以此與第三表相較、益見頻度與烈度、迥然二事。兩晉南北朝震數雖多、劇烈者少。漢及唐宋、則震數雖少、劇烈者多。衡以年數、無多軒輊。明清二朝、國祚等長、地震之頻度烈度、亦約相若。可見長時期以內、地震分配、尚屬均勻。統計平均之數、未必全無意義也。

欲求破壞震在地理上之分布、古今地名不同、範圍迥異、精確比較、頗非易易。茲就重要地方破壞震之次數、分記如下。

第九表

隴西	八	鹽州	二	莊浪	三
武都(階州文縣)	七	寧夏	二	岷州衛	一
涼州(武威)	四	環	三	臨洮	四
酒泉(張掖)	二	慶陽	五	山丹衛	一
西平(西寧)	五	平涼	四	肅州	一
秦州(文水)	八	鎮戎	二	隆德	一

河西	二	固原(開成路)	三	靜寧	二
靈州(靈武)	四	蘭州(金城)	三	崇信	一
鎮原	二	西和	一	靖遠	三
眞寧(正寧)	一	兩當	一	通渭	一
平虜	一	安定(定西)	一	平羅	一
鞏昌	三	中衛	三	伏羌	一
靈台	二	禮	一	寧遠(武山)	一

以上各地、以記載詳略之不同、頗難確定其分布之規則。約略言之、似可分爲數區。(一)武都區。今武都、文縣成縣等屬之。漢代即有大震、明清以來、震動尤著。(二)隴西區秦州至臨洮、蘭州一帶、自古以來、地震最多。(三)涇原區。平涼、鎮原、固原、慶陽等地屬之。(四)寧夏區。平羅、寧夏、靈武、鹽池、中衛等地屬之。震動亦甚多而烈。(五)西寧區。(六)涼甘肅諸州、姑名之爲武威區。西寧、武威二區、巨震較少、或以地較偏僻、記載缺乏之故。茲以上列各區、歷年破壞震、列如第十表。表中數字爲西歷紀年。其括弧內數字、則指二大震之間相距之年數。

此表示地震中心、往復遷移、及各區間動靜循環之狀。古代記載既難盡全、所記破壞震之地、實際又或未必盡爲震中、謂此表即可確符震中遷移 migration of epicentrum 之眞相、自非盡當。第就大致而論、除西寧武威二區、紀錄過稀、姑置不論、其甘肅東部之震中、則頗有旋南旋北、往復繼動之趨勢。十七世紀以後、紀錄愈詳、此形勢愈爲顯。然自一六三二年、西和大震後、震中北移、越二十年始復南還、而有一六五六年階州之大震。嗣是

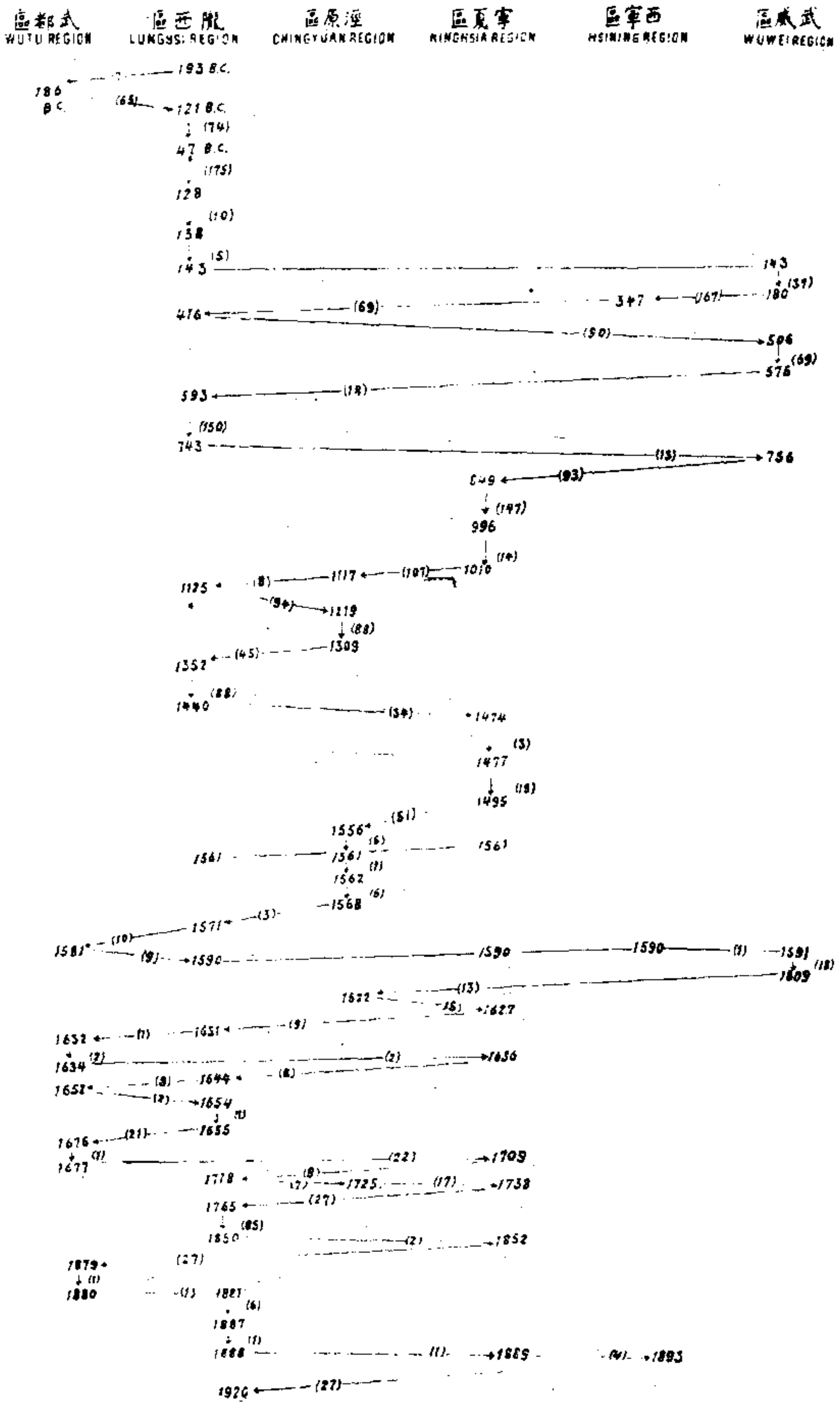
震中又復北移、越二十四年始復南還而有一六七六年階州之大震。嗣是震中又復北移、越三十年始復南還、而有一七一八年秦州通渭等處之大震。嗣是震中又復北移、寧夏大震、越四十七年始復南還、而有一七六五年伏羌之大震。此次時間相距視前較長、然其間如一七三八年文縣之震、一七五五年通渭之震、均以記載不詳、未備於破壞震之列、苟以之入選、則相距年數、自當減小。自一七六五年伏羌大震後、越八十五年、始復有一八五〇年寧遠（武山）之震、其間涇原寧夏二區、均未有劇震。紀錄之疎漏歟、抑地盤之特爲靜固歟、蓋不可知。寧遠震後、震中旋又北移、中衛大震、越二十九年震中又南、始復有一八七九年階州文縣之鉅震、灾禍之烈、爲歷來所稀見。嗣是震中又逐步北徙、西和、禮縣、秦州、皋蘭、靖遠、靈州等處、先後繼動。至最近一九二〇年之大震、距一八八八年秦州等處之震、計三十二年。假定震中徙移自南至北、復自北返南、往復之間、爲一週期、則此週期、照上所述、當在二十至四十七年之間。平均約三十年。此係就近三百年來甘省地震之經驗、而見震中遷徙、依稀若有規則之可循者、舉而出之、或足以備科學推論之一助。原因所在、驟難懸斷、固亦未敢以爲定論也。

四、地震之繼續

地震與地震之間、互相關係。大抵大震之後、地盤繼續動搖、不卽歸寧靜、是爲餘震。after shocks 餘震之中、有時間有巨震、毀屋傷人。故大震之後、餘震未已之地、往往人心皇皇、懼禍之復至。以是研究餘震繼續之規律、不特爲學理之問題、亦實震地居人所亟欲先知之事實。惜中國舊籍記錄、大抵失之簡略、絕少詳記、足資參研。茲姑就可考者、論其大概如下。餘震之繼續、可分二種。（甲）大震之後、繼以餘震、烈度漸弱、頻度漸稀、有如滄溟巨浸、斗起狂濤、急浪乍過、餘波未已、迴環蕩漾、漸卽於平。此蓋由於地盤原本靜固、突受動力、遂起震象、力漸消磨、

動亦隨而減退。(乙)餘震之烈度頻度、並不漸減漸少。往往小震未平、大震又起、有如敗劣建築、均勢未固、稍有

第十表
Table 10



動機、卽見震蕩。餘力所及、又生動搖。因果相生、再接再厲、必數經震動、始漸達暫時均勢。此蓋地殼構造、新經變

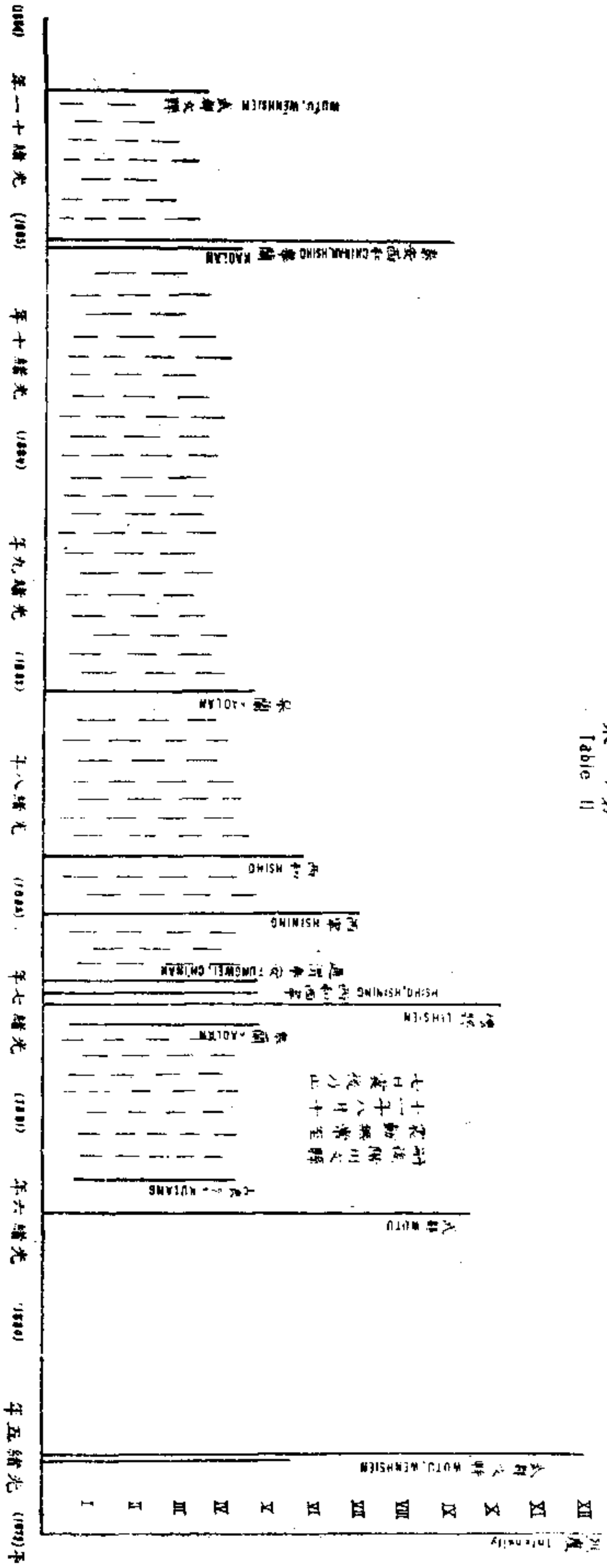
動、基礎未固、易生搖撼也。由是理論、窮其究竟。大抵甲類地震、原於外力、即謂動力起于地質構造之外。（力之所自、或在殼外、如氣壓等等、或在殼內、如火山噴發、岩汁上衝等等、姑置不問。）而地質構造、特予以易受動力之弱點。乙類地震、則震動之因、即在於地質構造之中、原動之力、即種自地質變動之日。雖無外力、亦將自動。凡此區分、似尙未經人道、循果溯因、疑若當然。惟二類之間、原無絕對界限。他動者必先有構造之弱點、一遇外力、受動始易、自動者原在不固之均勢、一有動機、影響更深。惟就大多數觀之、於各地地震之性質、或不無分別耳。大森房吉氏、嘗就日本地震之研究、知餘震之數、漸進漸小。例如安政元年、十一月五日、及明治二十四年十月二十八日地震之餘震、皆久而愈稀、其平均進行之形狀、可以直雙曲線（拋物線）代表之。依律推測、屢試不爽。Cancanni 氏統計義大利自一三一九至一九零二年三百次地震之統計、則餘震漸稀漸弱者、佔百分之七十、而不遵此規則者、佔百分之三十。可見乙類地震、固亦甚爲常見。

甘肅地震表中、於地震繼續之關係、略有可考者、僅三十餘次。其中歷時之最久者、如明萬歷三十七年六月十一日肅州大震、後連七八年、每年地震一二次、至四十五年方息。淸光緒五年五月十二日階州文縣大震、後震動無常、歷六七年至十一年秋八月十七日震後乃止。其餘同地地震、延長數月至三四年者、尙不乏其例。其中震動次數之較多者、如漢漢安二年九月至建康元年四月、地震百八十日。光和三年秋至次年春、酒泉表氏、地八十餘動。宋至道元年九月丙戌秦州之震、明成化十年十一月甲寅靈州之震、宏治八年三月己亥寧夏之震、萬歷三十二年閏九月庚辰鞏昌之震、均一月間震動十餘次。以上皆僅言地震繼續之時期、及震動之次數、其有記載較詳於震動進行之狀態、尙可約略忖度者、似有二種規律、存乎其間。（一）巨震之後、餘震繼作、照上分

類、近乎乙種。其中間有大震、其烈度雖不及初發巨震之高、而往往亦有破壞作用。惟此類大震、漸久漸稀、終歸寧靜。(二)當餘震繼起之時期內震中有逐漸徙遷或一再分析之勢。初震震中方漸歸平靜、而次生震地接厲而起。以上二律、可舉例證之。

清光緒五年五月十二日、隴右諸地同時大震、山谷響應、土霧亙天、山飛石走、地裂泉涌。階州文縣、震災尤鉅、死者各達萬人。自此巨震後、小震時作、間以較大之震、而此較大之震地則有逐漸徙遷之趨勢。六年六月、猶仍在階州、文縣、七年六月、則在禮縣、八年以後、乃在西和。此其進行之狀態、可以表明之。

表一十一
Table II



餘如明嘉靖四十年、隆慶二年、萬歷三十六年、崇禎五年、清順治十一年、康熙十五年及四十八年、乾隆三年及三十年、諸震及其繼續之震動、雖記載較略、難得詳證、然意爲比附、亦約略似有合乎上舉之規律。誠使假定不謬、則甘肅地震之原因、殆完全在於地質構造、均勢未固、故震撼時作。然古代記載、每病掛漏、雖細心推求、似略有途轍可尋、而精確研究、固不得不有待於當代之考察。漢張衡傳、衡造地動機、嘗一龍機發而地不覺震、京師學者、怪其無徵、數日驛至、果震隴西、於時皆服其妙、自此乃令史官記地震所從起。奈何是類研究、繼起無人、時至今日、猶或爲灾祥迷信之談、而不急爲科學觀察之計。除外人所談一二地震儀外、本國毫無設備。以中國重要之事情、而中國人不自研究之、豈不大可惜哉。

甘肅地震表

前七八〇	周幽王二年三川震涇渭洛竭　鳳翔岐山崩
前一九三	漢惠帝二年春正月隴西地震壓四百餘家　正月癸酉蘭州　秦州　大森房吉氏地震表第一次
前一八六	漢高后二年春正月乙卯武都道地震山崩殺七百六十人羌道武都山頹震動歷數日　秦州　成縣　禮縣
前一二一	漢武帝元狩二年春正月隴西地震敗城郭屋室壓殺多人　法文表未載
前七〇	漢宣帝本治四年夏四月清水縣地震　四月壬寅　西安　曹州　青州　諸城　膠州　開封　琅邪宗廟毀　黃河東南(河南山東)四十六州皆震死六千餘人
前四七	漢元帝初元二年春二月戊午隴西地震山崩水泉涌出毀城郭民屋壓殺人衆七月地再震　蘭州　秦州　太上皇廟牆傾　道縣內外城垣及官署民居均受損　洛陽亦有大震
前七	漢成帝綏和二年北陲地震壞城郭壓傷甚重　九月丙辰　西安　乾　延安　西安以北郡國二十餘壞城郭凡殺四百一十五人(漢書五行志)
九三	漢和帝永元五年春二月戊午隴西地震　十二月戊午　蘭州　秦州

九七	漢和帝永元九年春二月庚辰隴西地震　三月庚辰　蘭州　秦州
一二八	漢順帝永建二年春正月丙子漢陽地陷裂壞屋殺人　秦州　河南　按此漢陽法文表誤爲湖北之漢陽實在隴西今伏羌西和等縣屬之張衡四愁詩曰吾所思兮在漢陽欲往從之隴坂長卽其明証
一三八	漢順帝永建三年春二月乙亥金城隴西地震裂壞城郭屋室多壓殺人　蘭州　狄道　秦州　西寧　河南
一四三至一四四	漢順帝建康元年春平襄地震正月涼州都郡六地震從去年（漢安二年）秋九月以來至夏四月凡百八十日震山谷拆裂壞敗城市傷害人物　涼州　甘州　鞏昌　秦州
一六一	漢桓帝延熹四年夏四月右扶風及涼州地震　六月　西安　秦州　涼州　同年六月山東泰山崩
一八〇至一八一	漢靈帝光和三年自秋至明年春酒泉表氏地八十餘動涌水出城中官市民舍皆傾縣易處更築城郭　六月肅州水涌出　按此則法文表刊爲春酒表是地題係誤讀致不可解
二四一	魏齊王芳正始元年（蜀漢後主延熙四年）冬十二月秦州地震　十二月辛巳
二四二	仝上二年冬十二月南安郡（鞏昌）地震
二四三	仝上三年秋七月甲申南安郡地震八月秦州地震　是年十二月魏郡（彰德）地震
二四五	仝上六年春二月丁卯南安郡地震　震歷數年
二七八	晉武帝咸寧四年六月丁未陰平地震甲子又震　階州　代州　陰平及廣武地震
二八五	仝上太康六年冬十月南安郡山崩水出　南安新興山崩
二八六	仝上七年春二月陰平仇池崖傾　按仇池今成縣西北百里
二八七	仝上八年秋七月陰平地震
二九五	晉惠帝元康五年夏六年金城地震
三一八	東晉元帝大興元年夏四月乙酉西平地震涌水出　西寧　汝寧　是年十二月南昌吉安黃州義寧皆震
三一九（三二〇）	仝上二年夏五月地震祁山崩殺人　三年（據史記及秦州新志）五月己丑　鞏昌　秦州

三一九	仝上三年高平郡山崩出雄黃數十斤
三四七	東晉穆帝永和三年春二月乙亥西平地震裂城郭室屋多壞壓殺人冬十月西平地震涌出水
三五八（三六二）	仝上升平二年夏六月西平地震秋八月涼州地震　法文表據乾隆西寧府新志及圖書集成作爲五年
三六二	仝上隆和元年夏六月丁丑西寧浩亹山崩涼州地震（文獻通考圖書集成）新通志未載
三六五	仝上興寧三年秦州地震裂水泉涌出　法文表未載
三六六	東晉帝奕太和元年春二月西平涼州地震水湧夏四月浩亹山崩
三七一	東晉簡文帝咸安元年西平地震
三七四	東晉孝武帝寧康二年秋七月甲午西平涼州地震
四〇六	東晉安帝義熙二年金城苑川地震裂生毛　法文表未載
四一〇	仝上六年甘州地震山崩（乾隆甘州府志）新通志未載
四一六	仝上十二年秦州地震者三十二殷殷有聲者八崩壞民居
四一九	東晉恭帝元熙元年夏四月西涼地震　法文表未載
四二一	宋文帝元嘉元年西秦地震草木皆自反
四七五	北魏孝文帝延興五年春二月秦州地震　法文表未載
四七七（四七八）	仝上太和元年閏五月秦州地震殷殷有聲　五月秦州楡林　閏十一月（據圖書集成）地震有聲按同年不能有二閏月新通志所載閏五月之閏字似衍
四八一	仝上五年春二月秦州地震
四八二	仝上六年夏五月秦州地震秋八月甲午復震有聲如雷乙未又震

四八三	仝上七年春三月秦州地震有聲
四八六	仝上十年閏正月秦州地震二月秦州地震有聲　是年一月太原地震有聲二月及三月大同地震二次
五〇〇	北魏宣武帝景明元年夏六月庚午秦州地震　法文表未載
五〇三(五〇四)	仝上四年春正月辛酉涼州地震夏六月丁亥秦州地震　秋七月乙丑涼州地震冬十二月秦州地震
五〇六	仝上正始三年秋七月己丑涼州地震有聲城圮八月秦州地震
五〇八	仝上永平元年春正月庚寅秦州地震
五一二	仝上延昌元年冬十月秦州地震有聲　是年四月庚申山西大震幷及直隸河南山崩地裂泉湧出死五千三百十八人傷二千七百二十二人死傷牛馬牲畜三千頭
五一七	北魏孝明熙平元年冬十二月秦州地震有聲　圖書集成作熙平二年
五二一	仝上正光二年夏六月秦州地震有聲東北行八月始平郡地開成井
五七五	北周武帝建德三年涼州地頻震壞城郭地裂湧泉出　十二月癸卯
五九三	隋文帝開皇十三年冬十一月大風拔木秦隴地大震壓死千餘人　法文表未載
六〇〇	仝上二十年冬十一月戊子天下地震京師大風拔木壞尾淨利寺鐘三鳴隴西地震壓殺千餘人（據文獻通考陝西通志等）新通志未載或係誤爲十三年
六〇二	仝上仁壽元年夏四月隴西地震　四月庚戌　秦州　鳳翔　楡林　九月乙未　鞏昌
六四六	唐太宗貞觀二十年秋九月辛亥靈州地震有聲如雷
七〇五	唐中宗嗣聖二十二年春二月秦州地震　按中宗嗣聖二十一年後卽改元神龍此言二十二年或有誤他志未見載及者　法文表亦未載
七四三	唐元宗開元二十二年春二月壬寅秦州地震壞廬舍殆盡壓死四千餘人
七五六	唐肅宗至德元載冬十一月辛亥朔河西地震裂有聲陷廬舍張掖酒泉尤甚至二載三月癸亥乃止　同州　甘州　肅州　河西　河西地震有聲地裂壞廬舍

七八三	唐德宗建中四年春正月金城地大震　法文表未載
八〇九	唐憲宗元和四年慶州地震者再　法文表未載
八二一	唐穆宗長慶元年地震　法文表未載
八三〇	唐文宗太和四年地震裂水泉涌帳山崩洮水逆流　法文表未載
八四九	唐宣宗太中三年冬十月辛巳河西靈武鹽夏等州地震壞廬舍壓死數千人　同州　榆林　懷遠（陝西）　西寧直隸山西亦震
八七六	唐僖宗乾符三年夏六月雄州地震裂水湧至七月辛巳止城垣廬舍盡壞　直隸　山東　按所謂雄州未知是否今直隸省之雄縣若是則似與甘肅無關新通志列此未知何據
八七七	仝上四年夏六月庚寅雄州地震　按仝上
九八六	宋太宗雍熙三年階州青龍峽山圮壅白江水逆流高十丈許壞民田數百里
九九六	仝上至道元年秋九月丙戌秦州　普州（平陽）　地震一日夜震十二次（圖書集成及山西通志）　冬十月靈夏環慶等州地震城郭廬舍壞（甘肅新通志）
一〇〇一	宋眞宗咸平四年正月秦州成紀山縣山摧壓死六十餘人秋九月慶州地震者再
一〇〇七	仝上景德四年秋七月秦州成紀縣崖圮壓死居民渭州（平涼　瓦亭地震者四　是年七月益州亦地震
一〇一〇	仝上大中祥符三年冬十月靈武地震壞廬舍壓人甚多　法文表未載
一〇二七	宋仁宗天聖五年春三月秦州地震
一〇九二	宋哲宗元祐七年秋九月蘭州鎮戎永興軍地震冬十月庚戌朔環州地再震
一一一五	宋徽宗政和五年涇原（鎮原）　地震（據道光鎮原縣志）　新通志未載
一一一七	仝上七年夏六月熙河環慶涇原路地震經旬城砦關堡官私廬舍並皆摧塌居民覆壓死傷甚衆　七月壬申（據宋史）蘭州　河州　涇州　鎮原　慶陽　環縣
一一二四	仝上宣和六年春三月蘭州地震諸山草木盡沒山下麥苗反在山上　閏三月涇原地震

一一二五	仝上七年秋七月己亥熙河路地震有裂數十丈者蘭州尤甚倉庫皆沒
一一四一	宋高宗紹興十一年（金熙宗天眷三年）冬十二月丁丑熙州地震　新通志未載
一一四三	仝上十三年春二月夏國地震踰月不止地裂湧泉出黑色沙　法文表未載
一一六〇	仝上三十年（金海陵王正隆五年）春三月陝西地震德順鎮戎軍大風壞廬舍人多壓死　二月原州地震
一二一九	宋寧宗嘉定十二年（金宣宗興定三年）夏四月癸未平涼鎮戎德順地大震廬舍傾壓死者甚衆　陝西是日大風有聲如雷旋大地震平涼鎮戎德順尤甚死者一萬人（圖書集成雍正陝西通志）　西安　平涼　涇州　鎮原
	是年五月杭州地震　六月成都地震
一三〇二	元成宗大德六年關隴地震月餘不止　法文表未載　是年八月山西路安地大震
一三〇七	仝上十一年秋八月開成路（固原）地震壞王宮及官民廬舍壓死五千餘人　法文表作爲十年八月壬寅未知孰是
一三〇八	元武宗至大元年夏九月丁西鞏昌隴西寧遠地震　鞏昌　通渭　寧遠　秦州　雲南　畢節　威寧　雲南三日內地震六次
一三一一	仝上四年春三月己亥甘肅寧夏等處地震裂秋七月癸未甘州地震大風有聲如雷閏七月甲子寧夏地復震
一三一五	元仁宗延祐二年夏五月乙丑秦州成紀縣山移是夜疾風雷電北山南移至藉水側次日再移平地突出土阜高者二三丈陷沒居民　按上述現象或與地震有關　法文表未載
一三一七	仝上四年秋七月己丑成紀縣山崩
一三一八	仝上五年春二月丁酉成紀縣秦安縣（山東）山崩夏五月隴西縣山頹秋七月戊子寧遠縣山崩八月伏羌縣山崩成紀縣暴雨山崩朽壤墳起覆沒畜產
一三二一	元英宗至治元年秋八月秦州成紀縣山隕
一三二七	元泰定帝泰定三年冬十二月丁亥寧夏路地震聲如雷發自西北連震者三
一三二七	仝上四年秋八月鞏昌等處地震聲如雷通渭縣山崩九月壬寅寧夏地震　八月鳳翔　漢中　興安　洵陽　白河　通渭　陝州　涇州
一三二八	仝上致和元年秋七月辛酉朔寧夏地震

一三三〇	元文宗至順元年八月己酉西隴西地震　七月己未通渭山崩
一三三二	仝上三年八月己酉隴西及京師地震　新通志未載或同下
一三三三	元順帝元統元年秋八月己酉鞏昌隴西徽州等處地震山崩九月秦州山崩冬十一月丙申成紀縣山崩地裂辛亥秦州山崩地裂
一三三四	仝上二年秋八月秦州雞鳴山崩陷落爲池方百里　依法文表當在直隸
一三三五	仝上三年春二月成紀縣山隤水湧溺死者無算　法文表未載
一三三六	仝上至元二年夏五月秦州山崩
一三三八	仝上四年秋七月鞏昌山崩
一三四〇	仝上六年夏六月成紀縣山崩地裂
一三四一	仝上至正元年伏羌山崩水湧溺死者無數　法文表未載
一三四三	仝上三年春三月鞏昌成紀寧遠伏羌等處山摧水湧溺死人畜無算秋七月鞏昌山崩
一三四五	仝上五年冀城地震百餘日方止　法文表未載
一三五〇	仝上十年夏五月甲子寧州山崩數十處　法文表未載
一三五二	仝上十二年春三月隴西等處地震百餘日移山湮谷陷沒廬舍閏三月丁丑全陝地震莊浪定西靜寧會州尤甚
一三五三	仝上十三年莊浪定西靜寧會州復地震
一三七一	明太祖洪武四年春正月己丑鞏昌臨洮慶陽地震
一三七三	仝上六年春正月壬戌夜伏羌高山崩
一三七八	仝上十一年夏四月寧夏地震壞城垣

一三八一	仝上十三年冬十二月甲戌河州地震
一四〇三	明成祖永樂元年冬十一月甲午寧夏地震　山西直隸均震
一四〇七	仝上五年春二月戊午西和地震
一四四〇	明英宗正統四年冬十月庚午朔蘭州莊浪等處地震十日十月十一月屢震壞城堡廬舍壓死人畜　十月死二百餘人
一四四八	仝上十三年陝西通渭平凉華亭三縣山傾軍民壓死者八十餘口　法文表未載
一四六一	仝上天順五年秋七月河州南山崩壅大夏河水數日不流　法文表未載
一四七四	明憲宗成化十年冬十月丁酉臨州大河井驛地震聲如雷繼後屢震至十一月甲寅臨州一日十一震城堞房屋多圮（續文獻通致）
一四七七	仝上十三年閏二月臨洮鞏昌等處地震夏四月戊戌陝西甘肅冰厚五尺間以雜沙有青黃紅黑四色地震裂生白毛有聲如雷寧夏城垣崩壞者八十三處鞏昌甘州凉州等處同日俱震　閏二月癸卯　蘭州　鞏昌　通渭　秦州 四月戊戌　榆林　鞏昌　寧夏　凉州　甘州　滕縣　嶧縣　郯城　費縣　沂州　濟寧　寧夏最甚
一四八二	仝上十八年環縣地震　法文表未載
一四八五	仝上二十一年閏四月癸未鞏昌固原及蘭州洮岷等處地俱震　蘭州　固原　鞏昌　岷州　河州
一四九三	明孝宗宏治六年春三月寧夏地震連三年共二十震
一四九五	仝上八年春三月己亥寧夏地震十二次有聲如雷傾邊墻屋宇傷人
一四九七	仝上十年寧夏臨州鎮番等處地震　是年五月山西直隸安徽陝西皆有地震山西尤烈
一五〇一	仝上十四年春正月朔平慶等處地震裂水湧出有聲如雷至曙未已　正月庚戌　陝西河南均震陝西尤烈朝邑壞屋舍五千四百八十五間死百七十人傷九十四人壓牲畜三百九十一頭蒲州連震八日　前二年雲南大地震
一五〇五	仝年十八年慶陽地震　六月寧夏地震　是年九月浙江江蘇安徽福建均震　山西蒲州亦震
一五一〇	明武宗正德五年夏六月癸子秦州山崩壓壞田舍（續文獻通考）　新通志未載

一五二二	明世宗嘉靖元年夏寧夏地震有聲如雷　法文表未載　是年直隸山西河南湖北湖南江西均有地震
一五二三	仝上二年夏四月甘州地震（乾隆甘州府志）　新通志未載　是年正月陝西山東江蘇安徽地震
一五二四	仝上三年秋九月會寧河州地震　是年正月直隸山東河南江蘇安徽諸省均地震
一五三四	仝上十三年閏三月洮岷地震　法文表未載
一五四〇	仝上十九年夏四月庚午甘肅洮州衛地震
一五四二	仝上二十一年秋九月甲戌固原寧夏洮州同日地震冬十一月秦州屬縣地震山崖崩墜塵飛蔽野十二月丁巳鞏昌固原地震　陝西山西亦震
一五四四	仝上二十三年秋八月秦州雞鳴山摧塞雞川水經年不流　八月鞏昌地震秦安地震如雷
一五四六	仝上二十五年夏清水縣弓門鎮山裂深二百餘丈長亙山四月初十日肅州地震有聲如雷　八月戊子及癸子秦安地震
一五五〇	仝上二十九年冬十月夜肅州地震　法文表未載
一五五一	仝上三十年伏羌縣山崩
一五五五	仝上三十四年夏四月寧夏地震（乾隆秦州新志新通志未載）冬十二月陝西諸郡地震聲如雷山移地裂郡邑皆陷慶陽尤甚壓死人畜無數　十二月壬寅亥時山西陝西山東安徽河南湖北均地震陝西渭南華州朝邑三原蒲州為尤甚地裂水湧出咸陽一日震二十次白水咸陽均震數日不止藍田至次年春始止甘肅省內靈台死人一千九百餘其他各處死人有逾萬者　山西蒲州屋宇皆壞泉湧出井枯山移太原震一月　據明史本年地震各省共死八十三萬兆人大森房吉氏以此為中國最大之地震
一五五六	仝上三十五年肅州地震　法文表未載
一五五七	仝上三十六年冬十月十五日肅州地震有聲　法文表未載
一五五八	仝上三十七年隴右地震十餘次　六月酉辛秦州
一五六一	仝上四十年春二月戊戌靖虜衛山丹衛地震夏六月寧夏固原莊浪等處地大震城垣墩臺屋宇皆摧地湧黑黃沙水壓死軍民無算踰月乃止　六月壬午山西陝西皆震

一五六二	仝上四十一年春正月丙申寧夏地震傾邊墻
一五六六	仝上四十五年秋八月地震 秦州
一五六八	明穆宗隆慶二年春三月甲寅陝西慶陽寧夏等處地震寧遠地崩夏四月癸未寧夏地又震乙酉平慶地又震 三月甲寅（初四日）山西陝西甘肅湖北四川均震榆林衛臨灌地震有聲傷人 初五日十五日十六日陝西漢中府及所屬南鄭等縣地震歷十一日二十八日直隸山東地震 四月初二日陝西大震涇陽咸陽高陵城無完室人畜死傷甚衆 癸未初三日河南亦震 乙酉（初五日）陝甘又震 十九日榆林興平地震傷人咸寧縣涇陽縣村鎮有倒塌如平地者壓死二百餘人（續文獻通考）
一五七一	仝上五年冬十二月初七日寅時岷州衛地震其聲自東南起振響如雷經十餘日漸止廟宇城垣官私民舍半就傾倒居民壓死者無數 法文表未載 是年八月雲南臨安大震有聲傷人方向亦自東南至西北
一五七五	明神宗萬曆三年冬十月岷州衛自乙丑至壬午地連百餘震 十一月己卯岷州地震己丑又連震百餘次（續文獻通考）
一五八一	仝上九年夏六月文縣地震山崩城垣多壞清水縣床穰川山崩 法文表未載
一五八八	仝上十六年秋八月西寧地震十九日靖虜衛雷鳴地震
一五九〇	仝上十八年夏六月靖虜衛雨雪地震臨洮西寧等處亦地震壞廬舍城溝壓死人畜無算 六月丙子 西寧 甘州 蘭州
一五九一	仝上十九年春三月靖虜衛煤洞火出觸死者三人其一人衝起數十丈墜地二目足俱碎 按此或與地震有關係故志之 冬十月戊戌山丹衛地震 十月戊戌甘州山丹震壞城垣
一五九八	仝上二十六年春正月丁亥朔寧夏地震
一五九九	仝上二十七年秋七月臨洮鸚哥山摧八月甲午狄道城東山崩其一冲成一溝山南耕地湧出大小山高二十餘丈
一六〇四	仝上三十二年閏九月庚辰鞏昌諸處地一日十餘震 閏九月庚辰白楊吳泉地裂長三十尺 同月四川茂州保寧龍安松潘均震 十一月初九日寅時福建等省地震有聲興化尤甚
一六〇八	仝上三十六年秋八月寧夏中衛等處地震 法文表未載
一六〇九	仝上三十七年夏六月十一日夜肅州狂風起地大震壞城垣墻室廟宇壓死人畜甚衆裂東關地連七八年每年地震一二次至四十五年方息 六月辛酉 秦州 甘州 階州 南山崩紅崖清水地震死者八百四十人長八百七十里間邊城墩台受毀

一六一五	仝上四十三年夏六月二十五日地震從西北往東南有聲洪廣營傾倒城西兩月城十三丈尖塔墩北面月城七丈　法文表未載
一六一八	仝上四十六年清水縣地震四十餘日　法文表未載
一六一九	仝上四十七年夏五月狄道地震聲如雷　法文表未載
一六二一	明熹宗天啓元年春正月初一日夜半寧夏地震聲如雷初九日又震冬十二月戊辰寧夏石空寺地震礌山石毀傾倒壓死僧人　十二月之震欽定續通志作爲天啓六年（一六二七）月日均同
一六二二	仝上二年秋九月甲寅平涼隆德靜寧崇信鎮原眞寧等處鎮戎平虜諸所地震凡翻壞城垣七千九百餘丈屋宇萬一千八百餘區壓死男婦二千餘口　是年涇州地震房屋盡裂
一六二四	仝上四年五月十九日夜莊浪縣地大震凡十四晝夜山摧地裂　法文表未載　六年六月丙子子時山西直隸山東地震大同宣化靈邱震月餘日十餘次城垣壞死人無數
一六二七	仝上七年寧夏各衛營屯堡自正月己巳至二月己亥地凡百餘震大如雷小如鼓城垣房屋邊墻墩台悉圮
一六二九	明莊烈帝崇禎二年蘭州眞寧等處地震　十一月靈台
一六三〇	仝上三年寧遠縣紅嘴山崩塌垣俱亡塌禾在周樹生川莊一夕移于山上
一六三一	仝上四年夏六月乙丑臨鞏等處地震壞廬舍損人畜冬至夜五鼓天震一聲如礮火光迸裂熬華亭縣如弓曲狀移時方沒　是年秦安秦州地震
一六三二	仝上五年冬十月十三日夜成縣地震十一月西和地震十二月十五日成縣地震　西和之震損城垣房屋死三十餘人　乾隆西和縣及成縣志均作崇禎六年（一六三三）新通志作五年似誤
一六三四	仝上七年秋七月十三日成縣地震有聲自東南來次日又震連數日不止冬全省地大震壞房屋傷無數　冬秦州　秦安　禮縣
一六三六	仝上九年春三月寧遠縣地震冬十一月壬子靈台縣地震十一月壬子靈台地震山洞崩塌死人甚衆
一六四一	仝上十四年夏四月二十日階州地震五月戊子甘肅地震是年秦州禮縣同日地震裂水出　五月戊子秦州　禮縣甘州地裂泉湧出
一六四三	仝上十六年秋八月地震是年虎頭山崩山下閻家莊墳壓無遺惟一佛寺移數里外一椽未損　八月靈台地震
一六四四	仝上十七年秦州有二山相距甚遠民居其間者數百萬家一日地震兩合居民並入其中　法文表未載
一六四九	清世祖順治六年兩當縣地震裂湧出黑水山崩壞民舍壓死人畜無數半月始平　法文表未載

一六五二	仝上九年階州地震月餘城垣盡頹民屋多壞至次年　法文表未載
一六五三	仝上十年秋八月禮縣地震
一六五四	仝上十一年六月臨鞏平度等處地震有聲如雷壞房舍壓死人民甚衆　五月鎮原地震六月初八日鳳翔地大震翻房屋連震十日初九日靈台涇川山洞崩坍死人甚多六月秦州地震一年餘聲如雷官署民房均毀死萬餘人羅寺堡二山移合爲一（乾隆秦州新志）禮縣山崩
一六五五	仝上十二年安定縣地震數月傾倒房舍壓死人口　法文表未載
一六六二	清聖祖康熙元年春正月二十五日伏羌縣地震　法文表未載
一六六四	仝上三年夏六月秦州地震　法文表未載
一六七二	仝上十一年夏五月徽州西和地震木門里數村滙爲巨浸　法文表未詳載
一六七四	仝上十三年階州地震　法文表未載
一六七六	仝上十五年階州地震五月餘墻垣傾頹壓死人畜甚衆　法文表未載
一六七七	仝上十六年階州地震墻宇傾頹壓死人畜數月乃止　法文表未載
一六七八	仝上十七年階州地震　法文表未載
一六七九	仝上十八年階州地震樹鳴　法文表未載
一六八一	仝上二十年夏六月階州地震　法文表未載　前一年秋雲南楚雄地震死千餘人
一六八六	仝上二十五年夏六月寧夏地震　法文表未載　二十七年五月雲南劍川地震死百九十人歷六月
一六九五	仝上三十四年平涼府地震　四月初六日戌時甘肅陝西河南直隸湖北湖南均震盂縣聲自西北來如黃河水漲之音平陽毀房屋死人甚多
一七〇四	仝上四十三年春三月平涼府地震秋七月寧遠地震八月真寧地震安化環縣地震

一七〇八　仝上四十七年秋七月西安堡地震泉源壅塞　法文表未載

一七〇九　仝上四十八年秋九月十二日涼州西寧靜寧固原寧夏等處地震傷人中衛尤甚河南各堡平地水溢魚游推出大石有合抱者井水激射高出數尺壓死男婦二千餘口自是震動無常人率露棲年餘始定冬莊浪所阿壩嶺等處地震傷人靖遠衛地屢震有聲摧塌邊墻一千六百六十丈七尺墩台二十座民房二千餘間壓死男婦三十二人至次年正月朔復震　九月十二日辰時城固　鎮原　西寧　中牟

一七一〇　仝上四十九年環縣地震　法文表未載

一七一四　仝上五十三年夏靜寧州地大震　法文表未載

一七一八　仝上五十七年夏五月二十一日臨洮鞏昌秦州平涼慶陽寧夏等處地大震傷人畜秦安尤甚數十日山崩地裂傷人畜通渭筆架山崩城垣塌其半地裂寬尺餘南鄉尤甚壓死四千餘人　秦州　秦安　禮縣震

一七二五　清世宗雍正三年冬十一月朔環縣地震壞廬舍　法文表未載

一七二七　仝上五年合水地震　法文表未載

一七三〇　仝上八年夏五月中旬洮西四十里古鳳山崩是年合水正寧地震　法文表未載

一七三八　清高宗乾隆三年夏四月文縣地震冬十一月靖遠慶陽寧夏地震平羅北新渠寶豐中衛香山等處尤甚一時地如奮躍土皆墳起斥裂數尺或盈丈水湧溢甚氣皆熱村堡城垣隄壩屋舍窰莊盡倒壓斃官民男婦五萬餘人閱十餘日有掘窰搜物者洞開而入猶生自云探盆中粟嚼之得不死　法文表未詳

一七三九　仝上四年冬十一月二十四日涼州地震是年秦安縣北山崩隴水壅不流者數日　法文表未載

一七四一　仝上六年冬十一月正寧縣地震　法文表未載

一七四八　仝上十三年冬十月朔環縣地震　法文表未載

一七五六　仝上二十一年秦州邽山之陰山鳴有聲人畏避之數日山崩　法文表未載

一七六〇　仝上二十五年春二月十七日鎮原地震　新通志未載

一七六四　仝上二十九年秋八月通渭縣地大震六日乃止　二十年八月（據光緒通渭縣志）通渭地大震人多露棲六日乃止年份不符似係通渭縣志之誤

一七六五	仝上三十年（會寧縣）秋七月地震城垣多裂十八日辰時伏羌縣地大震倒塌房屋二萬八千七百零壓傷人口七百七十零　三月丁亥狄道地震七月十八日辰時鳳翔地震申時又微震東華錄記同日甘肅地震十二處
一七八五	仝上五十年春三月初八日永昌縣大風霾拔木越二日地震　是年四月肅州玉門地震（東華錄）
一八〇七	清仁宗嘉慶十一年十二月十四日戊時鎮原地震窗戶作聲歷一時乃止（道光鎮原縣志）　新通志未載
一八一四	仝上十八年十二月甲寅亥時鎮原地震有聲如巨風自西北來（道光鎮原縣志）　新通志未載
一八一五	仝上二十年九月丙寅鎮原地震（道光鎮原縣志）　新通志未載　是月無丙寅似誤
一八一六	仝上二十一年二月鎮原地震（道光鎮原縣志）　新通志未載
一八二〇	仝上二十五年春正月初九日鎮番縣地震有聲如雷自西北來　法文表未載
一八四五	清宣宗道光二十五年八月鎮原地震（道光鎮原縣志）　新通志未載
一八四七	仝上二十七年夏六月十一日西寧縣北川郭家堡泉山崩南川田家寨北山崩壅塞河道冲倒房屋居民避居高阜　法文表未載
一八五〇	仝上三十年寧遠地震房屋傾倒人有壓斃者　法文表未載
一八五二	清文宗咸豐二年夏四月初八日中衛地大震轟轟如雷者三次地裂房倒湧出黑沙泥壓傷男婦數百口自是震動無常月餘始息六月朔夜半狄見馬衔山裂火自地中作光𤆬燭天照耀山川至明始滅　法文表未載
一八五三	仝上五年大通縣西十里塔磤山崩
一八六一	仝上十一年甯遠地震東鄉尤甚
一八六二	清穆宗同治元年八月皋蘭縣地震有聲自艮方來　法文表未載
一八七二	仝上十一年三月皋蘭縣地震　法文表未載
一八七三	仝上十二年春正月二十六日黎明肅州地震　法文表未載
一八七四	仝上十三年秋八月西山崩裂走入城中壓倒西城墻垣二百四十餘丈民房九十餘院壓斃男婦大小四十九丁口受災者二百一十餘戶　法文表未載

一八七五	清德宗光緒元年春正月元日西寧縣西川陰山崩壓蓋田地壅塞水渠秋九月皋蘭縣地震　法文表未載
一八七八	仝上四年秋九月皋蘭縣地震　法文表未載
一八七九	仝上五年五月初十日階州文縣地震十一日階州大水十二日隴右諸州縣同時地震山谷響應土霧亙天場內礫礎相觸甕中水傾出室廬搖落壓死人畜階州城中突起土阜周二里許各處山飛石走地裂水出殺九千八百八十一人文縣山崩水壅城垣傾圮殺一萬八百三十餘人　五月十二日通渭　十日丑時寧羌地震十一日子時岐山地震十二日寅時富平定遠寧羌岐山未傷人地搖動如舟寧羌震歷一時定遠震四次屋瓦傾落房宇傾側窗戶作響岐山大震後繼以小震五次
一八八〇	仝上六年夏六月二十五日地復大震殺四十二人嗣後階州文縣震動無常至十一年秋八月十七日震後乃止
一八八一	仝上七年五月乙卯皋蘭縣地震翼日復震六月禮縣岳平大潭二里地大震斃人民四百八十口傾倒房屋四千有奇牲畜無數二十五日西和西寧等處地震秋七月通渭秦安地震冬十一月初二日子時西寧丹噶爾地震天明巳時又震其聲自北而南初三日寅時四鄉皆震　法文表未載
一八八二	仝上八年春二月初八日丑刻西和縣地震有聲冬十一月（皋蘭縣）地震　法文表未載
一八八五	仝上十年冬十一月（皋蘭縣）地震二十九日夜秦州西和等處地大震有聲如雷　法文表未載
一八八七	仝上十三年閏四月十二日亥時西和地震有聲如雷六月皋蘭縣北鄉紅水等處地震壞城垣廬舍十二月甲戌河州地震　法文表未載
一八八八	仝上十四年夏四月皋蘭縣地震秋九月秦州西寧等處地震靖遠蘆塘營永安堡鎖罕尤甚傾倒城垣房屋壓死人畜無算　法文表未載
一八八九	仝上十五年秋八月疊州地大震傾倒房屋甚多九月地又震　法文表未載
一八九〇	仝上十六年春正月二十八日卯時西寧縣地震有聲　法文表未載
一八九三	仝上十九年夏四月十七日西寧縣小南川貴爾干地震傾倒房屋三百餘間壓斃人口甚多　法文表未載
一八九四	仝上二十年河州東八鄙藺山崩　法文表未載
一八九五	仝上二十一年冬十二月初四日夜山丹縣地震有聲自西南而東北　法文表未載

一八九六	仝上二十二年河州東哈家山崩　法文表未載
一八九七	仝上二十三年春正月二十四日省城地震　法文表未載
一九〇〇	仝上二十六年六月漳縣新寺南谷山連日有聲如雷地土鬆湧如豬喙然初四日遙山忽崩壅塞河水三日不流　法文表未載
一九〇一	仝上二十七年夏皋蘭五泉山三台閣下山崖崩落石破塵飛數日始止　法文表未載
一九〇一	仝上二十八年冬十月初九日戌時山丹縣有聲如雷十二月除夕永昌地震　法文表未載
一九〇九	清宣統元年秦安雒家山南山自六月十五日響動飛塵時起至二十後忽崩伏家聚樹莊被壓傷斃三人　法文表未載

附鳴聲表

古書中有載鳴聲者、或發自天、或出諸地。究係何種現象、頗難索解。其中有與隕星相關者、理自顯然、其未有隕星者、當另有一種原因、或與外國所謂 Retumbo, Rombo, Mispoeffers, Barrisal Guns, Bramidos, Marinas, Brontidis 等相同。觀其命名之紛異、即可想見對於發聲原因眞確知識之缺乏。近來研究、大抵謂與地震現象有關。甘肅爲中國地震最烈之地、鳴聲記載亦多。茲考宣統新通志所載、除記明隕星者不計外、約二十餘則、表列如左。

前三〇	漢成帝建始三年夏五月乙亥天水南山大石鳴如雷聲聞三百里野鷄皆鳴
前一八	仝上鴻嘉三年冀城南山石鼓自鳴如雷
三五四	東晉穆帝永和十年夜有光如車蓋聲若雷霆震動城邑
四一六	東晉安帝義熙十二年天水冀縣石鼓鳴聲聞數百里野鷄皆雊

一三三二	元文宗至順三年夏五月己巳天鼓鳴于西北
一四九六	明孝宗宏治九年閏三月戊午天鼓鳴
一六二九	明莊烈帝崇禎二年冬十月天鼓鳴
一六四三	仝上十六年春二月中夜半天鼓鳴如雷
一六五四	清祖世順治十一年十月十二日夜靜寧階州天鼓鳴
一六六七	清聖祖康熙六年十月階州山鳴
一六七四	仝上十三年冬十二月涇州天鼓鳴
一六七六	仝上十五年秋八月皋蘭縣西方天鼓鳴聲如雷
一六七七	仝上十六年秋八月臨洮天鼓鳴於西方聲如雷
一六八四	仝上二十三年春三月寧夏天鼓鳴于西南
一八三一	清宣宗道光十一年春正月十三日狄道天鼓鳴既止有火光大如斗照耀村郭如白晝
一八五七	清文宗咸豐七年冬十一月十三日戌時山丹縣有聲如雷
一八六二	清穆宗同治元年夏六月狄道鳳凰山有聲如雷數月不息
一八六五	仝上四年春四月十四日通渭秦安有聲鳴如鼓火光西現如星隕清水縣北山亦有火山至秋七月乃息
一八九五	清德宗光緒二十一年閏五月狄道天鼓鳴
一九〇一	仝上二十七年冬十二月二十三日辰時丹噶爾天鼓鳴
一九〇四	仝上三十年秋七月海城縣西北角無雷而響　八月十二日海城縣西北角天鼓鳴

一九〇七

仝上三十三年秋八月狄道天鼓鳴十五日夜山丹縣有聲如雷

山西紫金山鹹性正長岩

那林著
董常節譯

紫金山在山西臨縣治北北西二十公里。山孤小、峯巒參差成階級、峙立於中生代砂岩高原之上。鹹性正長岩、爲岩石之主體、成餅盤形、居最高位置。其噴火口之一部、今且存在、爲最高峯。其次乃岩頸所成也。

調查範圍、自黃河以西至太原盆地之東。本爲高原、而爲無數長谷小峽所間斷者。其最高點、不越二千二百公尺。爲一大水成地層、名曰山西層。岩石之大半、爲紅色或灰綠色砂岩硬砂岩、次爲粘板岩、含石灰甚多。考其時代、下部若屬二疊紀或二疊石炭紀。上部則屬三疊紀。在此地層之下、各層無顯明境界、有陸相海相地層含煤層、李希脫霍芬與維理二氏歸之於石炭紀者即此。

岩石層次、大概水平、惟亦有沿前寒武紀地壘斷層線而向外傾斜者、斜角自十度至二十餘度不等。中生代以前地層、有寒武奧陶紀石灰岩、再下有極厚之太古代礫質砂岩、褐紅色雲母粘板岩、中有輝綠岩脈貫於其間。寒武系地層乃覆於五台片岩中眼球花崗岩之上者。

地形與地質、兩相對照、前寒武紀地壘、横貫山西層、方向自北北東至南南西、在黃河與太原府之間、厚約五十公里、作無數高峯、由石英岩、砂岩、粘板岩所組成。岩脈有片麻岩、片麻花崗岩、花崗岩。層次平坦、走向大旨與斷層線一致、厚度至少有千六百公尺。而寒武奧陶紀石灰岩厚度、尚未計及。

前寒武系所成之地壘、向北北東則漸低失跡於嵐縣東南、向北復現於寧武府之南。西部界線、山西層起而爲高大山嶺。東部則僅有片麻花崗岩、起作階級狀、且有穿入相等傾斜線中者。與斷層相伴之噴出岩石、僅見於地壘東部、有岩脉穿入於寒武奧陶石灰岩中者、有噴出成餅盤形、而爲奧陶系石灰岩與石炭系粘板岩、片岩

之分界線者。在噴出鹹性岩處。則並有霞石透長岩脈。

前寒武紀地壘、由斷層隆起所成。時代約在中生代或中生代後。噴出岩石、限於斷層線中。其時代略與地壘造成相前後。霞石透長岩以其噴出岩床、覆於中生代地層之上、其時代當在中生代以後。西部紫金山鹹性正長岩之時代、亦在中生代或中生代以後。申言之、即兩噴出岩、同屬於一時代也。

紫金山鹹性正長岩

紫金山噴出岩之面積、成三角形、約有十五方公里、最高點千八百五十公尺。其分布大概、略如總圖。岩成長帶狀餅盤、覆於水成層之上、坡緩斜向西南。噴火口頸及熔岩、今猶見之。熔岩成細胞狀、有孔。岩石分為粗面安山岩、輝石正長岩、變體霞石正長岩與霞石鈉鐵輝石正長岩數種。粗面安山岩中、含斜長石極多、屬於鹹性石灰質岩類。輝石正長岩與霞石正長岩、則為標準鹹性岩石。其噴出次第、首為粗面安山岩、繼以輝石正長岩與霞石正長岩、終於霞石鈉鐵輝石正長岩。岩石均極鮮潔、少風化。凝固之後、似未經偉大壓力。惟偶受霞石透長岩脈之影響而已。

粗面安山面

此岩直接與水成岩相接觸、東北兩面、又與黃土接觸。下部有紅褐色粘板岩、粘土質砂岩、傾斜內向於岩床。距岩盤西北西約二公里、有許多粗面安山岩脈、其中直立而大者、寬七公尺、走向自西北至東南。由此向南二公里谷中、上有大塊安山岩露頭、此蓋大岩脈之一部也。

岩石呈微粒組織、灰色、含交錯石灰長石、小片重矽酸鹽。其接觸部分、具斑晶流狀組織。鑛物分解特甚。有斑晶

中性長石、鹼性長石、綠色角閃石、輝石、楣石、燐灰石及養化鑛物。石基爲全晶質而堅。由灰鈉長石、鹼性長石、小粒石英、不透明鑛物所成。次生鑛物、有綠簾石、綠泥石、石英、蛋白石、黃鐵鑛等。其組成鑛物中、以中性長石爲最要。

輝石正長岩

本區之中、因此岩連接鹼性煌斑岩與純粹霞石正長岩、故最爲重要。其分布適在中央、除西南一部與水成層相接外、餘均環以粗面安山岩。兩岩之接觸明顯。然當輝石正長石噴出之時、粗面安山岩尙未完全凝固也。在西北接觸部、粗面安山岩、絕少斑晶、與粒狀輝石正長岩相接、有如岩脉之穿入其間者。接觸之處、無角礫岩碎片、呈流狀組織、粒微面光滑、帶藍色光澤。顯微鏡下顯半自形粒狀構造。組成鑛物、有鹼性長石、霞石、鈉鐵輝石、輝石、鹼類角閃石、楣石、燐灰石、不透明鐵質、及次生沸石鑛物。

變體霞石正長岩

岩粗而富霞石、種類甚多、有霞石鈉鐵輝石正長岩、有細粒或粗粒輝石正長岩、因其轉變無定、故名曰變體霞石正長岩。色淡而粗、多含霞石、無一定質量。有色鑛物、增減無定、粒之大小亦不等。中含鹼性長石、鈉鐵輝石、黑雲母、鎂尖晶石、楣石、黃鐵鑛、燐灰石。次生鑛物、有鈉沸石、方沸石。中以長石爲最多、霞石次之、餘又次之。

霞石鈉鐵長石正長岩

此岩所占之面積較小、在大肚山東側谷中、形成小嶺。西及西北、與噴出角礫岩相界。東與岩頸連接。南雖爲土所覆、然與角礫岩相界處、猶得見之。上盤蓋以砂岩、此蓋在深處與餅盤分離。因機械力而隆起者。砂岩風化、正

長岩遂顯。中含圓大斑晶霞石與片狀鉀長石。其上部斑晶霞石易以粒狀、頗似長英岩。更上在砂岩層下、又轉爲糖粒狀色暗灰綠粗粒正長岩中所含鑛物爲鹹性長石霞石、鈉鐵輝石、黑雲母、燐灰石及次生鑛物之鈉沸石、榍石少許。

岩脈

霞石正長岩中、岩脈甚多、別之可得數種。(一)霞石透長岩、粒粗、色淡、質重、無斑晶。(二)同上、有透長石斑晶。(一三)同上、有斑晶霞石、透長石、色綠或灰綠、含鈉鐵輝石、石基多鹹性長石、霞石、鈉鐵輝石。(四)同上、有白榴石斑晶。(五)白榴石正長斑岩。(六)粒狀灰黑霞石透長性岩。(七)各種正長偉晶花崗岩。此可分酸性基性兩種。

火山頸

大肚山居頸之中心、頸之周圍、大部爲變質角礫岩、中含噴出氣體液體、裂隙中充以新生之長石、方解石、及鐵鑛。界線雖難確定、然南、北、東三面、均己侵蝕成谷、大體可辨。頸之外部、爲分解極甚之角礫岩、中無噴出物質、惟近口頸處含有噴出物質、且岩石亦堅。內部爲噴出角礫岩、色淡含長石。在大肚山東西兩坡岩多孔色雜、爲含透長石之斑狀粗面岩。在口頸角礫岩處、岩脈羣出、大都入於口頸之內、間有直透外部入於正長岩中者。

結論

各種岩石、均屬鹹性。粗面安山岩噴出最早、以富石灰質、故多斜長石、因含重矽酸鹽、故乏鎂鐵質、此岩或由輝石正長岩分解而成。輝石正長岩、富鎂與鹹而少矽質、鹹性噴出岩、多在莫兒棟之東、且多岩脈、惟霞石正長岩未之見耳。輝石正長岩之所以易於分解者、以其多含石灰與鎂、而少鹹類、故無榍石。變體霞石正長岩、確由輝

石正長岩分解而成、以其比母岩少矽質與重矽酸鹽故也。鹹類之存、以多霞石與鈉鐵輝石而然。楣石則基於變化而成也。

山西大同左雲懷仁右玉煤田地質

王竹泉

緒言

民國六年十月奉令調查大同煤田。(所謂大同煤田者實在大同縣之西、兼屬左雲懷仁右玉各縣)二十三日乘京綏車出發、二十五日由大同往口泉鎮、遂以是鎮爲測量煤田之起點。後由口泉而鵰窩嘴、而石岩莊、皆大同屬。再西南而白朵村、而鵶崖村、皆懷仁屬。更至張家峰長流水水窖溝四十里莊吳家窖鎮皆左雲屬。復東至懷仁城西北至左雲城、南入上石岔、至右玉屬之張家堡、應縣屬之安東衛(一名口泉在北中村之西)等處。調查所及、自東北而西南共長二百餘里寬約百里左右。惟煤田面積、尚不僅此。聞由安東衛仍向西南延伸百餘里、至朔縣城北而止。彼時限於旅費且地近塞外、冬日大雪頻仍、乃於十二日二十四號返京。七年九月復往研究煤層及採集化石、更歷雲崗溝、踰兩月而返。玆將前後所見者、分爲二章。首章論地質上之事項、次章專論鑛產、試各述之於左。

第一章　地質

地層

大同附近一帶地質以片麻岩分布爲最廣。惟在大同西南乃有紅色頁岩鮞狀灰岩與竹葉灰岩等。更有含煤之岩系、顯露於大同朔縣間。今試分論之。

(一)　片麻岩系　大同屬口泉之西南、在七峰山與黃土平原接觸之處、始見有外現淺紅色之片麻岩。含長石甚多、且長石結晶有時甚粗、片理不甚清晰。由此沿山足向西南引伸、至鵝毛口附近、露頭隔斷。更由鵝毛口之

西南起、仍向西南延長、中經小峪口大峪口、以直至朔縣屬。惟在小峪口于此片麻岩中、見有黑色脈形之火成岩侵入、寬約四尺。又至大同西小站口附近、片麻岩露布亦甚廣。更在大同東北陽高天鎭間、於火車中亦可見其爲片麻岩。由此可推知自大同至懷仁山陰間平川之東南山脈、大抵亦爲片麻岩所構成。故片麻岩在大同一帶分布殊廣。惟此與歸綏地質相較稍有不同、蓋在歸綏一帶(見彙報第一號翁著綏遠地質)於片麻岩之上復見有結晶片岩如雲母片岩石英片岩等、更有大理岩層以錯雜其間。若在大同西南則除片麻岩外、他變質岩層皆無遺存之跡。(圖一)此固可表其與上覆之岩層中間之缺失、而其間不整合之狀態乃因而愈顯。依維理士(Willis)氏研究中國太古元古界區別之標準。此次所見之片麻岩似甚古、大抵皆爲太古界之岩層矣。

(二)寒武紀紅色頁岩系　在口泉西南、直接位於片麻岩之上者、爲紅色頁岩系、全系厚約一百餘公尺。中夾有薄層灰岩、砂岩甚少。(圖一)昔維理士氏在山東曾名爲饅頭頁岩、而屬於寒武紀。翁師在歸綏清水河岸亦見此等岩層。惟其組織與此稍異。蓋紅色頁岩系之在清水河者紅色砂岩甚發達、此則以紅色頁岩最多、且間以石灰岩薄層。又在清水河全系厚度不過五十餘公尺、此則倍之。但在小站口附近于片麻岩之上、此系缺失、以致片麻岩與寒武紀石灰岩系或含煤系相接觸。

(三)寒武紀石灰岩系　口泉西南紅色頁岩系之上、爲石灰岩系。全系厚約二百六十餘公尺、由竹葉灰岩與鮞狀灰岩所組成。惟其上部有淺灰色石灰岩薄層、下即接以顯著之竹葉灰岩。鮞狀灰岩爲層亦較薄。(圖一)不若在山西南部之發達。又在口泉鎭南、於竹葉石灰岩中、曾見夾有石英岩薄層。總之、此石灰岩系與紅色頁岩系同爲震旦系之一部、而屬於寒武紀。至若如山西南部之所謂奧陶紀石灰岩者、在此則完全缺失。且此系

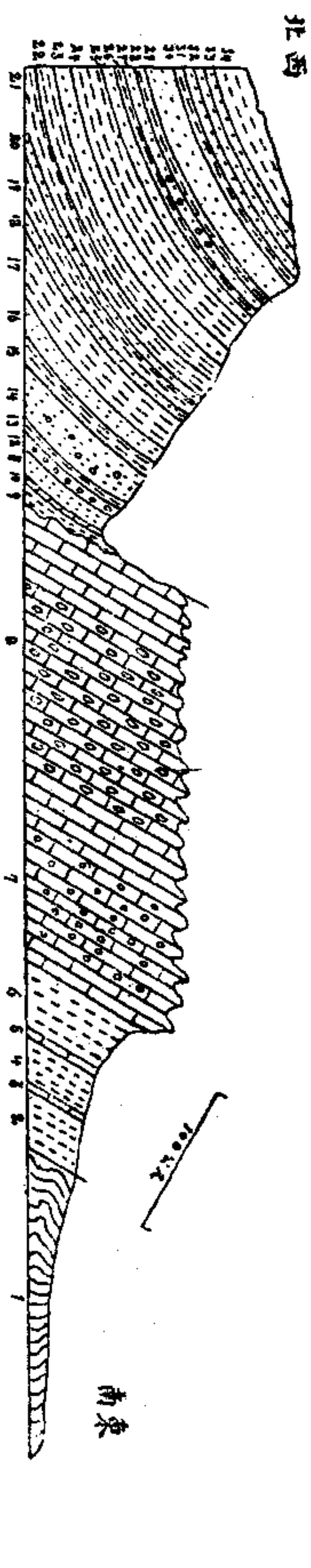
之分布頗爲整齊、由口泉鎮起向西南延伸數百里。入朔縣境、爲大同朔縣間黃土盆地與其西北煤田現天然之界線。惟在大同西此系露出於拖平青磁窰一帶者、厚度較薄、有時若斷若續、以分布於片麻岩與含煤系之間。

石灰岩之成分、曾經工業試驗所鄭寶善君爲化學分析。錄其結果如左。

產地	鈣養	鎂養	鋁二養三	炭酸	硅酸
火藥溝	三〇、二二	一、五三	九、〇八	一五、五六	四〇、〇七
拖平村	五〇、三五	一、七〇	二、五八	三一、七九	一〇、〇四
口泉南山坡	四三、八九	一一、六七	四、二〇	二〇、〇九	一九、五八
頭道溝	四九、八七	三、三六	〇、七八	三三、四二	三、八八
蛇腰溝	四〇、六七	一〇、〇〇	〇、六八	三一、五六	六、九八

(四)寒武紀石灰岩系上之不整一　在直隸之蔚州廣靈一帶、及歸綏之淸水河附近、侏羅紀煤層皆直覆於寒武石灰岩之上。此地則於寒武石灰岩與侏羅煤系間、尙有屬於石炭二疊紀之含煤系。故在大同煤田寒武石灰岩上之岩層、其不整一有二。一、在寒武紀石灰岩二疊紀岩層之間。其不整合之狀態、可以奧陶石灰岩之缺失證明之。一在寒武紀石灰岩及石炭二疊紀煤系中部頁岩砂岩系等與侏羅紀煤系之間。蓋在靑磁窰白山子一帶、可見侏羅煤系直接覆於寒武紀石灰岩或片麻岩之上、畢石炭二疊紀煤系及中部頁岩砂岩系全部缺失。察其接觸、似爲不整合之表示、非由斷層所致。因在拖平附近可見石炭二疊紀煤系與寒武紀石灰岩

第一圖　懷仁縣花林溝東南岩層剖面圖

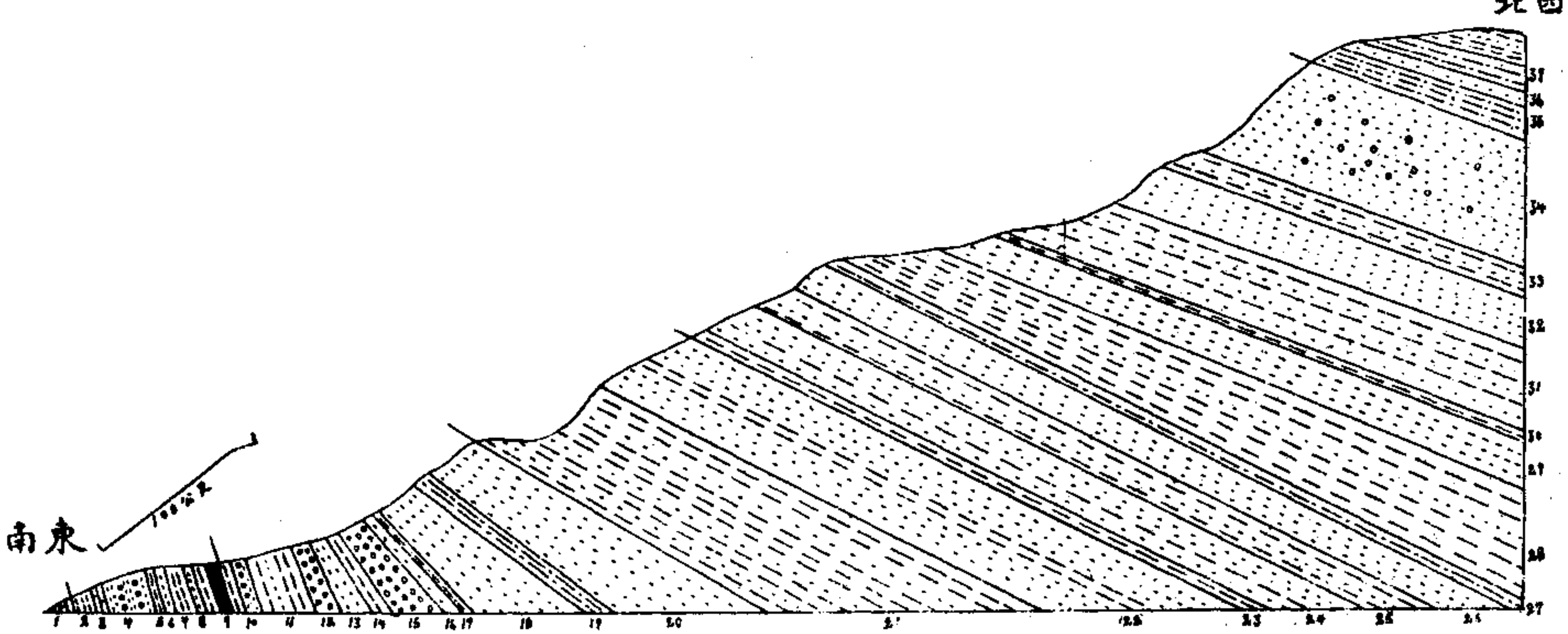


1 片麻岩　2 紅色頁岩　3 石灰岩　4 紅色頁岩　5 石灰岩及薄層砂岩　6 紅色頁岩　7 鱝狀石灰岩　8 竹葉狀石灰岩　9 藍色及紅色頁岩　10 含紡錘蟲石灰岩　11 砂岩　12 礫岩　13 頁岩　14 粗砂岩或礫岩　15 灰黑色頁岩　16 粗砂岩　17 黑色頁岩　18 灰色砂岩　19 灰色石灰質頁岩　20 砂岩　21 黑色與綠色頁岩相間　22 紅色及綠色頁岩　23 白色砂岩　24 藍色頁岩及砂岩　25 白色砂岩　26 紫色及綠色頁岩　27 白色砂岩有時局部現礫岩狀　28 紫色頁岩　29 砂岩　30 淺紅色頁岩　31 綠色砂岩　32 紫色砂岩　33 淺紅色砂岩　34 紅色頁岩

接觸處爲厚約十公尺之一種紅色粘土、而在青磁窰白山子一帶、雖惟見侏羅煤系與寒武石灰岩或片麻岩之接觸、而接觸帶間之紅色粘土始終保存如故、不過於此含鐵質較富耳。

(五)下煤系　此系位於寒武紀石灰岩層之上、全系共厚約二百餘公尺。其下部爲藍色或紅色頁岩與粘土、及含紡錘蟲珊瑚蟲等之灰色石灰岩。再上爲砂岩頁岩等之互層、中含煤層。圖(一、二、三、)在口泉鵝毛口間

第二圖 大同縣口泉鎮北煤系岩層全部剖面圖



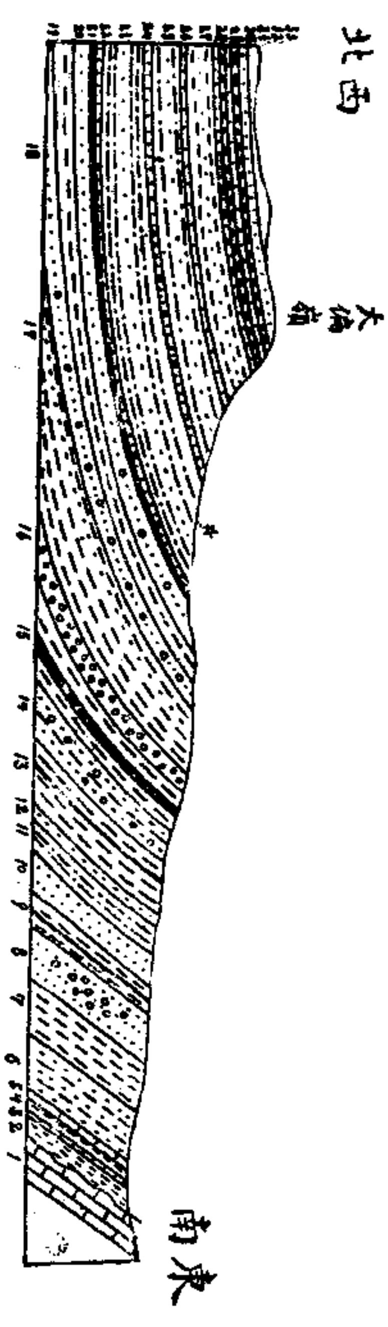
1 寒武紀石灰岩
2 紅色頁岩及藍色粘土
3 含紡綞蟲石灰岩
4 灰色礫岩狀砂岩
5 灰黑色頁岩
6 淺黃色砂岩
7 藍色頁岩
8 白色砂岩
9 黑色頁岩及煤層（在口泉二道溝所採者此煤層厚約一公尺六）
10 灰色礫岩及砂岩
11 藍色砂質頁岩
12 礫岩
13 淺黃色砂岩
14 藍色頁岩
15 礫岩
16 白色砂岩
17 紅色及藍色頁岩
18 白色砂岩
19 藍色砂質頁岩
20 白色粗砂岩
21 藍色及紅色頁岩與薄層砂岩相間
22 白色砂岩及薄層灰色與紅色砂岩並含有少許藍色與黃綠色頁岩
23 黑色頁岩含有植物化石
24 藍灰色細砂岩及少許頁岩
25 紅色砂質頁岩
26 淺紅色及黃灰色砂岩
27 砂質頁岩及砂岩
28 藍色與淺紅色頁岩及砂岩或少許灰黑色頁岩
29 灰色砂岩
30 藍色頁岩
31 黃灰色砂岩並含有藍色頁岩
32 白色砂岩
33 白灰色砂岩及藍色頁岩
34 白色及淺紅色砂岩有時局部現礫岩狀
35 藍綠色及淺紅色砂質頁岩
36 白灰色砂岩
37 紅色與綠色砂質頁岩及薄層砂岩等

此系所含主要之煤層內恒夾有砂質頁岩、含有古生代之植物化石。茲在靜石溝於此頁岩中得有羊齒類化石數種、又在鵝毛口莊瓦溝於此頁岩中得有輪木 ANNULARIA、楔形木 SPHENOPHYLLUM 及他種植物化石。故觀其化石及岩層之組織、與山西太原及平孟潞澤一帶之石炭二疊紀岩層相當無疑。惟此系在拖平附近厚度大減、其下部含紡綞蟲石灰岩層于此亦未見。更沿岩層之走向由拖平向西北行數里、則斯系全部皆歸消滅。又考歸綏大青山一帶、尚未確定有此煤系、惟有紅色頁岩與砂岩上之侏羅煤系。雁門關以南則只有石炭二疊紀煤系、無侏羅煤系。故同一煤田內得見石炭侏羅二紀煤系、而已得有確證者、此時所知似惟在大同西南之煤田。大同煤田殆為關內石炭二疊紀煤田與邊外侏羅紀煤田之過渡區域乎。然大同煤田前經有名地質學者李希霍芬氏 VON RISHTHOFEN 調查、亦謂僅有侏羅紀而無石炭紀。此次調查、始發見石炭二疊紀存在之確證。卽北京西山、亦有石炭紀煤系與侏羅紀煤系並存、從前調查者亦多併為一談。大抵侏羅紀煤系發達之地、石炭紀層厚較弱、調查者中於先入之言、更以其岩石性質、皆以砂岩頁岩為主、偶未經意、即易致誤、不足怪也。下煤系之在口泉鎮北者、為二道溝煤窰、在口泉鎮西者為大石頭溝煤窰、西南為小峪煤窰、吳家窰煤窰四鳳山煤窰、再西南而為盧家窰煤窰安東衞(一名口泉)煤窰。其煤層之露頭就此次所測得者其長徑已達二百餘里。

(六)中部頁岩及砂岩系　下煤系之上、為紅色頁岩與砂岩礫岩等相間成層。(圖二、四、)全系厚度約由一百餘公尺至三百五十餘公尺。頁岩現露恒為碎塊、有時綠色砂岩則因硬度較高在山坡間易突出而為懸崖。其色澤或白或灰或紅、雜然並生、以致會同頁岩而組成燦爛之岩層。惟自遠方視之、則以紅色為特著。此系之時

代雖無化石可資考據、然既界于石炭二疊紀及侏羅紀二含煤系之間、大抵與北京西山所見之石英砂岩層相當、而屬於二疊三疊紀。此系之在口泉鎮東北者分配於拖平之西、及其西北一帶。在口泉鎮北及其西北者則如平面圖上所示。至在白朵村及老窰溝東南一帶、因受岩層斷裂及倒置之影響、全系露頭甚薄、不過尙能表明其岩層存在而已。西南

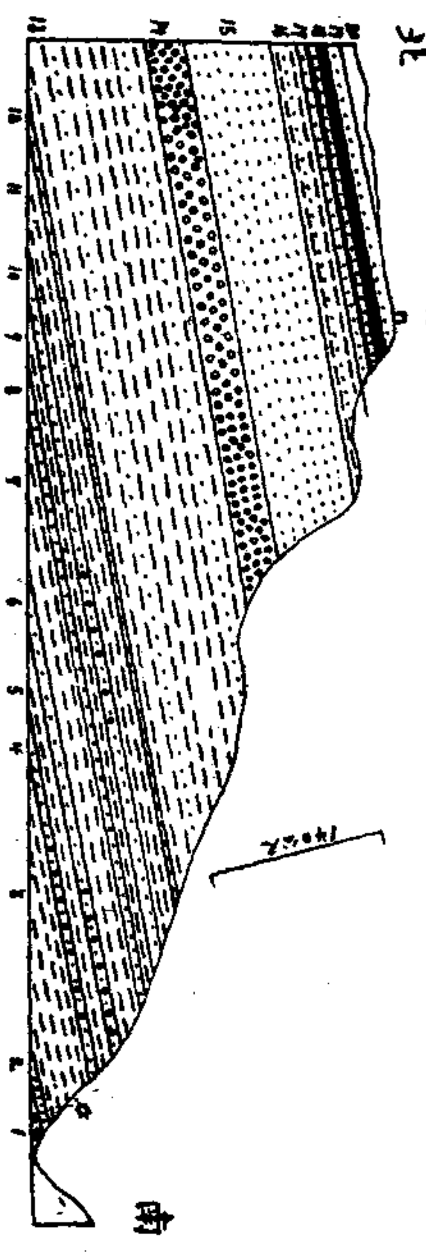
第三圖　大同縣寨子頭村南岩層剖面圖



1 寒武紀石灰岩
2 藍色及紅黃色頁岩厚約十公尺
3 白色砂岩厚約一公尺三
4 藍色頁岩一公尺七
5 含紡錘蟲石灰岩厚約一公尺四
6 灰色砂岩及頁岩厚約十九公尺
7 藍色及灰黑色頁岩厚約二十公尺
8 礫岩狀砂岩厚約二十公尺
9 頁岩及煤層厚約十公尺
10 白色砂岩十一公尺五
11 灰色砂質頁岩厚約十公尺
12 灰色砂岩厚約五公尺三
13 藍色頁岩及煤層厚約二十公尺
14 灰白色礫岩狀砂岩中含有少許灰色頁岩共厚約十五公尺
15 煤層及黑色頁岩厚約十八公尺五
16 礫岩厚約七公尺五
17 灰黑色頁岩及砂岩厚約二十八公尺
18 灰色礫岩狀砂岩厚約十公尺八
19 灰色頁岩厚約十一公尺
20 灰色砂岩有時間含土質稍多成現礫岩狀厚約十二公尺
21 煤層厚約九公寸
22 灰黃色礫岩狀砂岩厚約五公尺
23 藍色砂質頁岩及砂岩厚約四十公尺
24 灰色礫岩狀砂岩厚約三公尺
25 藍色砂質頁岩及砂岩厚約二十八公尺
26 灰色砂岩厚約六公尺六
27 黑色與藍色或紅色頁岩等及砂岩厚約三十五公尺
28 白灰色礫岩狀砂岩厚約四公尺五
29 紅色及藍色頁岩厚約四公尺
30 黃白色石英砂岩厚約八公尺五
31 灰色及紅色或藍色頁岩厚約七公尺
32 白色石英砂岩厚約十公尺
33 黃土

行至窰子頭東北、則全系厚度忽猝增。雖沿岩層之走向與口泉北或西之中部岩系仍相連接、而厚度則幾數倍之。更西經王邊莊、三井、柏山等處、復西南分布於黃家店、黃家山、張家堡、觀音堂一帶、再西南入朔縣境。若由

第四圖　大同縣窯子頭村東北岩層剖面圖



1 紅色及黃色頁岩
2 白色礫岩狀砂岩
3 綠色及淺藍色頁岩上部間呈紅色
4 淺灰色礫岩狀堅密砂岩
5 紅色頁岩及少許綠色頁岩
6 白灰色砂岩有時局部現礫岩狀
7 紅色頁岩有時局部現藍綠色
8 白灰色砂岩
9 紅色頁岩有時局部現藍綠色
10 白灰色砂岩有時局部現礫岩狀
11 紅色頁岩有時局部呈藍綠色
12 紅色砂岩
13 紅色與藍綠色頁岩及砂岩
14 礫岩
15 白色砂岩
16 紅色及藍綠色頁岩與砂岩相間
17 白灰色砂岩
18 煤層、兩含有礫層砂岩共厚約十二公尺
19 淺黃色白砂岩
20 黃土

注一　上圖中*層疑與圖三之第二十三層*相當

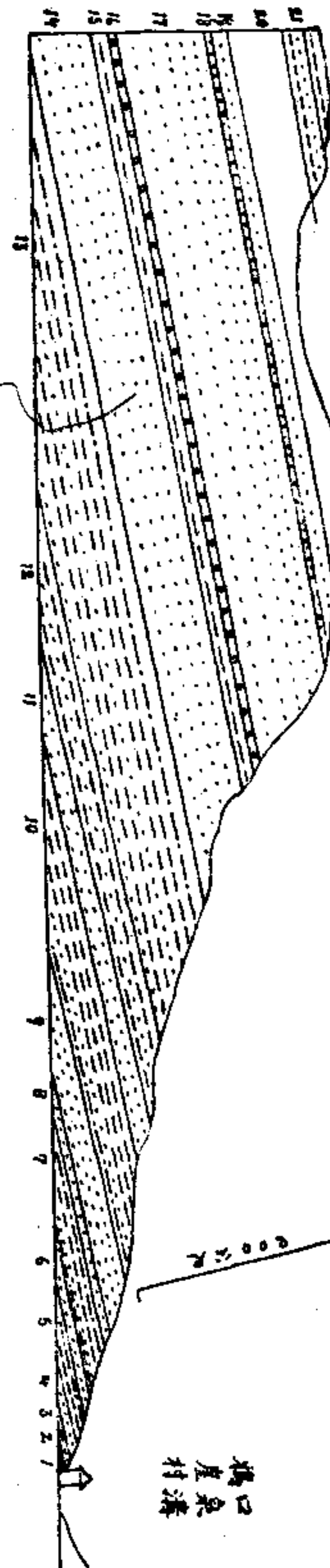
注二　圖上所繪煤層因為顯著起見其厚度較實際為大今在下頁重將其真實厚度表出之

雞毛口入溝向西北行、適沿此系岩層之傾斜方向、則見紅坡起伏、緩急相間、層序井然。其爲上下二含煤系中之居間岩層、由此而西南達右玉屬、無不歷歷如畫、極易供地層上之研究。

(七)上煤系　此系在中部頁岩及砂岩系之上。其岩層組織大部分爲灰色或白色砂岩及青色頁岩等、間有少許黑色頁岩含有重要煤層(圖二、五、六、七、八))覆於煤層上之砂質頁岩、含有植物化石。此

次在大溝得有BAIERA及PODOZAMITES二種、在鴉崖村南小草溝得有ASPLENIUM, DICHSONIA PTEROPHYLLUM (?) 等化石、皆足資以斷定煤系之時代屬於侏羅紀。全系由煤峪口永定莊一帶、西南至官窰鴉崖村附近、厚度漸增、約由二百六十餘公尺增至四百八十餘公尺。然由斗窰溝而北、全系厚度則漸減。至雲崗溝以北、驢圈東北、則惟餘數層砂岩及少許頁岩耳。在調查區域內、上煤系恒為本地著名重要煤窖所在之地。

第五圖 懷仁縣鴉崖村東北岩層剖面圖

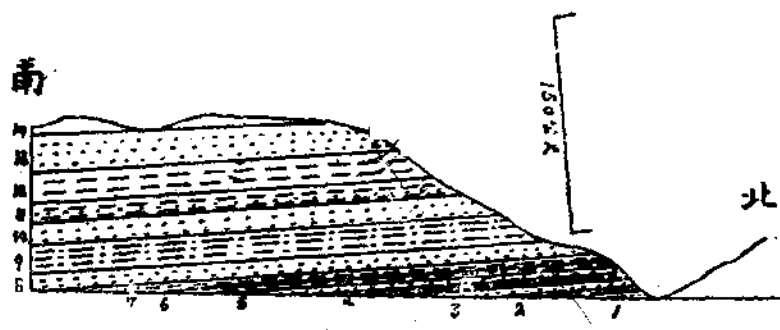


1 煤層厚約四尺
2 白色砂岩
3 藍色頁岩
4 白灰色砂岩
5 藍色頁岩及灰色砂質頁岩（有時間呈紅色）
6 灰色砂岩
7 藍色頁岩及砂質頁岩（局部間呈紅色）
8 薄層灰色砂岩有時間呈紅色其上部並有少許藍色頁岩
9 白色頁岩
10 藍色頁岩及藍色砂質頁岩有時間呈紅色並含有薄層砂岩
11 白灰色砂岩
12 黑灰色頁岩及砂岩
13 紅色及藍色砂質頁岩與灰色砂質頁岩或砂岩相間
14 白灰色砂岩
15 藍色頁岩
16 礫岩其礫石多為石英
17 白灰色砂岩
18 土黃色砂岩
19 白灰色砂岩
20 黃土掩沒之部分
21 紅色頁岩及砂岩

如雲崗溝內則有馬營窪萬家嘴南溝千溝等煤窖。口泉溝內在鵰窩嘴鴉崖村之間則有店上溝楊澗溝官窰溝馬營澗之煤窖。由此而西則有張家峯鵰落寺之煤窖。西南則有青楊灣土溝掌大石頭山及杜家溝之煤窖。

注　圖上所繪煤層因爲顯著起見故其厚度恒較實際稍大今在下列煤層下垂將其眞實厚度表出之

第六圖懷仁縣鴉崖村東南岩層剖面圖



1 灰色砂質頁岩．
2 煤層厚約二尺五有時至三尺
3 白灰色砂岩
4 煤層厚約四尺
5 白灰色砂岩有時間含頁岩
6 煤層厚約三尺
7 黑灰色頁岩及藍色頁岩並含有淺黃色砂岩
8 灰色土狀砂岩上部並有藍色頁岩
9 淺紅色砂質頁岩與灰色砂質頁岩相間
10 淺紅色砂岩
11 灰色與淺紅色頁岩及砂岩
12 藍色頁岩有時局部現紅色
13 淺紅色砂岩有時局部現白灰色
14 黃土

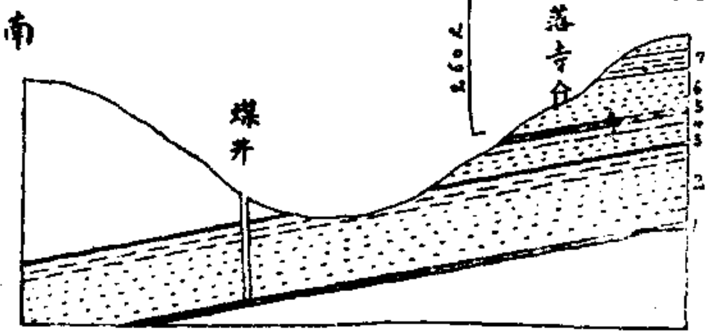
自杜家溝而西南、岩層漸掩沒於黃土及冲積層之下、鑛業驟止。惟段家溝附近煤系下部之粘土尚露出、本地多用以燒缸甕、再西南則上煤系全部入於黃土下矣。但在段家溝西南約七十餘里、聞尚有煤窖名鑽子窰者、煤層厚達四十八、大抵爲上煤系復露出之證。只因時間過迫、未能考察。

（八）侏羅煤系以上岩層　侏羅煤系之上、覆以紅色或綠色頁岩及砂岩。此等岩層內大抵無化石、故欲鑒定其時代絕非易事。然考北京西山侏羅紀煤層以上、有所謂紫綠岩系（即九龍山系見地質專報甲種第一號葉著西山地質誌）者、當與此等岩層相當。惟在京西紫綠岩系全部岩質堅密、恒構成尖聳山脊、此則岩質鬆弱、頁岩現露者每呈碎末、易組成平圓之山頂。在四老溝銀塘溝之間、以及太子山井窪峰子澗各處、此等岩層恒星布於山頂。由此向東北、更廣布於新窰子南辛莊石岩莊石頭村雲崗水泉郭家坡一帶、現露之面積甚大。

（九）玄武岩　在煤田之西北與黃土或礫石層接觸處、每有玄武岩突出。此次發見者一在外澗堡東南、一在郭家坡之北、而尤以在戴家溝南及東南之玄武岩現露爲較廣。惟在後窰子東可見玄武岩與石灰岩之接觸甚爲明顯。其剖面如下。

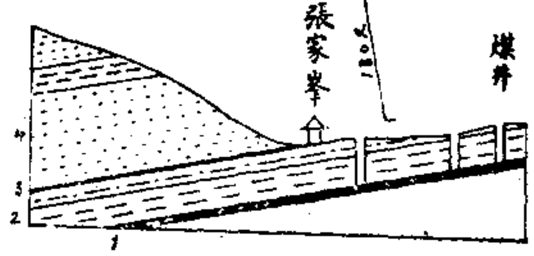
注　圖上所繪煤層因爲顯著起見故其厚度恒較實際稍大今在下列煤層重將其與實厚度表出之

第七圖左雲縣雕落寺附近煤層剖面圖



1 煤層厚約五尺
2 藍色頁岩及砂岩
3 煤層厚約二尺
4 白色砂岩其上部爲土狀砂岩
5 煤層厚約七尺
6 白色砂岩
7 藍色頁岩及砂岩

第八圖左雲縣上張家峯附近煤層剖面圖



1 煤層厚約八尺至十尺
2 藍色頁岩及土狀砂岩
3 煤層
4 白色砂岩

第九圖上紅色頁岩與石灰岩大抵即寒武紀岩層之一部、而玄武岩反居其下。推原其故、蓋自侏羅紀煤系沉澱後、煤田西北岩層斷裂、而玄武岩因之噴出、而此剖面圖或適當其噴出口、以致玄武岩一部分擠入寒武岩層之下耳。

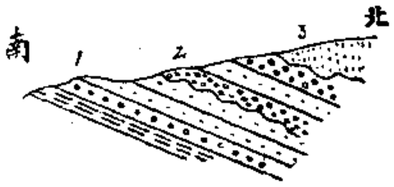
（十）礫岩層　存界溝山一帶往往於高山之頂、現有石灰礫岩、成層狀與紅土相間。至石墻課西北見有堅固之礫岩層露出、更至新村及郭家坡北部一帶。此礫岩層分布殊廣、又因其與所有岩層皆不整合、故如剖面圖所示。或在侏羅煤系之上、或覆於侏羅煤系以後砂岩層之上、隨地而異。然於新村等處在礫岩層中、時夾有薄層砂

岩、且所含礫石除石灰岩外大部分爲玄武岩、其圓徑大者約至三寸、又石灰岩間有受磨擦之痕跡。礫岩層之受風化者、則成爲散礫。茲考礫岩層之分布、蓋知煤田西北一帶之盆地爲古河道之河床後因地層升降河道變遷、現在惟於山嶺間遺有礫岩層暴露耳。

第九圖後窰子玄武岩剖面圖

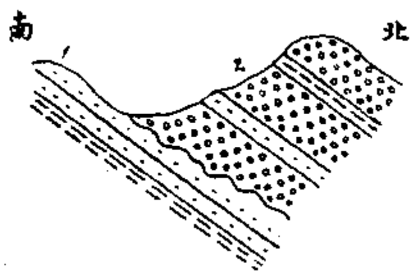
1 玄武岩
2 紅色頁岩
3 灰紅色石灰岩

第十圖新村東礫岩剖面圖



1 上煤系中砂岩
2 礫岩層
3 黃土

第十一圖郭家坡西礫岩剖面圖

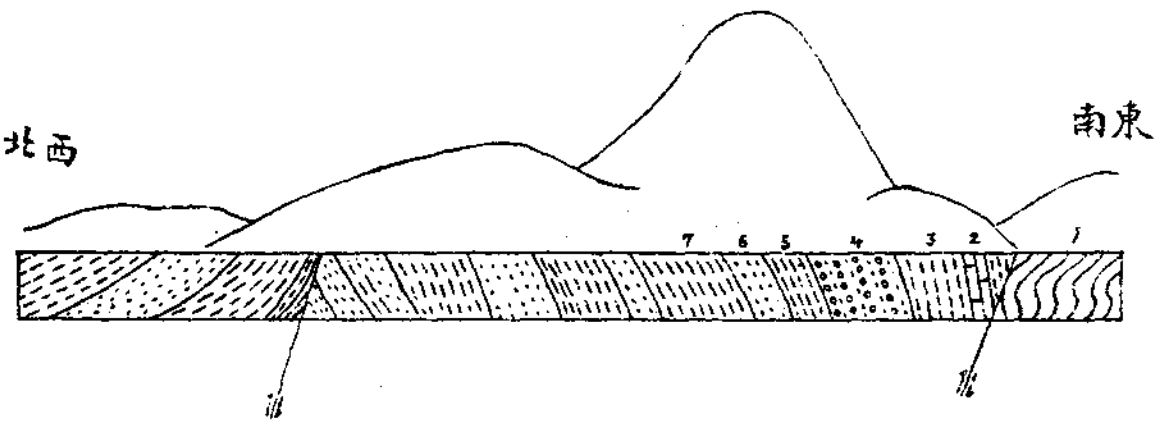


1 侏羅煤系上砂岩層
2 礫岩層

構造

大同西南煤田岩層之傾斜、大致皆向西北、殊爲簡單。其傾角在石灰岩則甚急、而含煤系及其以上岩層則頗緩（圖一、二、三）且有時近乎平層狀態。或成爲局部之背斜及向斜層、其傾斜之緩多不易覺察。但由口泉鎮至煤峪口附近、凡上下煤系及中部頁岩砂岩系之傾斜每在二三十度之間、更在煤峪口之東北以達掩平岩層有時直立、且有易其傾斜之方向而爲東南者。若在萬家嘴峰子澗新高山白廟子一帶、或因地勢高起、或因河流侵割較深、以致上煤系復行露出、頗似與鵰窩嘴鴉崖村等處之煤系成爲淺向斜層者。然上煤系之在白廟子萬家嘴一帶雖近侏羅煤系以上紅色岩層時間有傾向東南一二度者、而大部分則皆近乎平層。且在西北與黃土或礫岩接近部分、則傾斜仍皆趨向西北。其他若東北至郭家坡水泉一帶之侏羅煤系上紅色岩層、

第十二圖懷仁縣四老溝東南眞珠窰溝地質剖面圖



1 片麻岩
2 含紡綞蟲石灰岩
3 含煤頁岩
4 砂岩及礫岩
5 紅色及綠色頁岩
6 白色砂岩
7 紅色頁岩

西南至鵰落寺杜家溝段家溝一帶之上煤系、以至酸家號觀音堂一帶之中部頁岩及砂岩系、凡此無不緩傾、約在三四度左右、而斜入於煤田西北之黃土或礫岩層之下。故煤田西北與在左雲北之片麻岩山脈中間爲一大斷層、其長度約在二百里以外、其上下移動亦在一千公尺之上。以致煤田西北之黃土盆地北部上升、現在尙絕壁高聳、而爲山西與綏遠天然之界線。又由口泉鎭至拖平一帶煤田突起、於大同平原分界截然、大抵亦爲斷層所致。又在白朵村東南、發見斷層二。一斷層線爲南北向者、至村之東北似漸減而消滅、其地平移動（HORIZONTAL MOVEMENT 約有一千五百餘公尺。一斷層線爲東北西南向者、其斷裂情形可以眞珠窰溝剖面圖（圖九）表示之。在此二斷層間岩層之傾斜均極倒置錯亂之狀態。其他如在青磁窰東南亦有小斷層、特無甚重要耳。

地形

大同煤田一帶地形可分爲三部。一、平原區域、自大同向西南經懷仁山陰以達朔縣、共長約三百餘里、寬亦由四十里至六

十里不等。是爲黃土之平地、桑乾河支流分配其間。本地曾有大同川懷仁川朔州川之名稱。村落星列、農田遍布。爲雁門道較富之區域。其西北或東南皆以大山爲之界。二、高原區域平原西北與大山交界之間爲平圓緩坡之低山、現紅色之狹帶。由此登石灰岩山脊。即至高原、俯瞰平原、曲折如大江、蓋即桑乾河之冲積谷也。更轉而察高原之狀態、則見由石灰岩所組成之山自東北而西南、奇峰怪巖、怒插天空、突立如牆。沿牆西北則平台銜接、淺波起伏、此蓋石炭紀以上地層之所成、而層近水平傾斜又緩故成此地形也。游者至此、殆不復知其中尙藏有深溝、及所立之地高出於平原數百尺以上也。高原中之村落、多居溝內、亦偶有負山坡而建設者。又遠望斗窰溝白山子一帶、山勢亦頗兀突、宛然組成高原之東北界。總之、就地勢而論、高則以界溝山居最、爲各河支流發源之地。就山形而言、則以口泉鎭至界溝山一帶山勢最猛、而竹林寺及驢圈東北之片麻岩山脈次之。至若以河道與山之高度相較、則尤推口泉西南之七峰山爲首。青磁窰及口泉鎭以至界溝山一帶、其西北已皆漸趨低平。界溝山之西南以達安東衞、雖有愈西南山勢愈緩之現象、然在此山勢漸緩之部分中則由東南而西北、黃土亦漸廣、更有漸趨平夷之勢。故至煤田西北左雲一帶、遂成第三箇近乎平原區域之盆地。此區域西北限於長城一帶片麻岩之山脈、覈其地形又與平原稍異。蓋此盆地中如外淌堡之玄武岩山毛官屯西北產磨石(作磨之石大抵爲花崗質片麻岩)之馬營山、其岩石有時尙突出而現露、卽黃土在此區域亦恒波湧起伏、積爲極低之崗埠、非若大同一帶之一望無阻也。

又在界溝山附近以及新村等處、於山脊之上每見礫岩層分布其間、可知當此礫岩層沉積之時、此等山脊尙爲平原。(PENEPLAIN)後復上升、經大氣風雨之侵蝕、始成現在之山脈。至礫岩層之時期今尙不易確定、比

較言之則當新於玄武岩之噴出、而前乎現代地形之生成。

河流　此次所見各河之支流、無通舟運輸之利、本無關重要、茲稍述其本源歸併之概略、以資參考。支流之發源於界溝山者有六、一經葫蘆峪至張家莊、與馬到頭之主流合、而東南出大峪口、更東南經懷仁縣、南入桑乾河。一由無風嘴東南流經鵝毛口、折而東北與經黑流水出口泉之支流會合。此外經興隆溝與大老坡之支流則會同出高山、經雲崗堡青磁窰一帶。然以上之支流、終則皆入桑乾河。惟經潘家窰之支流則入紅河歸於黃河。

第二章　鑛產

煤層

(一)下煤系　下煤系在口泉鵝毛口間所採者僅煤一層、恒現露於山坡而呈黑色之煤帶。其厚度若按露頭計算、約達二十公尺左右、但中間時隔以頁岩、故二道溝窰內所採之煤其厚度只有五尺上下。大石頭溝窰內則爲八尺左右。在口泉東北拖平附近此煤層厚度大減、不過尙餘少許黑色頁岩而已。若由鵝毛口而西南、則於此煤層下復發見煤層二、故下煤系在鵝毛口西南者、所含重要煤層增加爲三、乃有上層中層下層之分。在小峪吳家窰一帶三層中各夾有黑色頁岩及砂質頁岩等。據採煤者言、上煤層本地於此稱爲賊炭、厚約三尺或四尺、然本地普通稱爲六尺或八尺、因尙有岩石數尺亦須與煤同時採出也。中煤層本地稱爲黃河、厚約二尺餘、惟尙有厚約二尺之岩石須同時開採、故本地稱煤厚爲四尺或五尺。下煤層本地稱爲四四、其組織先上覆岩石一尺、(就須與煤同時開採之岩石而言)次爲煤厚約三尺、次復爲岩石一尺、再下爲煤厚約二尺半、故

普通稱煤層厚爲八尺或一丈。臟炭與黃河之距約六丈、黃河與四四之距約四丈。而小峪吳家窰一帶較爲重要、各煤窰現在所採者皆爲四四煤層。

(二)上煤系　上煤系所含之煤層在斗窰溝大溝店上一帶就現在開採之結果、已知者約有三層、本地因對於煤層有墒節中節底節之稱。墒節即第一煤層厚度約由一尺至四尺、中節即第二煤層厚度約由三尺至六尺、底節即第三煤層厚約由三尺至四尺。第一煤層與第二煤層間之岩層厚約由四丈至十一丈、第二煤層與第三煤層間之岩層厚約由二丈至五丈。惟煤層自斗窰溝而北似漸有變薄之趨向、故雲崗溝內集成公司所占之位置、交通雖佳、將來所得之煤層恐太薄不足以供開採。又煤層在口泉溝內至白朵村、于上所述三煤層下復發見第四煤層。其厚度約由八尺至三十尺、即本地所謂大窰煤層也。其煤層之位置約居上煤系之底部、至第四煤層與第三煤層中間岩層之厚度、因在同一窰井內未有此二煤層可同時得見者、故頗難確測。然據地面岩層之推究、要亦在二十丈之內。前在地層章內曾謂上煤系由永定莊西南至官窰鴉崖長流水張家峰附近厚度漸增、煤層亦然。在口泉溝內愈趨西南厚度愈增、故第一第二第三等煤層至官窰村之胡家灣及四老溝一帶厚度恒增至七尺。更西南至秦家山少家煤附近厚度恒增至十尺左右。以致初稱謂小窰煤層者至此則變爲大窰煤層矣。然以上皆就大致而言也、同一煤層往往在距離甚近之溝谷其厚度變遷亦甚大。又第一第二第三等煤層於雲崗溝內在萬家嘴千溝馬營窪等處厚度亦恒達十尺上下。惟雲崗溝內煤層遠不及口泉溝內開採之盛、其故有二。一、因上煤系之露出於雲崗溝、其煤層蘊藏皆較深開採較難、故如在口泉溝內沿煤層之露頭而採煤之平窰皆未之見。二、因雲崗溝地勢較低、窰內水患或較在口泉溝內之煤窰爲甚。

總之無論上下煤系、凡所含煤層皆具有三利。一、煤層頂底恒爲堅固之砂岩、窰內可省支柱。二、煤層每呈平層狀、採取頗易。三、煤質堅硬皆成塊狀、運輸較便。以上三利實與採煤者以極大之便宜。

煤質

上下煤系所產皆爲烟煤。下煤系所含煤層據本地採煤者之經驗大抵不能煉焦。此次所採煤樣化驗之結果、在二道溝雖不能煉焦、而在大石頭溝則可以煉焦。至上煤系所含煤四層普通多能煉焦、惟煤質不但因各層或異地而生變遷、卽在同一窰內同一煤層又往往分爲上下二部或分至數部、其上下各部之接觸或隔以少許頁岩、如陽澗溝所採之第三煤層、以及韓家窰狗圪墶窰溝南溝等處所採煤層是也。或上下各部現自然之分界、不隔以岩石、如大溝店上四老溝紅石崖干溝張家峰秦家山鵰落寺等處所採煤層是也。至上下各部之煤質或下部較上部焦質爲佳。或上部較下部爲佳、亦無一定。又或一部完全能煉焦、一部含半煉焦性如花林溝紅石崖張家峰秦家山鵰落寺干溝等處所採之煤層是也。甚至有一部完全能煉焦或含半煉焦性、一部則完全不能煉焦如南溝少家溝等處所採之煤層是也。總之同一煤層內煤質之變化實甚、又有在距離甚近之煤窰所採、雖係同層而煤質則大異者。但就大致而言、據本地採煤者之經驗及所採煤樣分析之結果、煤田全部焦質最佳處約在口泉溝內店上楊澗溝窰溝一帶。且此處距口泉車站路約二十里、據鐵路中人言由口泉向白朵修支路、爲事尙易。是產焦質最佳之區、又當交通較便之衝。此處煉焦較佳之煤層大抵有三層、而各層厚約三四尺、再下當更有得第四較厚煤層之希望。然焦質據現在花林溝煤窰之分析恐不能佳耳。又各煤層經古來開採年代既久內部往往採空、而新開之煤井若與相通爲患實甚、此亦應注意者也。若由此稍西南在

胡家灣四老溝大馬營澗等處、以所產之焦質及交通上所占之位置而言、雖不如上述之區域、然煤層厚度在此頗見增加、要亦不失爲煤田中之重要區域也。

煉焦試驗

關于大同烟煤鍊焦之性、曾由李鳴和君詳細試驗、並參合他處適於煉焦之烟煤試其焦性。茲先錄其煤質分析如下表。

種類或產地	水分	揮發分	定炭	灰	硫	焦性	灰色
桂枝窩A	四、四八	二一、八四	六二、四五	一一、二三	—	不粘結	黃灰
仝上B	三、八九	二三、二七	六二、六五	一一、〇九	—	仝上	仝上
仝上C	三、〇九	二三、三八	六二、九三	一〇、六〇	—	仝上	黃白
仝上D	三、二四	二四、八一	六一、六六	一〇、二九	—	仝上	白
青陽灣A	五、一五	二三、七一	六五、四四	五、六〇	—	仝上	微紅灰
仝上B	五、〇二	二一、四四	六六、七二	六、八二	—	仝上	仝上
仝上C	三、七八	二五、五一	六四、五一	六、二〇	—	仝上	微紅褐
仝上D	三、八九	二四、八〇	六四、八二	六、四九	—	仝上	仝上
斗窰溝A	四、二九	二五、一一	六六、九二	三、六八	—	仝上	微紅灰
仝上B	三、九三	二三、〇二	七〇、〇八	二、九七	—	仝上	褐白

*仝上C	四〇一	二五、七九	七〇、二〇	三、七七	——	粘結
萬家嘴A	七〇七	二五、九二	六〇、二三	七、〇八	——	不粘結紅灰
仝上B	六八八	二三、八五	五九、四八	九、七九	——	仝上暗灰
*仝上C	七二六	二七、九九	六四、七四	五、〇八	〇、二四	粘結
大溝	三七五	二四、五〇	六六、八三	四、九二	——	不粘結淡褐
高山鎮A'	七一六	二二、〇九	五六、一八	一四、五七	——	仝上微紅灰
*仝上B	七〇〇五	二三、五九	六九、四〇	一三、二七	——	半粘結灰
南溝A	三六七	三〇、六六	六一、七五	三、九二	〇、九四	粘結暗紅
仝上B	六五七	二五、三三	六〇、七一	七、三九	——	不粘結白
仝上C	六三一	二二、五九	六一、五四	九、五六	——	仝上白
*仝上D	六二〇	二一、七四	七二、〇五	七、七九	〇、三八	半粘結白
慶封梁A	一八八	三四、三三	六一、九七	一、八二	〇、一一	粘結微褐白
仝上B	三五〇	三四、四一	五五、〇四	七、〇五	〇、一八	半粘結灰
仝上C	二五八	三三、六五	五八、二八	五、四九	〇、二三	仝上白
馬營窪	三六〇	三三、九五	四八、一二	一四、二八	一、四〇	粘結暗紅
山西紅煤(比較)	二三八?	六、〇六	七九、七六	一一、八〇		不粘結微紅褐
河南六河溝(比較)	〇五五	一六、六六	六九、五五	一三、二四	〇、六〇	粘結微黃褐

上表中有❀號者爲鄭寶善君分析之結果

據以上分析、李君結論如下。(一)大同煤含水特多。(二)煤質變化甚多。同一地方之煤或能鍊焦或不能。(三)含揮發分較多至百分三十左右或以上者、多能鍊焦。然不能鍊焦之煤、必與能鍊焦者混合鍊之、往往亦能鍊成佳焦。李君試驗結果如次。

第一組

南溝A	一〇〇%	焦粘結灰色硬不甚疏空微有片狀	南溝A 慶封梁B	五〇% 五〇	焦粘結灰色稍硬
南溝 馬營窪A	五〇 五〇	粘結灰色甚硬疏空適宜	南溝 六河溝A	六〇 四〇	粘結灰色甚硬不甚疏空
南溝 六河溝A	七〇 三〇	粘結灰色甚硬不甚疏空	南溝 六河溝A	八〇 二〇	粘結灰色甚硬不甚疏空微有片狀

第二組

慶封梁A	一〇〇	粘結暗灰色太疏空但甚硬	慶封梁B	一〇〇	半粘結
慶封梁 斗窰溝A	九〇 一〇	粘結淡灰色甚硬太空疏	慶封梁 斗窰溝A	八〇 二〇	粘結灰色甚硬太疏空
慶封梁 斗窰溝A	六〇 四〇	粘結暗灰或黑硬	慶封梁 斗窰溝A	五〇 五〇	粘結暗灰色不甚硬有片狀
慶封梁 斗窰溝	三〇 七〇	半粘結	六河溝	一〇〇	粘結暗灰甚硬疏空適宜
慶封梁 六河溝A	三〇 七〇	粘結灰色甚硬疏空適宜	慶封梁 六河溝A	五〇 五〇	粘結暗灰甚硬疏空適宜
慶封梁A 南溝A	三〇 七〇	粘結甚硬半疏空			

第三組

馬營窪	一〇〇	粘結色暗甚硬但太疏空	馬營窪 斗窰溝	七〇 三〇	粘結色暗尚硬
馬營窪 斗窰溝	九〇 一〇	粘結色暗甚硬	馬營窪 慶封梁B	五〇 五〇	粘結灰色硬稍有片狀
馬營窪 六河溝	五〇 五〇	粘結灰色甚硬疏空適宜	馬營窪 六河溝	七〇 三〇	粘結甚硬太疏空
馬營窪 慶封梁A	五〇 五〇	粘結硬太疏空			

第四組

山西紅煤	一〇〇	粉狀	慶封梁A 紅煤	九〇 一〇	粘結灰色甚硬但太疏空
慶封梁A 紅煤	八五 一五	粘結灰色硬	慶封梁A 紅煤	七〇 三〇	粘結暗灰色不甚硬稍有片狀
慶封梁B 紅煤	九〇 一〇	半粘結	南溝 紅煤	九〇 一〇	粘結暗灰色尚硬有片狀
南溝 紅煤	八五 一五	半粘結	馬營窪 紅煤	七〇 三〇	粘結黑但粘結甚弱
馬營窪 紅煤	九〇 一〇	粘結灰色硬稍嫌疏空			

第五組

斗窰溝 六河溝	八〇 二〇	粘結灰色甚硬	六河溝 萬字嘴	八〇 二〇	粘結暗灰甚硬
六河溝 萬字嘴	七〇 三〇	粘結暗灰甚硬	六河溝 慶封梁B	五〇 五〇	粘結暗灰半硬甚疏空

以上係在化學試驗室中用小磁罐試驗之結果。李君曾復用耐火土罐在燃炭爐上試驗之、每次試驗用煤約一百五十格蘭姆、所得結果如左。

南溝A	一〇〇%	焦質不甚疏空頗硬淡灰色或銀灰色敲之發金屬聲
南溝A 六河溝	八〇 二〇	焦質較前佳甚硬色仝上金屬聲稍有纖微狀較上稍爲疏空
南溝A 紅煤	九〇 一〇	不成焦易破碎無烟煤(紅煤)碎屑四散嵌入不與烟煤同化可見其妨礙成焦
慶封梁B	一〇〇	半粘結但易碎
慶封梁B 紅煤	九〇 一〇	煤不同化易成粉狀
六河溝 紅煤	九〇 一〇	焦暗灰色頗堅粘結不強無烟煤小塊散嵌焦中閃閃有光

李君結論如下。(一)大同煤煉焦之性質良否不等。(二)如以大同煤之含揮發份百分三十以上者與他種可煉焦之煤(例如六河溝煤又井陘煤亦可)混合燒煉、亦可製成佳焦。(三)以大同煤與無烟煤混合燒鍊之結果大抵不佳。

又大同煤燒餘之灰、亦曾經化學分析。錄表如下、以資參攷。

種類	硅酸	鐵二養三	鋁二養三	鈣養	鎂養
馬營窪	六五、四五	二〇、三一	九、五〇	一、八八	〇、三六
南溝A	六二、三七	一〇、三一	一三、八八	七、九八	一、二八
慶封梁A	三二、八一	二六、七九	一五、八一	二〇、〇四	三、九五
六河溝	四三、五五	一七、三三	一八、六九	一五、二七	三、八九

煤量

此次調查因限於時間、煤田之在朔縣一部分尚未測及、以致不能窺煤田之全豹。然產煤重要之區域已得其梗概。就已測量之部分計算、則下煤系之在口泉鎮鵝毛口一帶長約二十八里、寬約里許、面積計二十八方里。

其在鷄毛口安東衞間之露出者、則自東北而西南長約九十餘里、寬則平均爲四里、面積計三百六十方里。合計下煤系現露之面積約達三百八十八方里。玆因煤層多現平層狀、故可定煤系現露之面積爲可採煤層之面積、若定煤層平均厚度爲二公尺、比重爲一、三、則下煤系所含煤量約可得二億五千二百萬噸。但如吳家窰一帶煤層每因太薄、無開採之價值、且各處土窰星列、其開採不知已經若干年月、是以除去不能開採之煤層及已採去之煤量、所餘存可採之煤約亦不過達二億萬噸、而煤質往往不甚佳。故最足注意之煤層、不在下煤系而在上煤系。上煤系在斗窰溝煤峪口間計長約十八里、寬約四里、面積爲七十二方里。設定煤層平均厚度爲二公尺、則可得煤量約四千六百萬噸。至上煤系在煤峪口鵰窩嘴鴉崖村界溝山杜家溝一帶、其露頭計長五十里、寬約平均七里、面積爲三百五十方里。更露出於太子山萬家嘴新高山一帶者計長約二十四里、寬則平均約八里面積爲二百方里。又在新高山馬營窪之間、計長約二十里、寬約五里、面積爲一百方里。以上合計面積共爲六百五十方里。於此三區域設定煤層之平均厚度爲五公尺、可得煤量約十億零五千六百萬噸。若與斗窰溝煤峪口間可產之煤量統計之、則上煤系共合煤量約達十一億萬噸。除去已採去之煤至少約亦可得十億萬噸。若用新法開採、每日出煤二千噸、亦足供一千數百年之用。其他上煤系之掩沒於黃土下者、如在潘家窰關家坪大堡紅安王母莊李石匠一帶、尚待探測者比比皆是。總之上下煤系因皆傾斜極緩、故煤層距地面鮮踰二百公尺者。此誠大同煤田內煤層之特色也。

煤稅及產額

凡產煤之區、煤稅之徵收機關爲煤厘分卡、直屬於山西財政廳、分設於各運路之要衝、專事徵收於運煤者。其

組織凡收入較重之分卡、皆派有專員經理。其他卡若收入甚微、無派員之必要者、則包辦於本地人民、言明每年包價若干、其卡稅即由包辦人徵收。然各卡無論包辦與派員、其徵收方法要皆分為三類。(一)大車、凡運煤之大車其納稅之多寡按其套數為比例。套者即用以拖車之牲口也、每套約收制錢三十五文。然套又有整套半套之別、凡用騾馬牛拉車者皆為整套、故一律皆收二十五文。驢為半套則每匹只收十八文。普通之大車約由兩套至四套其載重約由一千斤至二千五百斤。(二)馱子、凡拖煤馱之為騾馬者每匹收制錢十八文、若驢則收九文。駱駝二十四文。凡騾馬每馱約拖煤二百斤上下、驢則百斤上下、駱駝則三百斤上下耳。(三)人力車、凡二人推車每輛約載重二百斤左右、收制錢十八文。一人小車、每輛約載重百餘斤、收制錢十文。又有用人擔煤者、則免稅。合計以上三種徵收、大抵煤重一噸、約收制錢一百二十文。茲查大同左雲懷仁一帶煤田之全年徵收數目約在二萬五千吊以上。(約為二萬七八千吊)由此推算、可知大左懷三縣之煤產每年約在二十五萬噸左右。但煤田全部煤窰大左懷三縣約占十分之九、故此年採二十五萬噸之產額又可視為煤田全部每年所產之煤量云。

煤田內各窰所產之煤皆直接由窰塲售出、其煤價各窰因地勢而略異。又因時期與塊末之別、故平均價值甚難擬定。然普通約每噸煤值制錢二吊五百文、合銀元一塊八角。統計煤田內居住之人民、每年煤窰業之進欵共為銀元四十餘萬塊。

重要煤窰誌略

煤田內現在所採之煤窰皆係土法、且時開時閉、本無甚可述。即在上煤系有一二產煤較多之煤窰、規模亦極

小、茲略記之於下。

(一)爲煤峪口北之大溝、因此地距大同較近故產煤稍盛、有窰二。一曰興盛窰、井洞內有煤三層、上層厚約一、二尺、中層厚約三三尺。以上二層因上層太薄無開採之價值、中層已爲古人採空、故現在所採者惟有下層、厚約三尺。下層又分爲三部上部厚約○八五尺、爲含煤質之頁岩採煤者隨採隨棄之於煤層旁、概不取出。中部厚約○九尺、色烏而稍白可煉焦炭、採煤者恒特取之以供煉焦。下部厚約一一尺、斷面多光澤、與中部每現自然之分界多取之供燃燒之用。由井口至上層爲百四十八梯、每梯高約七寸。上層至中層爲九十六梯、中層至下層爲七十梯。此窰每日出煤八百餘筐、每筐重約八十餘斤值制錢約一百五十文。二曰德寶窰、每日出煤三十筐左右。然此窰所採之煤亦係第三煤層、厚約三尺。

(二)韓家窰村北桂枝窩煤窰有斜洞一、洞口長寬各五尺、斜向東北、深約三十餘石梯。洞下曲道長約二百餘步、始達採煤處。曲道殊狹僅通一人、兩旁皆用碎石砌成。蓋曲道所經之地、從前卽爲採煤之區、後因煤層採去、遂用碎石代之以爲支柱。至考現在之採煤處、係沿傾斜方向採取、先採西南之低處、漸及東北煤層。旁置一小井、使水由溝渠流入井內後十人復用水斗將水掏出使入於西南已採之廢地。煤層厚約四尺、中間夾有頁岩厚寸許、採時亦同雜於煤內。至窰內工作、凡採煤者每採取長五尺寬深各一尺之煤量、工錢一百五十文。掏水者每日工錢四百五十文。由窰內往外背煤者每筐工錢二十文。工人火食雖由窰主供給、但皆在工錢內坐價。又煤井上煤廠之組織、普通皆分貨房及人貨櫃兩部。貨房爲窰主所居、凡開井洞見煤後、貨房卽將雇工、採煤、售煤等項一皆委之於人貨櫃、而已則坐享其利。人貨櫃售煤所得之錢、貨房得分其十分之二。但井內修補出

煤路錢、以及吸水等項、須貨房任之。故貨房恒養有土鑛師、稱之爲把總。人貨櫃者、卽由售煤所得錢之十分之八、除將雇工人採煤費用開銷外、從中取所餘之利者也。煤窰之大者、人貨櫃往往有數家以至十數家、在井內分區而採。於貨房人貨櫃之外、更有所謂山主者。蓋有煤山者不必能開窰、故煤井所在之山、窰主每年內必將貨房護於山主若干日、令其取利、名之爲乾窰。

(三)張家峯銀塘溝附近、據班家璜君查明於煤層有關者如下。一、土司溝有平窰一坐、進窰四十尺、遠見炭厚四尺、向東挖無夾石。二、楊家澗侯世隆窰、深一五四尺、見炭厚四尺五寸、中有夾石一寸、向東北挖煤。三、子貴窩窰深三十尺、炭厚四尺、無夾石、向東挖。此區域內直井皆四尺寬六尺長、窰洞皆上寬四尺、下寬五尺五寸、中高五尺五寸、斜坡大抵三十度。

(四)其他各煤窰、若在店上溝、楊澗溝窰、胡家灣、花林溝、老四溝、馬營澗、紅石崖、青楊灣、張家峯、秦家山、鵰落寺、以及雲崗溝內之萬家嘴、南溝、干溝等處。其窰井上組織、與井內開採方法、皆大致相彷、茲不備述。

運輸及交通

產煤區之交通、大抵皆恃天然生成之山溝爲通衢、以大車與驢騾之拖馱充馳驅。故煤之銷路、恒視其煤窰所在溝之位置爲變異。煤之運往大同者、一出拖平爲斗窰溝之煤窰。二出距大同約三十里之煤峪口、爲大溝之煤窰、在此運煤者以驢騾拖馱爲較多。三出距大同約四十里之口泉鎮、爲韓家窰、店上溝、楊家溝窰、胡家灣、老四溝、大小馬營澗上、張家峯、紅石崖、青楊灣等處煤窰。運煤者以大車爲最多、惟花林溝所產煤則用驢騾拖馱、銷於全川。(卽懷仁所屬之平原)青楊灣所產之煤一部分亦用拖馱、出鷄毛口銷於懷仁川。又雲崗溝內之

萬家嘴南溝干溝等煤窰則多以大車銷於豐鎮。至土溝掌高車凹鵬落寺興隆溝等處煤窰則銷於左雲城附近。大石頭山煤窰則用大車出鷄毛口、小峪煤窰出小峪口、吳家窰煤窰出大峪口、而皆銷於懷仁城附近者也。但杜家溝煤窰及盧家窰煤窰、則只銷於窰洞附近之村莊。總之以上所論各處煤窰之銷路、仍只限於本地。自京綏鐵路告成後、大同煤田銷路似有驟增之機會。現在由大同至口泉之支路已設、而煤田價値甚可注意。但口泉溝上部各煤窰距支路站仍有三四十里、徒用人力牲口運送、恐仍有不便。若能沿口泉溝內再築若干里、於沿溝各窰運送上實有莫大利益。又上煤系中煤層多有足供煉焦者。雖其性質比之井陘臨城磁州安陽（六河溝）等礦、或有不及、然北方一帶煉焦煤田甚爲缺乏、則大同煤田亦自有研究試驗之價値也。

湖南耒陽東鄉煤田地質

朱庭祜

一　引言

余與謝君家榮於民國六年三月初、先後至耒陽縣境。耒陽處耒水下游、四時可通舟楫、又當湘粵往來孔道交通甚便。余等夙聞耒陽產煤之多、冠於湘省。此次入耒目的、即欲攷察煤田之範圍、煤層之厚度、鑛產之盛衰、煤系生成之時期、及構造狀況等。耒陽東鄉數十里間以至南與永興東與安仁交界之地、莫不產煤。此行遂從與安仁交界處之東湖三都等處著手、漸向西南進。謝君從耒陽東門外龍潭舖等處著手、漸向東北進。二人於中途相接。大約耒陽出煤區域經余等足跡所經者、已得十之八九矣。余等於調查地質之外、在煤田區域以內又作二萬分之一之地形圖。惟調查時適在春季、霪雨爲苦、其困難情形、有非他處所能比擬者。余等在煤田中測勘共一月、計所至之地約一千餘方里、測有詳地圖者約八九百方里。余所測者約佔五百方里、茲就余所詳察各地、論列於後。

一　調查範圍

余旅行之路線、乃自安仁入耒陽境、先至東湖地方、即從該處著手。其次南移至三都、在該處知煤層向東發展甚遠、遂向東勘測至高馬頭馬跡坑等處、東北至湯火泉相近處。煤層自此東南延長入永興縣界。余以該處交通不便、鑛業不易發達、乃改向西測至上板橋下板橋北至土山里、南北均以煤層與他地層之界限爲止。又西至大邱塘、北至通水鋪、自通水鋪東北煤層仍綿延不絕、然已由謝君詳爲測勘、故改向南進至于夏塘。又北至欄板橋相近處、南至元髮沖水積沖等處、煤層自此西南與相去十里許之肥江舖白沙舖等處者連接。因彼處

當耒陽與永興大道之衝、由謝君往永興時測勘、故余未測入焉。

三　地形

余所測勘之地在肥水上游、肥水者耒水之支流也。橫貫耒陽東部長數十里、發源於耒陽東南與永興交界處之侯憇仙馬跡坑等處、過三都水勢稍大、西行納北來數支流至夏塘水勢甚大、河面寬五六丈矣。復西南數十里至肥江舖而入耒河、自夏塘以下兩岸離山稍遠、田疇交錯、宛爲沃野。自夏塘而上、至於三都、兩岸多山、灘石顯露、自三都而上以至其源、則山中穿行、水勢湍急。山之高者如侯憇仙爲煤層以後地層所組成、如龍頂庵、爲灰岩所組成、二者並峙南北爲羣山首領。自龍頂庵而西、如老虎坳以及通水舖之東、皆一脉相連、實爲肥水北部各支流發源之處、亦卽爲煤層北面之界限也。自通水舖而南、大山脉向變爲南北、綿延至於夏塘以南、此其大略也。

四　地層概論

此處緊要地層大別爲三。其最古者爲石炭紀灰岩、此地層於湖南省東南各地見之甚多。其質頗純、色灰白、層積甚厚、裂縫中時見有方解石結晶。余自安仁入耒陽境、一路均爲此岩、道旁見石坑甚多、採取此岩以爲燒煉石灰之用、亦有用於鋪路者、凡大道上所用之青石均此岩也。此中化石甚多、如紡綞虫類等、余在東湖附近採得甚多、此岩位置直接在煤層之下、余在龍頂庵山上見之甚明。因龍頂庵山之北半部爲灰岩、而其南半部卽爲煤層、二者傾斜一致、接合處亦一致。又余在石壠煤窰之北、及湯火泉之南、亦見相同情形也。次卽煤系直接在灰岩之上、已如上述。其岩層性質俟後節詳敘。其中植物化石甚多。時有瑞典國古生物學家赫勒(Halle)氏

亦在境內採集、據云煤系屬於二疊紀。此後地層卽爲一種淡綠色頁岩、薄層灰岩、及粘板岩砂岩等。此岩層甚厚、并無化石發見。其位置常在煤系之上、而與煤層不相整合。如在三都與南莊之間煤層大致向南傾斜構造不甚複雜、而此岩則摺縐甚烈。又如南莊與大邱塘之間、煤系走向已變爲南北、而此岩並不隨之改變。卽在俟憩仙附近、煤系與該岩層走向平行似屬一致、然視煤系之摺縐及其與煤系接觸帶之不整齊已可知其不整合矣。總之此岩層與煤系岩層驟視之極易誤認爲整合、蓋因煤系在北傾斜向南、而該岩在南傾斜亦有向南者也。然細審之此岩種之構造情形、則無一處與煤系相整合者。層中化石既不易得、依位置論當在煤系之上、其究屬何時期則尚未敢決也。

五　煤系地層之詳述

余調查區域之內、煤系地層可分兩部。一走向近於東西傾斜大致向南者、卽馬跡坑板橋南莊等處者是也。此層東端自馬跡坑等處、向東延長入永興縣界、而其西端在南莊之西自廖立冲起、直至大邱塘一帶、已變爲南北走向。他一部則自欄板橋等處起、南及勾里夏塘元髮冲水積冲等處、走向近於南北(南稍偏西)、傾斜大致向東。北端由欄板橋而北與通水鋪相連、南端自水積冲等處走向自南稍偏向西與肥江等處相連。此二部之間如欄板橋與大邱塘之間、均爲煤系下部之含鐵及含錳砂岩所隔、其構造上情形當俟後論。

煤系地層直接在石炭紀灰岩之上、已如前述。煤系之中各種岩層亦各有其特証、茲詳述之如次。

(甲)含錳及含鐵砂岩　此層直接與灰岩相接、而含錳砂岩猶在含鐵砂岩之下、與灰岩相接者也。含錳砂岩者。常作黑色、質甚堅。每層厚約十生的公尺。破裂處凹凸如齒、其中含錳少者約十餘分、富者可開採。共厚約自

數十公尺至四百公尺、在老虎坰及通水鋪以東見之最多、在湯火泉之南亦見之。含鐵砂岩者常作紅色、質不甚堅、其侵蝕面有作淡紅色者。層積頗厚、含鐵不多、然甚富時亦可煉鐵。其厚度自百公尺至五百公尺。在通水鋪以東及老虎坰湯火泉等處見之均甚多、惟老虎坰成分極佳、可供冶煉。老虎坰北與東湖相近之處有鐵爐、所用鑛石卽此類也。此二種砂岩常相附而生、總厚自百餘公尺乃至八九百公尺、就各處所見實爲煤系中最下之地層焉。

(乙)石英岩　此岩直接在含鐵砂岩之上其質甚堅、約厚三百公尺。如湯火泉之南高馬頭之北顯露最著、又如元髮冲水積冲等處附近亦能見之。

(丙)及(丁)砂岩頁岩及煤層　石英岩層之上有砂岩頁岩等相互成層。(丙)亦有薄層之石英岩薄層之含鐵砂岩及薄層灰岩等夾入。其頁岩則以黑色質鬆者爲多、色黑而有雲母者亦多。頁岩中且有化石發見。此層與其上之含煤層(丁)實不能細分、不過含煤層之位置較高、而其中僅有頁岩與煤相間成層、而砂岩及石英岩等夾入其間極少耳。(丙)(丁)二層總厚約有八百餘公尺。

由此觀之、煤系地層之總厚當在一千五六百至二千公尺也。煤之層數甚多、然其厚度足供採取者約僅有五。又因種種構造及侵蝕之關係、亦未能處處全見。如在石壠湯火泉之南首僅有下部三層、惟在玉水龍土地坰板橋南莊等處一線則五層完備、故採者極盛。馬跡坑高碼頭等處亦有五層、惟其西部已爲煤系以後之灰岩頁岩等所蓋、向東發展又未知其止處耳。廖立冲一線雖有五層、而變動甚多、延至大邱塘始較整齊。至於欄板橋與元髮冲水積冲等一帶則亦有五層、茲將各層厚度及其相距之尺寸、列表如左。

岩壁	煤	岩壁	煤	岩壁	煤	岩壁	煤	岩壁	煤
三至八丈	二至三尺	六丈	四尺	十丈	七尺	二丈四	六尺	四丈	八尺

煤質均爲無烟煤、由比較論下面三層較上面二層爲優。因其色黑有光澤、成半介殼狀、且大塊多而末少、硫礦亦較少。而上面二層則反是。所出礦鐵鑛、可用以煉礦。

今欲知其鑛量、當先求其面積。石壠迤西一帶、長約六千公尺。玉水壠板橋南莊等一帶、長延十基公尺。馬跡坑等處、長約二千公尺。廖立冲大邱塘一帶、約四千公尺。欄板橋元髮冲一帶、約十基公尺。又煤層斜入地內以一百公尺計。煤之比重以一·三計。當約下之算式。

	長(公尺)		厚(公尺)		深(公尺)				
(一)石壠等一帶	6000	×	7	×	100	×	2 × 1·3	=	10,920,000噸
(二)南莊板橋一帶	6000	×	9	×	100	×	1·3	=	6,920,000噸
又玉水壠以東	4000	×	9	×	100	×	2 × 1·3	=	10,140,000噸
(三)高碼頭一帶	2000	×	9	×	100	×	2 × 1·3	=	4,680,000噸
(四)高碼頭南面一帶	2000	×	9	×	100	×	1·3	=	2,340,000噸
(五)廖立冲一帶	4000	×	9	×	100	×	2 × 1·3	=	9,460,000噸
(六)欄板橋水積冲一帶	10000	×	9	×	100	×	2 × 1·3	=	43,400,000噸
總計								=	87,860,000噸

六　煤層構造

此間煤層構造、頗爲複雜。自湯火泉而南至侯憇仙之間、(剖面圖ＡＢ)初灰岩含錳含鐵砂岩石英岩頁岩煤層均向南斜、繼頁岩及煤層卽向北斜、是爲向斜層。煤層適在向斜層之中心、位置最高、其上部大都已侵蝕而去、故所留煤層已不厚。此向斜層實西與石壠等處相連。自此而南頁岩卽改向南斜、煤層亦然、是爲背斜層。不久頁岩煤層又向北斜。是又爲向斜層矣。此向斜層西與玉水壠土山里板橋南莊等處相連。自此而南、頁岩又成背斜層。其下之石英岩亦多顯露、背斜層中部、斜度極小、南至高碼頭、則煤層頁岩等又成向斜層。高碼頭之南、又成背斜層。再南卽爲煤系以後地層所蓋矣。自石壠等處南行、(剖面圖ＣＤ)初煤層亦成向斜層、與湯火泉南面者相連、惟在石壠則露頭較多耳。石壠而南、亦如東部成背斜層。及背斜層之南部、煤層已爲煤系以後地層所蓋矣。自土山里以南、至下南莊間、其情形與石壠以南相同。(剖面圖ＥＦ)

自廖立冲以南至大邱塘一帶、煤層面積極狹、而變動極多、其走向大致南北、傾斜則東西相背成背斜層、且斜度爲七十度、其脊已裂、其與東部煤層相聯接處、似非由東部煤層轉折而來、蓋東部煤層中非特未有一處能見與此相似之背斜層、且多成向斜層、而斜度亦未有若是之大者也、故其間當爲斷層耳。又此層與西部地層之關係、亦頗複雜、蓋西部直接與煤系下部之含錳及含鐵砂岩層相接、砂岩傾斜方向頗爲雜亂、以大致言則向東者爲多。不特此也、通水鋪及欄板橋之煤層、亦自成背斜層、東邊者傾斜向東、西邊者傾斜向西、而煤層之東、亦卽與上述含錳含鐵砂岩相接觸、一若含錳及含鐵砂岩之層位反在煤層之上焉者。此種錯亂情形、似當俟他日再加詳細究研時、方能解决也。

自通水舖至水積冲等一帶、煤層走向近南北、傾斜向東西、成背斜層、已如前述。惟向東者、斜度較小、其西面與煤系以後地層之接觸處、則不一致。

七　煤業狀況

耒陽東鄉出煤之多、既冠全省。煤業之盛、亦非他處可比、其人民依煤爲生涯者、世世相傳、蓋由來久矣。其煤窿大小不等、分佈各地亦有多寡、大抵視煤層之發達與否爲變遷。如湯火泉南及石壠等處因煤層僅有下部二層。故煤質雖佳、採者不多、而玉水壠附近及板橋南莊等一帶、則採者最多、馬跡坑高碼頭等處亦多。若在廖立冲附近則因煤層構造複雜、幾無採者。大邱塘附近、地層較爲整齊、採者亦復不多。而通水舖至元髮冲水積冲之煤層、則採者極多。

本地採煤悉由土法、窿之大者、需工數百人、而其小者、則數十人或十餘人。就山坡鑿井、僅數丈、卽可得煤、若爲老窿則往往達三四十丈、鑛井以斜井爲多、直井甚少。大井井口大抵作八形、其尺寸大小、亦各視其採者之所願而異、而其採煤處之狹小、則僅能容身焉。取本地山上之木、以爲支柱。其通風多用手搖風扇、作圓形、徑達一丈四尺、置於窿口、兩人或四人搖之。窿內水勢頗大、有用竹筒(俗稱孔明車)由人力逐段抽之使出。窿內可用明燈、皆點茶油、每斤約四五十文。如鑿石放砲、則用本地所製之火藥、每斤約四百文。採得煤炭、由人用筐拖出、筐作長方形、每筐約四五十斤。此間工價頗賤、採鑛拖鑛抽水打風等每人每日約三百文。至於鑿窿則當論其大小、若高四尺半、寬五尺、深以一丈論、其爲土口、則需二十吊。石口則視其石質堅鬆而定、大約最大者、不得過六十吊。春夏二季、雨水甚大、窿內必停工。惟春夏水漲、則河流大通、正可運煤。秋冬水涸、不便運輸。故本地開鑛

咸以春夏爲運煤時期、而秋冬爲開採時期。

此間煤之產額、向無可稽、蓋煤窿大小無定、作輟無常、無從攷察也。查民國五年、長沙關運進衡煤一千噸、惟其中僅限於已繳鑛產稅有確數可查之一部分耳。查衡煤者、其大多數均出自耒陽與永興兩縣、如余所見耒陽東鄉小煤鑛、何止數百處、均未有鑛稅、則上所說者、乃僅所產之一小部分耳、

耒陽之煤、其用途多在供作家用燃料。除一部份供本地人民外、其大多數則運往長沙漢口、供市上燃料之用。

八　運輸及納稅

此處所出之煤、其運往他處、咸恃水路、即從肥水入耒水、往衡州、入湘江、再至長沙漢口等處。惟自鑛山至入水之處、其遠近各地不同、需用人力挑之、茲將各地挑力、列表於左。

鑛地	入河地點	里數	每担挑力
三都(即玉水壠及其附近各壠)	三拱橋	三四里	一百文
高碼頭馬跡坑	三拱橋	六七里	百七八十文至二百文
大嶺(即湯火泉南面)	三拱橋	十里	二百六十文
板橋	三拱橋	七里	百五十文
南莊	牛口	十里	二百八十文
大邱塘	牛口	八里	百六十文
夏塘	牛口	三里	一百文

元髮沖附近	元髮沖	一二里	五十文
水積沖附近	水積沖	一二里	五十文

肥水可通舟戢之處、以三拱橋爲止、故大嶺以東、入永興界上之煤、去河已遠、採者極少、今復將各裝運地點水脚納稅列表於後、

（甲）自礦地至肥江口

起點	止點	用船	担數	水脚每担	厘卡	納稅
三拱橋	肥江舖（即肥江口）	小船 大水 小水	二百担 四十担	一百四十文	牛口	每斤二文
牛口	肥江舖	小船 大水 小水	二百担 八十担	一百文	牛口	每斤二文
元髮沖	肥江舖	大船	四百餘担	五十文		
水積沖	肥江舖	大船	四百餘担	四十文		

（乙）自肥江至漢口長沙

起點	止點	用船	担數	水脚	厘卡	納稅
肥江口	漢口	大船	八百担	每担四百文	城陵磯	每担十文
					寶塔洲（湖北）	每担二十七文
肥江口	長沙	大船	八百担	每担二百文		

（九）煤價

本地	長沙	漢口

塊每担三百文
末一百文

塊煤每担六百文（二三年前四百文）

塊煤每担一千文

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CONTENTS

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THE HSI-K'UANG-SHAN ANTIMONY MINING FIELDS, HSIN-HUA DISTRICT, HUNAN.

BY

F. R. TEGENGREN.

INTRODUCTION.

China's predominating position among the Antimony producing countries of the World is already a well established fact, and it is, likewise, well known that the bulk of the country's supply comes from Hunan Province, although besides there are productive areas also in several other Provinces such as Kuangsi, Kweichow and Yunnan.

Among the Hunan Antimony fields the following are the most important: Hsi-K'uang-Shan (錫鑛山), Pan-Hsi (板溪), Lung-Shan (龍山), Wu-Hsi (烏溪) and Chiang-Hsi-Lung (漿溪壠), of which the Hsi-K'uang-Shan field is by far the largest as well as regards resources and production, in fact it is the biggest known antimony deposit and the largest producer of the Globe.

During a journey in the winter 1915-16, initiated by Mr. V. K. Ting, Director of the Geological Survey, and undertaken by order of His Excellency The Minister of Agriculture and Commerce, to some of the Southern Provinces, an opportunity was afforded to me to study in some detail this gigantic and interesting deposit. In the field work, especially in the survey which had to be executed under very unfavourable weather conditions, I was most skilfully and indefatigably assisted by my countryman and companion Mr. C. F. Erikson. The data on mining and smelting are largely collected by my Chinese assistant Mr. W. P. Lo. To these two gentlemen I herewith acknowledge my obligation.

SITUATION AND TOPOGRAPHY.

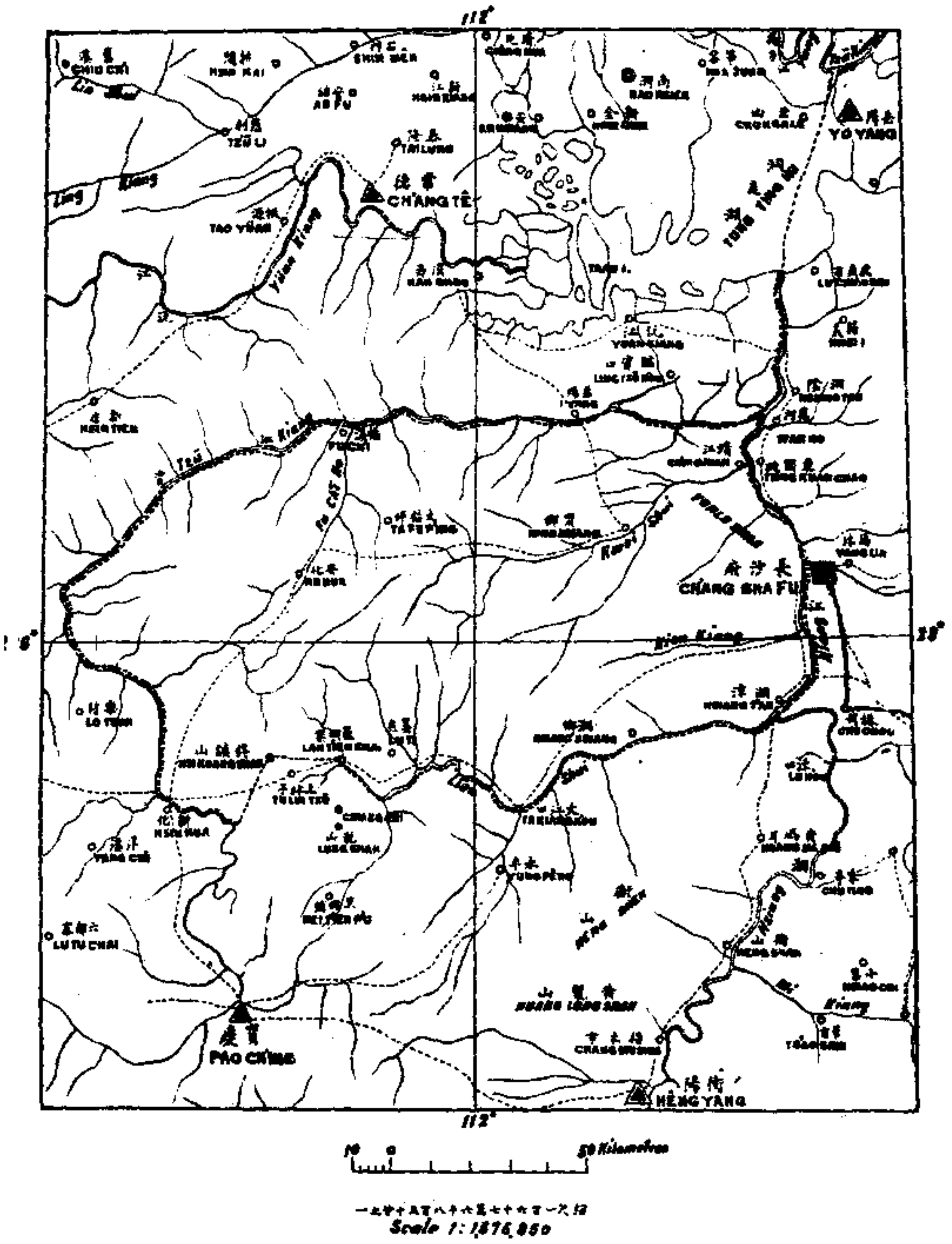
The deposits are situated (Plate I) in the very centre of Hunan at a latitude of 27°48' and a longitude of about 4°53' W of Peking and at an altitude of about 700 metres above sealevel. Their situation (see sketch map) near to the watershed between the upper part of the Tze-Kiang (資江), emptying into the Hsiang-Kiang not far from its outlet in the Tung-Ting lake, and the Lien-Shui (漣水), a tributary to Hsiang-Kiang, entering the main river at Hsiang-Tan (湘潭), offers two possibilities of water transportation down to Chang-Sha viz. 1) along the Tze-Kiang and up the Hsiang-Kiang, a distance of about 350 kilometres, taking 7 days to cover by boat in the summer and 14 days during the dry season; 2) along the Lien-Shui (漣水) and Hsiang-Kiang (湘江), a distance of 200 kilometres, that can be covered in five days and 10 days respectively according to season. Before reaching the former waterway a distance of 15 kilometres from the mines to the Tze river has to be covered by land to the village of Ping-Shui-Kiang (冰水江), the path descending gradually to the named river; in case of the other way the distance to Lan-T'ien-Shih (藍田石) is 23 kilometres.

As is shown by a glance at the map and photographs (Plates II, III) the country exhibits a very rugged surface, innumerable hills and ridges projecting above deep valleys. The great features of the landscape have a general trend of NE-SW, following the strike of the sedimentary formations.

The climate is humid; rains and fog, and in the winter even snowstorms, are frequent, and the temperature often sinks below zero, whereas the summers are very hot.

The region round the mines is not very populous, in fact there are only a couple of farmer's villages within a distance of 10 kilometres from the mines. Cultivated areas are rather scarce, most of the hills are overgrown by thorny bushes and it is, furthermore, striking that areas being formerly terraced ricefields have years ago been abandoned.

It may, thus, be said that the soil at present supports a very small population, and if not for its mineral wealth the region would be rather desolate. But owing to the expansion of the mining industry within the last few years a number of villages have grown up like mushrooms in the vicinity of the mines for the accomodation of the mining people, as well as the merchants, shopkeepers and grocers who provide the former with the necessities of life and means of pleasure. The villages at Hsi-K'uang-Shan,



湖南錦鑛位置圖

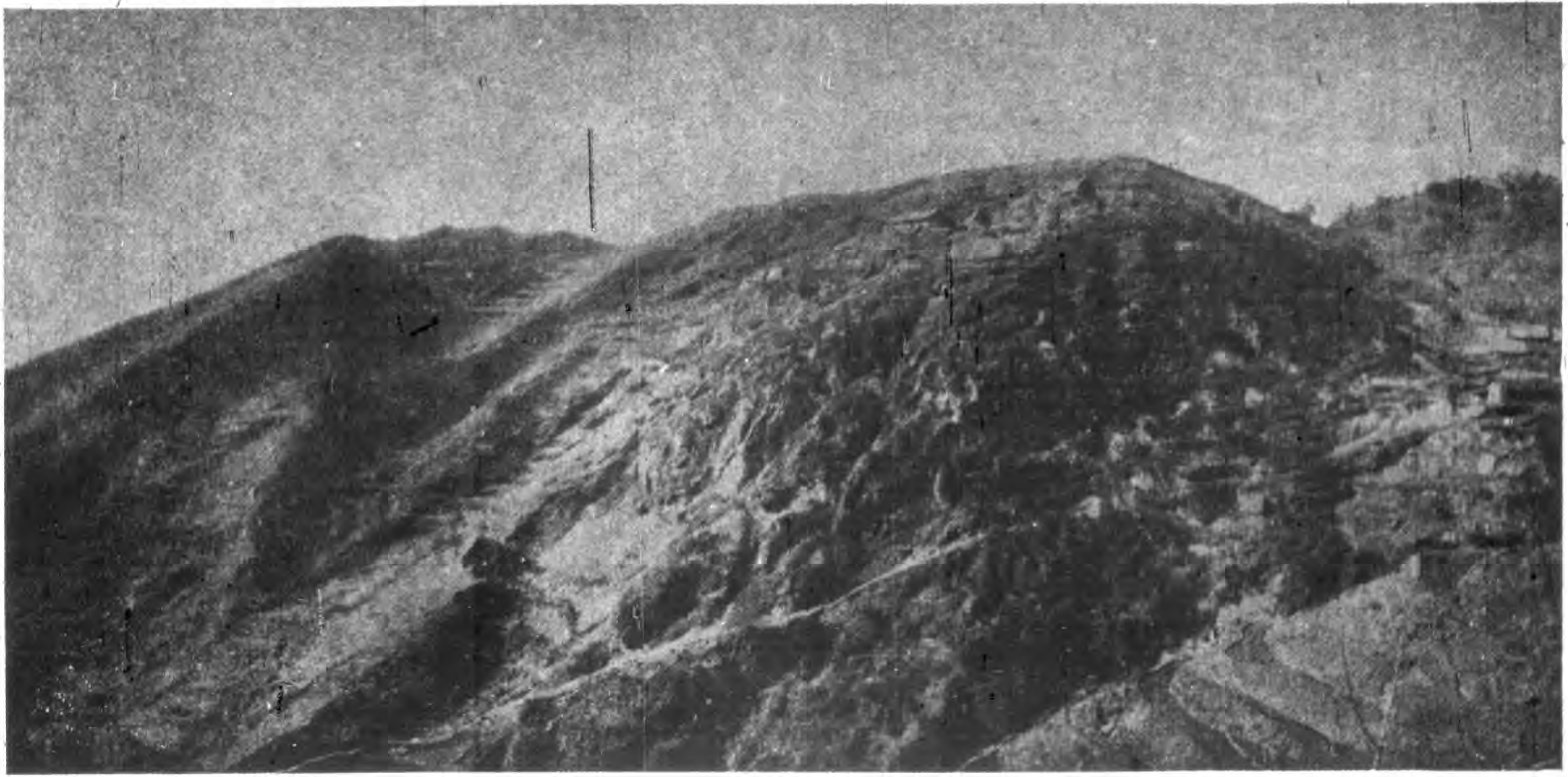
MAP OF CENTRAL HUNAN SHOWING THE SITUATION OF THE CHIEF ANTIMONY FIELDS.

- - - - - *Way of transport for Antimony*

• *Antimony field*

Panorama of the Hsi-K'uang-Shan Antimony ridge, view from the west.

Panorama of the Chih-Li-Kiang ridge, view from the west.



Panorama of the Kiang-Ch'un ridge, view from the north.

extending almost continuously for the whole length of the deposit, now shelter a population more numerous than that of the district capital itself. The present population is said to exceed 100.000 souls (though this figure may be largely exaggerated), assembled from all the surrounding districts: An-Hui (安化), Pao-King (寶慶) and Hsin-Hsiang (湘鄉). These villages have been allowed to grow without the slightest general plan, and hovels have clustered pell-mell on the ore hills themselves, among the mines. The sanitary conditions are beyond description · there being no scavenging system waste of every kind is allowed to accumulate indefinitely anywhere.

GEOLOGY OF THE MINING REGION.

The bedrock is built up exclusively of sedimentary rocks, ranging in age from probably Silurian up to Carboniferous.§ The sequence of strata is made clear by the cross section on the geological map, the only clear one that can be obtained in the neighbourhood. The thickness of the different strata as can be measured from this section is as follows:

	metres
Sandstone white, and dark shale (often coalbearing)	>20
Limestone dark grey alternatingly massive and thin bedded (often containing fossils)	230
Limestone richly fossiliferous carrying nodules of oolitic hematite	1
Limestone dark grey mostly dense & massive	40
Thin bedded argillaceous limestone, yellowish grey	120
Slate, hard and quartzeous	20
Quartzitic sandstone, Stibnite bearing	>50
Total	>481

The lower limit of the quartzitic sandstone is nowhere exposed but from observations during the journey it seems probable that this rock rests on dark gray, sometimes bituminous, sandstone and slate of probably early Palaeozoic or possibly pre-Cambrian age.

§ The fossils found in the limestone have not yet been determined.

The uppermost series of the section (sandstone and shale) is again overlain by limestone which is followed by the red strata of probably mesozoic age.

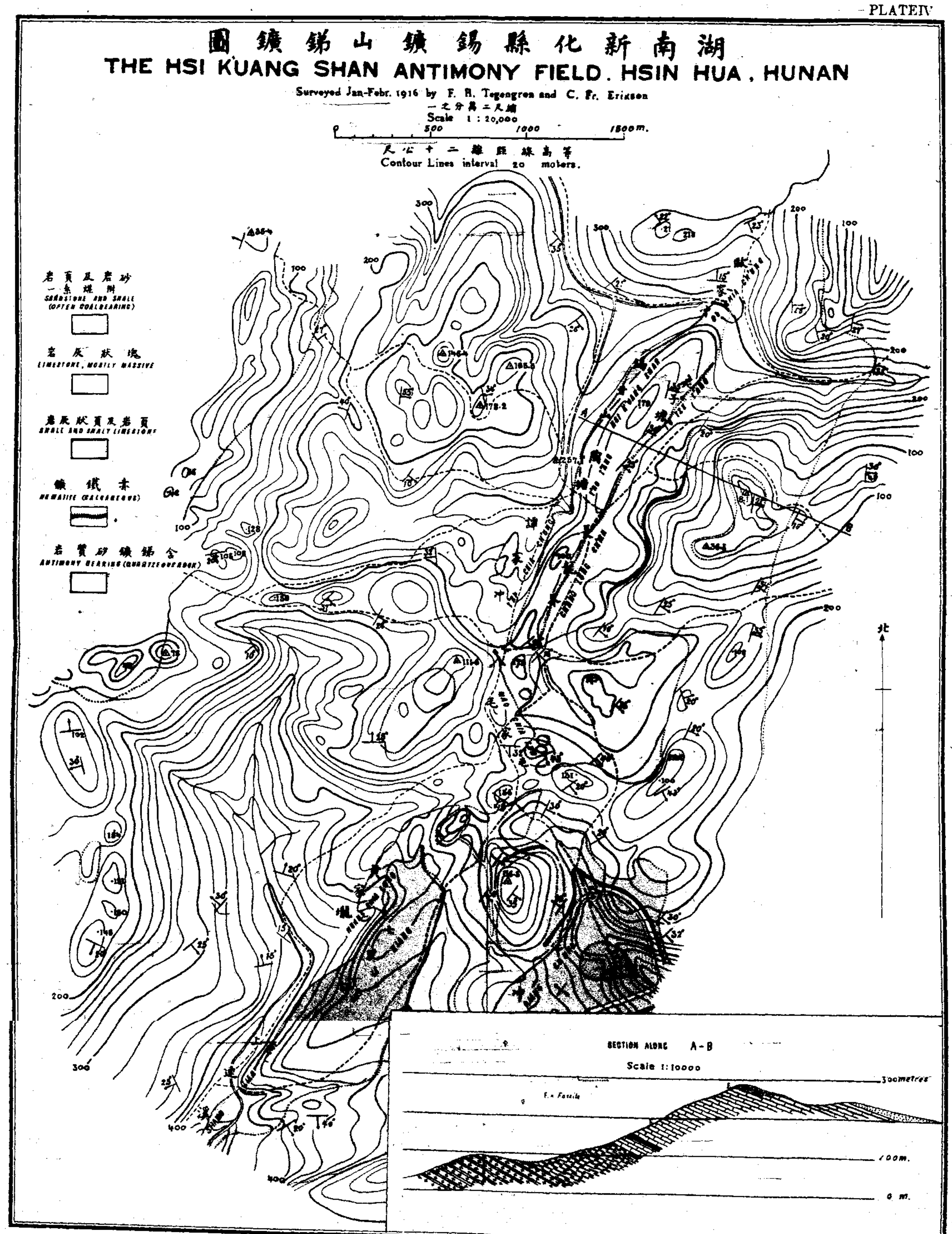
The original horizontal position of these strata has been disturbed both by folding and faulting.

The chief folding axis, as is evidenced by the map, runs NNE-SSW; along this the strata have been compressed into a series of anti-and cynclines the slopes of which dip some 20-30°. But besides this regular tilting of the strata also a doming has taken place which is most likely due to the intrusion of igneous laccolithic masses at deeper levels. The tectonical conditions are further complicated by faulting, although the lines of disturbance cannot be followed in detail owing to the obscuring soil. The chief line is, however, well marked. Along the whole extension of the hill ranges of Hsi-K'uang-Shan and T'an-Chia-Ch'ung (譚家冲) and from there traceable also across the limestone areas separating this deposit from Chi-Li-Kiang (七理江) it can be followed further along the whole length of the last named ridge. This fault-line is indicated by the steep escarpments on the western side of the hill ranges, (see the Plate V), by the limestone breccia found almost everywhere at the foot of the antimony ridge, and by the occurrence of the limestone down in this valley where otherwise the quartzitic sandstone or shale ought to be met with. The character of this fault, whether it is a normal one or a thrust, cannot be determined on account of the very fault-line being mostly obscured by soil. It is likewise not possible to estimate the extent of the displacement; its vertical component, however, may be somewhere about a hundred metres. Several minor dislocations seem to have taken place west of the main line splitting up the limestone areas there into many detached blocks, as can be noted by the extremely irregular and rapidly changing strike and dip.

THE ANTIMONY DEPOSITS.

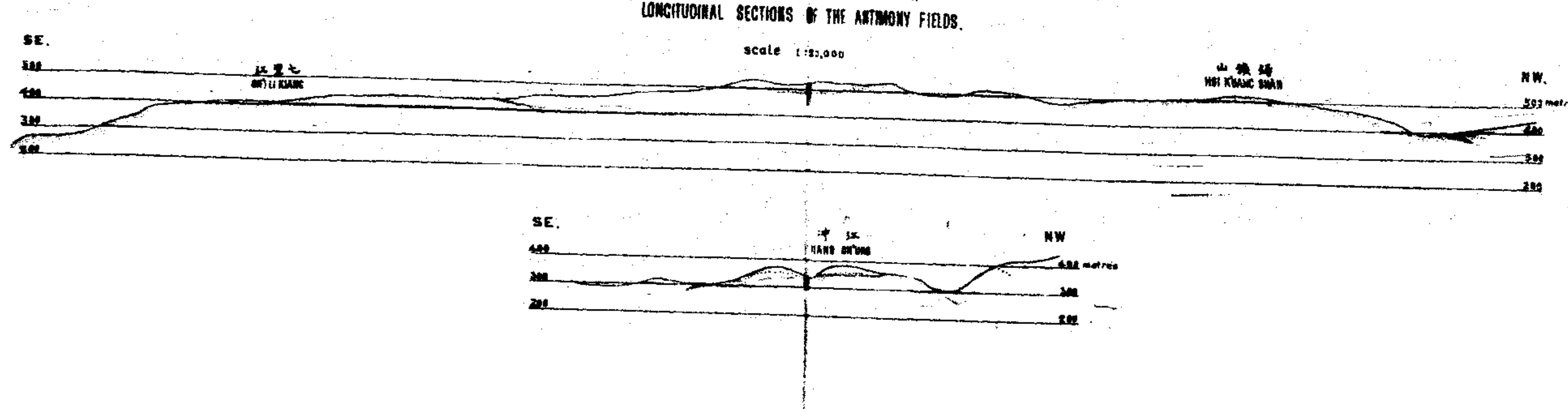
The deposits may be divided into four groups or ranges viz. (cfr the map Plate IV.)

1) The Hsi-K'uang-Shan ridge (Plates II, V) with the mining sections of Ou-Chia-Ch'ung (歐家冲), T'u-Tze-T'ang (兎子塘), Hsi-K'uang-



錫鑛縱剖面圖

LONGITUDINAL SECTIONS OF THE ANTIMONY FIELDS.



Steep quartzite cliff. West side of Hsi-K'uang-Shan.

Large native working near the crest of Hsi-K'uang-Shan.

Shan proper (老錫鑛山), and T'ao-T'ang (陶塘), together with its southern extension comprising the sections of T'an-Chia-Ch'ung (譚家冲) and Ch'ang-Lung-Chieh (長龍界).

2) The two isolated hillocks of Mao-Chia-T'un (毛家滃).

3) The Ch'i-Li-Kiang (七里江) ridge (Plate II) with its extensions Huang-Chia-Lung (黃家壠) and Shang-Lien-Hsi (上蓮溪).

4) Kiang-Ch'ung (江冲) embracing outcrops exposed in three different river gullys.

The mineral association:—The primary ore mineral is, as far as I have found, exclusively stibnite, occurring partly as prismatic or acicular crystals, (Plate VI) partly as pure crystalline masses; associated minerals are almost entirely lacking. Quartz, often in beautiful druses of small clear prismatic crystals, is the only gangue matter, and in fact other minerals are so rare that only in one place, at the southernmost end of the Ch'i-Li-Kiang ridge called Shang-Lien-Hsi, I have found some pyrites impregnating the dark brecciated silicious rocks which occurs there, and in the limestone breccia along the big fault line West of Ch'i-Li-Kiang occasionally some small patches of cinnabar occur in the calspar cement of the breccia. Herewith the list of the mineral association of this deposit is exhausted. Gold has so far not been proved.

On the other hand, secondary antimony minerals are frequent, especially in Ch'ang-Lung-Chieh. These oxidised masses, have not been examined, but probably several of the oxides, as valentinite and cervantite (Plate VI) are represented. Generally they occur as white or yellowish porous masses, or as beautiful pseudomorphoses after stibnite; real crystals have not been observed.

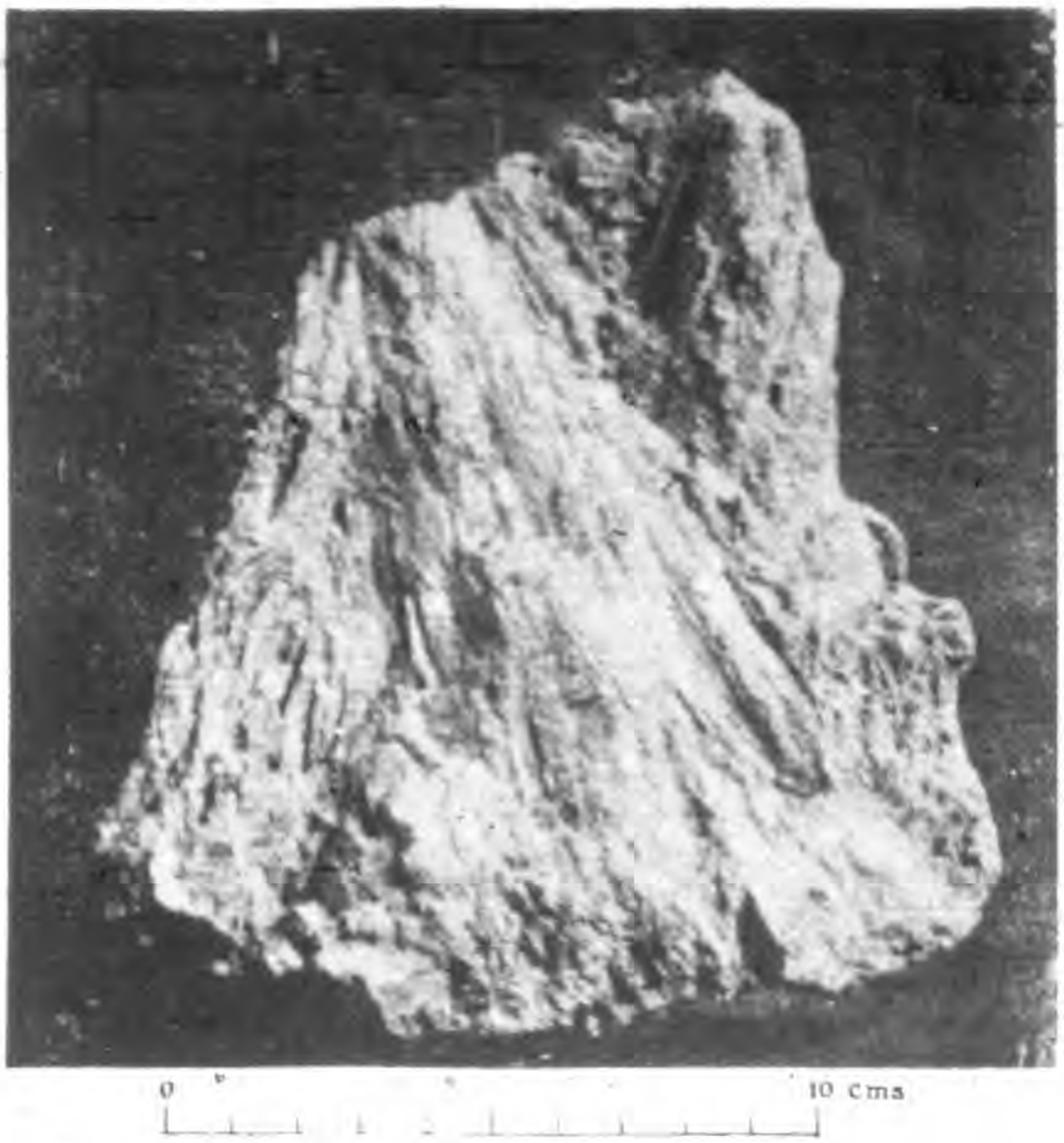
The occurrence and distribution of the ore:—The occurrence of antimony as already mentioned, is practically confined to the quartzitic layer representing the oldest strata of the series exposed in the neighbourhood and which is probably of Silurian or Devonian age. This quartzitic is exhibited only in some anticlines where denudation has effected deep sections. Such deep denudation is met: 1) where parts of these anticlines have been left standing while the adjacent country has sunk by faulting, or 2) where brooks flowing across such anticlines have cut their erosion channels down to this level. The latter case is represented by Kiang-Ch'ung; all other deposits are of the former type.

Within the quartzitic sandstone layer which, as stated above, seems to attain a thickness exceeding 50 metres, the ore is rather irregularly scattered. The structure of the rock is often distinctly fractured and brecciated, probably owing to the tensile stresses produced in the course of folding, and of the same origin are probably also the big caverns found at T'ao-T'ang and in the northwestern corner of Ch'i-Li-Kiang. According to Mr. Lo's estimation the former cave has a length of about 180 metres extending parallel to the ridge; its width is about 40 metres and height 5 metres; the other cave has approximately similar dimensions. The cavern at T'ao-T'ang was said to have been highly mineralised and clad with crystals of stibnite and quartz; now, however, most of the ore had been removed. A further indication of the fractured condition of this quartzitic layer in the anticline is that the cave is said to have been crowded with loose boulders, which evidently by joints and cracks had been separated from the roof and then fallen down. From these the ore could be won even without blasting.

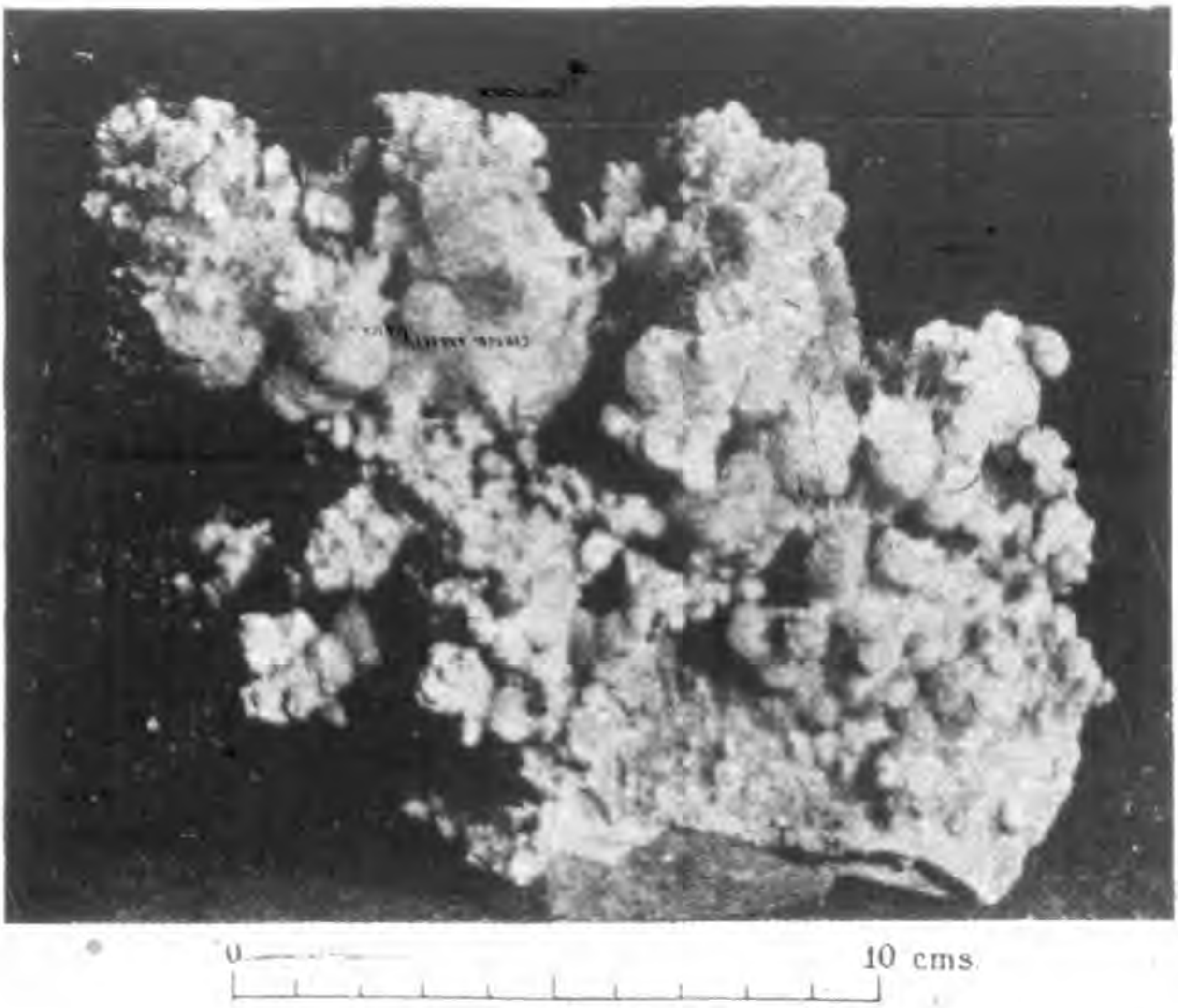
This breaking into pieces of the brittle quartzeous layer is, of course, partly due to the bending along the anticlinal saddle, but partly it must also be ascribed to the faulting.

Such rock strata intersected by cracks and joints, with numerous open spaces and cavities, and moreover covered with an impermeable roof of tough shale easily yielding to tensile stresses without breaking, obviously afforded an excellent receptacle for the deposition of minerals from ascending solution. Antimony and silica compounds were infiltrated and precipitated, and it seems as if upon the whole the ore shoots were most abundant underneath the dome shaped vaults formed by the cross folding, which have been referred to above. As is seen on the plan compared with the length and cross sections, Hsi-K'uang-Shan proper, the richest part of the ridge forms such a cupola; another less mineralized one is formed by Ch'i-Li-Kiang and a third one which is still very imperfectly known, by the Kiang-Ch'ung field.

Plate VI



Typical specimen of stibnite.



Beautiful druse of small, acicular quartz crystals formed in a cavity in the antimony bearing quartzite.

Besides, of course, other conditions such as the local abundance of ore bearing solutions, may have influenced the deposition of the antimony. Some layers look compact and therefore, apart from some impregnation with minute needles of stibnite, are mostly barren, whereas in more brecciated ones a rich mineralisation has frequently taken place, giving rise to irregular veinlets, veins, and lenticular bodies of almost pure stibnite, the largest of which § was measured to be more than .75 metres thick (the whole thickness was not exposed) with a length exceeding 5 metres and a breadth of 3.5 metres. Bodies of this magnitude, of course, are rare, but in many mines there are seen working faces with several irregular ore bands of 10-50 centimetres in thickness, separated by only a few decimetres of barren rock, or rock spotted with small bunches of stibnite crystals.

The mines very often have several levels separated by barren or too lean rock, of a couple of metres in thickness, which indicates the existence of so to speak several ore-bearing horizons in the quartzitic layers, evidently due to differences in composition or physical properties of the rock.

To what extent metasomatic processes involving the removal of rock in solution may have participated in the formation of these deposits, enlarging the cracks and openings, is difficult to state, but in view of the very hard and silicious composition of the invaded rock it seems hardly probable that a considerable replacement could have taken place, the more so since on the contrary there has been a deposition of silica accompanying the antimony compounds.

It is remarkable, as indicated above, that very few other metals and in almost negligible proportions have accompanied the antimony compounds. Complete analyses of the ore itself are wanting, but from a few partial ones and from the composition of the "crude" or concentrated sulphide the fact is equally well elucidated. With the exception of iron (about .5%) none of the other constitutuents exceeds .1% §§ Arsenic, lead, and copper, consider-

§ Worked by the Ch'on-Fu-T'ung (醇富堂) Company.

§§ Schieller, W. R. Notes on Chinese Antimony Ores Crude and Regulus. Journal Soc. Chem. Ind. March 31, 1913.

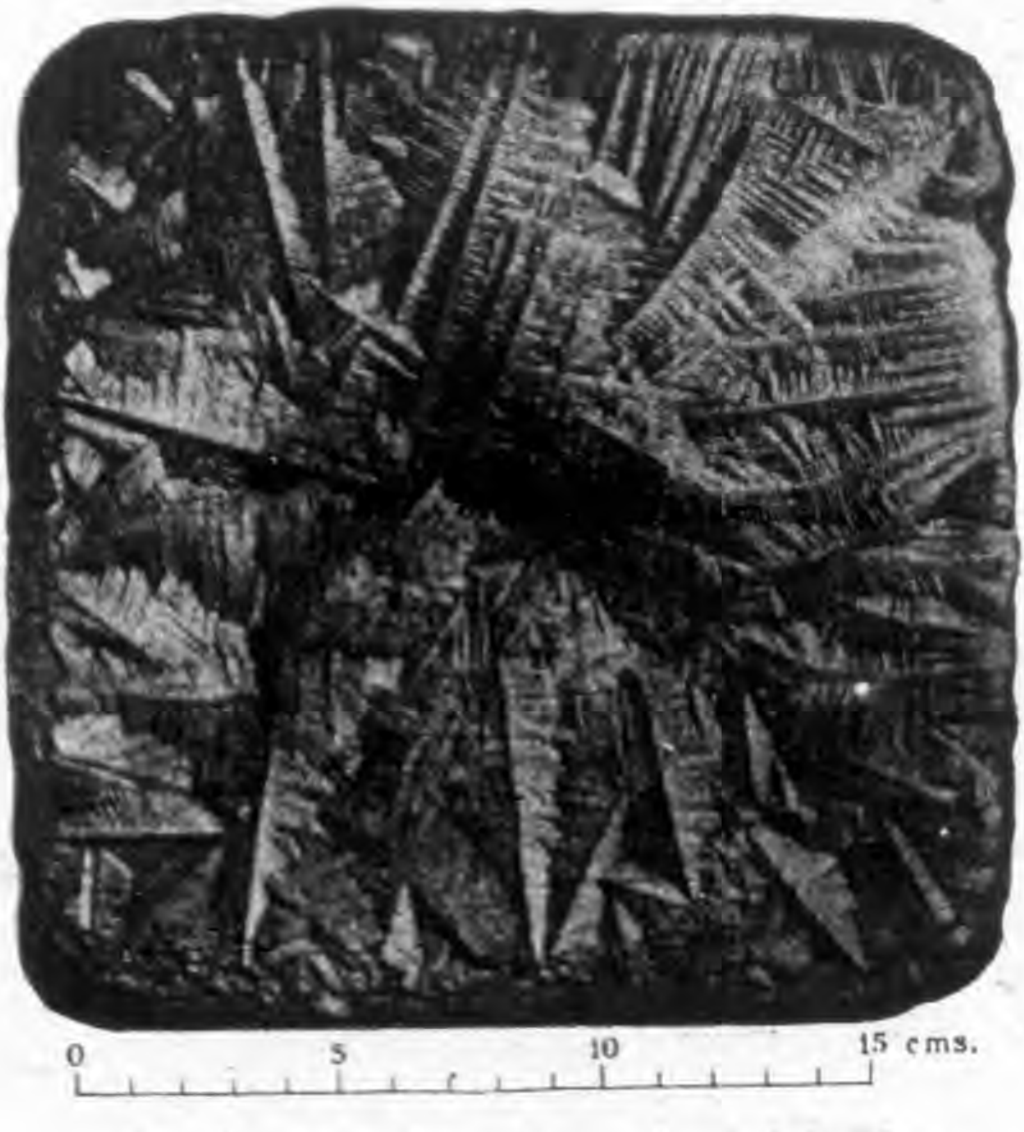
ed as lowering the quality, (and the percentage of which is generally not allowed to exceed: for Arsenic .25% and for lead and copper .75%) are present in much smaller amounts, the percentage of Arsenic seldom amounts to .1% and lead and copper as well as zinc, generally making up only .05%

The question as to what may be the average tenor of antimony in the whole quartzitic bed cannot be answered accurately, as too few data are available on which to base such a calculation. However, a rough estimate may be better than nothing.

As stated below the figure 104,000 tons may be accepted as an expression for the quantities of metallic antimony up to 1915 extracted from the Hsi-K'uang-Shan ridge. This figure, however, does not represent the total quantity of metal contained in the rock mined out. Firstly it is easy to observe that very considerable quantities of antimony are still contained in the waste rock, thrown on the dumps from which now hundreds of miners are recovering the metal by cobbing and washing, and secondly gress losses are suffered in the smelteries where very little care is taken to prevent the fumes from escaping. In estimating the losses only to 20% we get a total quantity of 124,000 tons of metallic antimony contained in the mined rock. In further putting the percentage of picked ore from the rock blasted at 30% (containing 55% antimony) which by no means seems too bold an assumption, since only the richest parts have been attacked,§ we get a total quantity of about 700,000 tons of mined rock. Hence it can be computed that the total percentage of antimony in the rock mined would have been about 18%. But this is evidently not the actual percentage of the deposit, since only the rich veins have been followed and as a little barren rock as possible taken out. What is the exact proportion between the poor rock left and the rich veins mined out can of course not be estimated, but judging from the honeycomb like appearance of the whole hill ridge, I could hardly put the former at less than 1/3 of the latter, from which it follows that the Antimony tenor of the ore bearing quartzitic sandstone of the Hsi-K'uang-Shan range is at least 6%.

§ From the data concerning the labour contract system in use it can be gathered that, as the price paid for 1 ton of ore is equal to that paid for 1.87 tons of rock, the percentage of ore would be as high as 73%.

Specimen of secondary antimony oxide, crystals pseudomorphous after stibnite.



Antimony regulus pig with the characteristic crystalline surface

The Chi-Li-Kiang ridge is comparatively much poorer; the Kiang-Ch'ung deposit, as already mentioned, is very little known so far, but it might be taken for granted that also this occurrence, although probably richer than Chi-Li-Kiang, does not reach quite the phenomenal concentration of Hsi-K'uang-Shan.

At last some remarks may be added regarding the correlation of this antimony field with other stibnite deposits of China as well as of foreign countries.

In the first named respect it is striking to note that the group of deposits described above under the common heading of the Hsi-K'uang-Shan mining field is so far the only known deposit of this nature in China,§ all other occurrences being well-defined veins, along certain tectonic lines. Their country rock also seems to belong to an older series than the quartzitic sandstone. These fissures, thus appearing in deeper sections of the crust, may perhaps be taken as representing such vents by which the Hsi-K'uang-Shan deposit was supplied with the antimony solutions from below. On the other hand the Hsi-K'uang-Shan antimony deposits strongly resemble the Quicksilver occurrences of Northeastern Kueichow and Southeastern Szechuan, which also are confined to similar brecciated anticlines, although the mineralization here has been less abundant. Also genetically there is evidently in this case, as has frequently been ascertained with regard to deposits in foreign countries, an intimate connection between the stibnite and cinnabar deposits, the former mineral accompanying the latter at, for example, Wan-Shan-Ch'ang (萬山場), and Ta-Tung-La (大東喇) quicksilver mines, and on the other hand, as mentioned above, cinnabar has been found at Hsi-K'uang-Shan. Furthermore a transition to the gold veins is exemplified by the Wu-Hsi antimony occurrence,§§ where gold is won from the waste rock, from which the antimony ore has been picked out.

To determine the geolgical age of the mineralization as well as to decide from what igneous magma the mineral solutions may have originated and,

§ Perhaps though the Fan-Ching-Shan (梵淨山) deposit NW of Tung-Jen. Kueichow, may be of a similar type.

§§ Report by A. S. Wheler.

further, what genetic relationship there may exist to the lead and tin deposits of South China, is at present not possible. These problems require for their solution a thorough and detailed geological survey of large areas of the Southern Provinces, which remains yet to be undertaken. However a few observations and suggestions may be added. It is a conspicuous geological feature of the regions traversed by us during our journey that igneous rocks are extremely scarce, in fact almost wanting. The only existing notes on the occurrence of such rocks in the vicinity of the antimony deposits are observations by A. S. Wheler§ about granite in An-Hua district and the discovery by Mr. Lo of a granite body between Hsi-K'uang-Shan and Pao-King. As to the age of these rocks, however, practically nothing is known and still less of the rôle they may have played in the formation of the mineral deposits in question. However, it seems very likely that the mineralization is connected to tectonic movements and igneous activity of the Tertiary.

Since I have not had access to original literature dealing with antimony deposits in foreign countries, detailed comparison is here impossible, but from brief descriptions in text books on ore deposits, Hsi-K'uang-Shan seems to expose a close resemblance to the deposit at Djebel Hamimat in Algeria, although the latter contains more oxides, and moreover to certain occurrences in the "Rheinische Schiefergebirge" and United States of America.

The extent and ore resources of the individual deposits.—The dimensions of the ore bearing quartzitic sandstone areas exposed at the different groups of mining fields are as follows:—

	Length metres	Max. Width metres	Area sq. metres
Hsi-K'uang-Shan range	2100	300	408.000
Mao-Chia-T'un range	20	20	
Ch'i-Li-Kiang range	1880	530	623.000
Kiang-Ch'ung range	850	250	40.000

Based upon the above figures, the percentage of metal as calculated above, and the thickness of the ore bearing layers the following deductions can be made:

If the ore bearing stratum in the Hsi-K'uang-Shan range, the actual thickness of which at least in some places, exceeds 50 metres, is taken as

§ The metalliferous mines of Hunan. Far Eastern Review. September 1915.

only 20 metres the total quantity of rock (specific gravity taken as 3), would be: 3 x 408,000 x 20=24,480,000 tons. This quantity of rock, if its tenor is put at 6%, would thus contain not less than 1,500,000 tons of the pure metal, corresponding to nearly 3,000,000 tons of ore of 55% grade. Of the total resources, only some what more than 100,000 tons of antimony, equal to about 200,000 tons of ore, have been removed, leaving a quantity of more than 1,300,000 tons of metal for future exploitation.

But very likely the above figures do not represent the total supplies of this profusely rich deposit. There is no reason why the strata should not, in some directions at least, extend beyond the present limits of the outcrop of the quartzitic formation. To the West the formation, it is true, is discontinued by a faultline the throw of which may reach some hundred metres, and at the end, towards N and S, it seems to become less mineralized, but there seems, on the other hand, to be no reason for doubting the continuity towards the East in the direction of the dip, (see the cross section) for a couple of hundred metres at least. If this were proved to be true, very considerable resources are to be found East of Hsi-K'uang-Shan to a maximum depth not exceeding 20 metres. Taking a length of only 1,500 metres, a horizontal width of 200 metres, and a thickness of 10 metres of the layer, this would make up a total tonnage of 3,000,000 containing probably 150,000 tons of antimony, the tenor taken as 5%.

At Kiang-Ch'ung the deposit could be easily opened up by shallow workings on a length of 900 metres and a width of 250 metres, covering an area of more than 200,000 sq. metres. As to this field, as well as Ch'i-Li-Kiang, it is better to refrain from attempts to estimate the tonnage of resources, since Ch'i-Li-Kiang seems evidently too poor altogether and Kiang-Ch'ung is by far too little known, although the prospect here seems much better than at Ch'i-Li-Kiang.

HISTORICAL AND STATISTICAL DATA.

Hsi-K'uang-Shan proper is said to have been worked at the end of the Ming and the beginning of the Ching Dynasty in the 16th-17th century. It was, however, believed to be a tin deposit and therefore it was given the name Hsi-K'uang-Shan, or Tin mining hill, which name it still retains.

After that time it was, for reasons not known, abandoned, and work was not resumed until in 1895 when its proper nature of any antimony deposit had been discovered. For the first few years the output remained very insignificant, attaining only some hundred tons, but at the beginning of this century it was largely increased and soon surpassed the production of any other country, as has already been mentioned in the introduction.

Soon after the mining operations were started, also smelting plants for "crude" antimony were established, and a large part of the ore output was treated in these and shipped out as crude. Finally, about two years ago, the then Mei-Hsiang (美祥) now Hsin-Hua-Ch'ang (新華昌) Company, after an agreement with the Hua-Ch'ang Company (華昌公司) of Chang-Sha (holding the monopoly of the Herrenschmidt smelting method) had been reached, started to produce regulus from oxidized ore, and last year the Kung-Yi (公益) Company followed the example.

Gradually the mining extended from Hsi-K'uang-Shan proper both N and S comprising T'ao-T'ang, T'u-Tze-T'ang and Ou-Chia-Ch'ung, as well as T'an-Chia-Ch'ung and Ch'ang-Lung-Chieh. On account of the antimony boom due to the World's war the much poorer deposits of Ch'i-Li-Kiang, with Huang-Chia-Lung and Shang-Lien-Chi were taken up, as well as the very little exposed field of Kiang-Ch'ung.

As belonging to the history of mining at this place it may, morever, be mentioned that the very lean iron ore from the seam mentioned above was mined and smelted until quite recently, only a couple of years ago when all attention was turned to the antimony.

Unfortunately there exists no accurate statistics relating to the output, and only rough approximations, either based on the Customs returns for the Hunan exports or on estimates of the larger mining companies can be attempted. I have tried to estimate the production during 1913, the last year of normal conditions on the antimony market, before these were upset by the World War, and have arrived at the figure 9,000-10,000 tons, expressed as pure metal. But, as already mentioned, the output has since been largely increased, not only at this deposit but at all antimony mines of China. Mr. A. S. Wheler, who visited this field in February 1915, gives the monthly production as about 1,000 tons of crude only, outside of the amount shipped as ore and the regulus which was then produced by one smeltery. At the time of our stay at the mines, the daily output was stated to be: at the Hsi-K'uang-Shan fields 50 tons of crude (of which more than 80% originated from Hsi-K'uang-Shan proper, T'ao-T'ang and Chang-Lung-Chieh), and 7 tons of regulus, now turned out by two smelteries. To this is to be added the output from the Ch'i-Li-Kiang and Kiang-Ch'ung fields amounting to 5 and 1 tons respectively. These figures correspond to a monthly production of about 1,700 tons of crude and 200 tons of regulus for all the smelteries together; besides, as already stated, also ore is shipped from the mines to the Chang-Sha smelteries. These figures represent all the direct data existing on the production of the Hsi-K'uang-Shan mines. They may, however, to some extent be supplemented by Tables I-III and the diagram,§ giving the exports of different Hunan ports and of the whole country. These customs figures probably come very near to the actual production since the quantities consumed within the country for pewter-ware and other alloys are almost negligible. As, moreover, most of the other Hunan fields have been taken up during the last few years the export figures from this province may generally be accepted as fairly well indicating the Hsi-K'uang-Shan output, which safely can be estimated at about 90% of the total.

I have furthermore, based on these data, ventured an estimate of the total quantities of antimony hitherto extracted from the Hsi-K'uang-Shan deposit and concentrated, the result in the following table:

	Total output of:			
	1) Ore tons	2) "Crude" tons	2) Regulus tons	Amount of Antimony metal contained in the ore, crude and regulus.
1895-1901	?	?	?	7,300
1902-1909	22,900	38,100	—	39,300
1910-1914	19,200	50,100	8,300	57,600
			Total	104,200

§ The exports of "crude" and "regulus" are recorded separately for Chang-Sha only; for all other ports only the total of these two items is given. Hence I have not been able to compile similar diagrams for the Province and the whole country, as for the Chang-Sha port.

1) Ore shipped to Chang-Sha.

2) Part of this "crude" and regulus has been produced at Chang-Sha from Hsi-K'uang-Shan ore.

In the above total are not included some "ash" or "refuse" (slag obtained from the crude smelting) which from time to time has been sold to foreign firms; these quantities may increase the total by 3000 to 4000 tons.

Thus the aggregate production of this deposit during the past up to 1915 may be estimated at more than 105,000 tons of pure antimony corresponding to about 200,000 tons of ore of 55% grade. This quantity is probably unsurpassed by any other antimony mine in the World.

To further illustrate the enormous importance of this deposit for the whole antimony trade of the World I adjoin the following table of the World's production, as far as figures have been available to me; most of them have been taken from the "Mineral Industry".

Antimony Production of the World in 1913

	Ore metr. tons	Metal § metr. tons
China	25,000	13,800
France	17,036	6,390
Austria)	1,270	
Hungary)	11,017	1,038
Mexico	?	2,340
United States	—	1,949 §§
Italy	1,822	76
Algeria	582	—
Japan	?	19
Bolivia	62	—
Portugal	19	
New South Wales		37 §§§
Total	56,808	25,649

§ Total of regulus and antimony contents in ores, crude, ash &c.

§§ Contained in hard lead obtained from smelting antimonial lead ore. Besides 2,506 tons of antimony were recovered from old metal, scrap, dross &c.

§§§ Including also ore.

Some antimony is also produced in Serbia and Asia Minor. As is shown by this table China's share (13,800 tons) in the World's production (25,600 tons,) was nothing less than 54%. To the country's production Hunan contributed about 11,500 tons or 83% out of which 9,000-10,000 tons (or between 80 and 90%) come from Hsi-K'uang-Shan. Thus this antimony deposit alone supplied nearly 40% of the whole World's production before the war, and by the rapid expansion in the last two years its share in the World's output of this metal has probably further increased, not only absolutely but also relatively.

THE MINING COMPANIES.

The general principle maintained with regard to the ownership of mineral deposits seems to have been that such property in the main belongs to the land owner, although some rights of taxation are admitted to the local and Provincial authorities. Nearly all the mining rights rest on this principle, established by old tradition, and few of the mining companies therefore, have applied for or obtained any license or concession from the Provincial Government, or even any kind of authorization from the District Magistrate. The big companies and those companies which have been working here for a larger number of years possess the ground themselves, whereas the smaller workers lease their mining area by the year, at prices which in course of late years have been enormously increased, although I am not able to give any figures since those obtained are evidently gross exaggerations.

Mining areas are very vaguely defined and in course of the operations often underground communication between workings pertaining to different owners has been established, rendering it extremely difficult to decide how much of the workings belong to one concern and how much to another. Disputes therefore are frequent and, in order to settle these, the Kuan-K'uang-Chü (官鑛局), a branch office of the Provincial Mining Bureau, was established here seven years ago. To what extent this office has been able to perform its difficult task I am not able to judge, but in laying hands on some forfeited mining areas situated within the richest part of the range, without a single dollar's outlay, it is certainly making great profit.

According to information obtained from the companies no taxes are levied on the mining products before they reach Chang-Sha.

There are more than eighty mining companies (including the Government Bureau) working in these mining fields; the principal concerns are enumerated below:

Hsi-K'uang-Shan.

Kuan-K'uang-Chü	(官 鑛 局)
Ch'ou-Fu-Tang	(疇 富 堂)
San-Yi	(三 益)
Lung-Fu Company	(龍 富 公 司)
China Company	(支 那 公 司)
Chin-Sheng-T'ai	(金 生 泰)

Ch'i-Li-Kiang.

Kai-Yuan Company	(開 源 公 司)
Lin-Chi ,,	(臨 記 公 司)

Kiang-Ch'ung.

Fu-Hua Company	(富 華 公 司)

Furthermore there are the following smelting companies, of which some are private, treating ores from their own mines, whereas others are "customs" works producing crude for the mining companies at charge of 30 tiao per ton crude.

Hsin-Hua-Ch'ang	(新華昌)	formerly Mei-Hsiang (美祥)
Kung-Yi	(公 益)	
Ch'ang-Ho-Fu	(長和富)	
Yi-Fu	(益 富)	
Hsiang-Yü	(湘 裕)	
Tsu-Shen	(資 深)	
Yuan-Hua-Ch'eng	(源化成)	
Chi-Ch'eng	(集 成)	
Mei-Chi	(美 記)	

The mining companies recently established an oganisation called the Antimony Association, the chief object of of which is probably the upkeep of a common police force numbering 100 men. The Association levies a tribute of 60 cash for every picul of ore shipped, corresponding to

$ 66 per ton, thus rendering a total annual sum of some 20,000 dollars. The Association was said to pay 10,000 tiao or $6,600 to the police yamen, to which the local merchants also contribute besides. The Kuan Kuang Chü, however, is exempt from the above tax.

THE MINING METHODS.

The technical side of the mining at Hsi-K'uang-Sha exhibits no characteristic features; it is the same ancient method, or perhaps rather absence of method, that for centuries has been practised everywhere within the country, resulting in what has been already accurately termed by various writers as ragged holes, rabbit warrens, honeycombs, &c. Owing to the thickness and extent of some of the ore bodies, or the abundance of veins within certain spaces, the workings here occasionally reach considerable dimensions of some metres in height connecting with winding drifts and inclined shafts. No timber support is used and no heed is taken to leave sufficient pillars, and hence it frequently happens that workings collapse.

The tools used are of the simplest possible description. Of the drill steel 95% is said to be imported from Japan and 5% from Germany, in the form of angular bars, which are hammered to the required chisel shape. The price paid for the steel at the mines is:

for Japanese	600 cash per catty=$ .66 per kilogram
for German	750 ,, ,, ,, =$ .83 ,, ,,

Mallets are made of native wrought iron from the vicinty, and sold at only 350 cash per catty-$ .58 per kilogram.

The mines are very little molest by water. Thanks to the favourable position of the mines, as well as regards surface as underground water, no special pumping appliances are necessary. In spite of the abundant rains, the inflow of water can easily be mastered by carrying in buckets only.

The only explosive used is native gunpowder, which all the mining companies formerly used to buy in common from the local market, but the latter nowadays, owing to the expansion of the mining, being unable to supply the necessary quantities, most of the large companies at present purchase all their powder from Shanghai. The only form of fuse used is thin tissue paper, rolled in threads with a core of gunpowder, and measuring about half a metre in length. Kerosene lamps are made of bamboo sections.

The companies—as is the general rule in China—do not engage their workmen themselves but leave this to one or several headmen, who are paid at a fixed rate either according to the amount of ore or rock produced or according to the number of workmen engaged by them. According to the information collected by Mr Lo the following systems are practised:

1. The headman is paid by the weight of the ore produced, and receives from the company 800 cash per picul of picked ore (=$8 80 per ton). Out of this he is supposed to pay to the workmen 60%, retaining 40% out of which, however, he has to provide the miners with gunpowder, fuses, and oil for the lamps, ~~whereas the~~ miners use their own tools.

2. The headman is paid by the volume of rock mined, and receives 120-160 tiao (according to the tenor of the rock) per every 5 x 5 x 5 Chinese feet=125 cubic feet or 4.6 cubic metres, corresponding to about $6.50 per ton of rock. Other conditions are as stated under 1).

3. The headman is paid per capita of workers, receiving 700 cash or $.46 per day of 12 hours for each workman.

The first two systems are practised in the richer mines, while in the poorer ones the third one is generally used.

The blasted rock is sorted in the mine and only ore pieces considered rich enough are carried up to the surface, where they are cobbed and picked again rendering ore of 40-60% grade; the waste still containing considerable quantities of the metal. These waste heaps now already have attained an enormous size, containing certainly hundreds of thousands of tons. The right of recovering antimony ore from these is leased on tribute by the mine owners to hundreds of coolies, who treat it by farther cobbing and hand jigging until a product, of nearly the same antimony percentage as the lump ore, is obtained, consisting of grains about 3-10 millimetres in diameter.

Although statistics have never been collected the number of workmen engaged in the mining work may safely be estimated in all the fields altogether to exceed 10,000.

TRANSPORT AND MARKET.

As already stated the mining products are transported (by two different ways) to the provincial capital Chang-Sha, which is the chief centre for the Chinese antimony refining industry and the antimony trade. To the rivers the metal is carried by coolies, then it is packed in wooden boxes and taken by river boats to Chang-Sha. Part of the ore is being converted into crude in the numerous smelteries there, part of the crude is transformed into regulus in the Hua-Ch'ang Company's (華昌公司) Works. Again part of the raw products are carried to Hankow and refined there.

The Hua-Ch'ang Company just mentioned holds a Government Monopoly for making regulus, recently defined as follows: The said Company possesses the sole right to produce regulus within a circular area around Chang-Sha with a radius of 100 Chinese li (57.6 kilometres). Within this area thus no other enterprise is allowed to produce regulus by any method whatsoever; outside the said area, however, regulus may be produced by other concerns, but not by the Herrenschmidt method.

This unfortunate monoply, now in force since about 9 years, has had the most unfavourable influence on the sound development of the antimony industry. It is easy to understand that it would be much more profitable to abandon the crude smelting entirely and produce regulus directly. As it is now, however, regulus smelteries have not been established at the chief mines until the last years and certainly these enterprises have to pay a heavy fee to the holders of the monopoly, which may perhaps be gathered from their declaration that it pays better to make crude.

The present war in Europe has caused a great boom in antimony, the price being quintipled and even more and certainly the Chinese antimony producers have earned large profits during the last two years. But very much of the profit has probably also gone to Japan, which is now, according to the Customs statistics, the largest buyer of the metal.

To what extent the prices of the raw materials and labour have risen in relation to the sale products is shown by the subsequent table, chiefly compiled by Mr. Lo. The figures, however must not be considered as absolutely correct, but still they give a fair idea of the matter.

Comparative table showing the cost of raw materials, labour and transportation, as well as the market value of the antimony products in 1912 and 1916.

Raw materials and labour:	1912	1916
Cost of production of 1 ton of ore	$ 112	$ 200
Cost of labour daily	$ 0.13 (200 cash)	$ 0.47 (700 cash)
Cost of coal for furnaces per ton	$ 3	$ 12
Cost of transportation to Chang-Sha per ton	$ 6.67	$ 27
Market products, sale price:		
Ore delivered at Chang-Sha per ton	$ 20	$ 323
Crude antimony at Chang-Sha per ton	$ 166	$ 533
Regulus at Chang-Sha per ton		$ 1,670§
Ash (Slag from crude smelteries containing 20-25 % Sb) delivered at Hsi-Kuang-Shan	$ 2	$ 53

SUMMARY AND CONCLUSION.

From the facts and considerations set forth in the foregoing it is easy to conceive what extremely valuable natural resources China possesses in the Hsi-K'uang-Shan antimony deposits, being quite unique in the World with regard to quality as well as quantity. Very large profits have already been gained by the owners and workers since the exploitation being; indeed, with the possible exception of some lead and tin mines, these are the only Chinese metalliferous mining enterprises where such a favourable result has been obtained. But on the other hand we have the losses incurred by mismanagement, indolence and ignorance, by lack of methodical mining plan, making the ore unnecessarily expensive and causing the frequent collapse and inaccessibility of rich portions of the ore-bearing stratum, by absence of any systematic dressing of the ore, by the crude and wasteful smelting method,

§ Hsiang-Ping (湘平) consisting of 6 mace 5 candareens or nearly equal to a dollar.

and last but not least by the monopolyzation of the smelting methods. It may be questioned whether the potential losses indicated above are not more than sufficient to counterbalance what has been won.

The general lines along with the future improvements ought to be effected in order to, at least partly, make good the blunders of the past and to enable the Chinese nation to reap the full benefit from this natural treasure can be indicated thus: centralisation, consolidation, organisation, and the adoption of technical improvements.

The rudimentary organisation already existing in the so called "Antimony association" should be extended, the numerous Mining Companies now operating separately without taking the least heed of the common interests should be united into one under a joint technical and economical management. The mining should be carried on according to a systematic plan, enabling the recovery and utilization not only of the rich shoots but of the whole mass of stibnite bearing rock; concentrating plants should be erected to treat the poor ore and modern regulus smelteries should, after the cancellation of the monopoly, replace the present inefficient crude smelting plants. The output should be regulated according to the demand for the metal, and the transportation and trade reorganised.

TABLE I.
EXPORTS OF ANTIMONY FROM CHANG-SHA.

Year	Ore (50-60 % Sb)		Metal contents Tons	Crude (70 % Sb)		Metal contents Tons	Ash (25 % Sb)		Metal contents Tons	Regulus (88 % Sb)		Total metal contents Tons
	Piculs	Tons		Piculs	Tons		Piculs	Tons		Piculs	Tons	
1903												
1904	3,759	224	123	14,297	853	597						720
1905	29,805	1,779	978	28,208	1,684	1,178						2,156
1906	38,105	2,277	1,252	39,902	2,381	1,667						2,919
1907	51,948	31,169	1,705	29,411	1,755	1,228						2,933
1908	14,330	855	470	100,060	5,972	4,180	26,826	1,601	400			5,050
1909	18,491	1,103	606	93,102	5,556	3,889	37,380	2,231	558	4,032	241	5,294
1910	21,655	1,292	710	120,060	7,165	5,015	33,684	2,010	503	13,490	805	7,033
1911	8,417	502	276	121,716	7,264	5,084	17	1	0.25	26,309	1,570	6,930
1912	11,424	682	375	90,485	5,400	3,780	17	1	0.25	33,802	2,017	6,172
1913	70,039	4,180	2,300	116,155	6,932	4,852	105,756	6,312	1,578	35,381	2,111	10,841
1914	6,976	9,369	5,152	247,585	14,777	10,344	42,890	2,560	640	45,948	2,742	18,878
1915	15,221	908	499	247,443	14,772	10,340	83,193	4,966	1,241	97,642	5,739	17,819
1916	4,519	278	151	213,888	12,769	8,938	209,345	12,497	3,124	106,315	6,347	18,560
1917	1,512	90	49	319,993	19,103	13,872	5,494	327	81	222,062	13,257	26,759
1918	5,376	220	121	15,893	948	663	—	—	—	248,897	14,859	15,643
1919	5,042	300	165	33,854	2,021	2,414	—	—	—	114,761	6,851	8,430

*) Chang-Sha became an open port in 1903.

TABLE II.

EXPORTS OF ANTIMONY FROM HUNAN AND HUPEI PORTS.
(PICULS)

Year	ORE				CRUDE AND REGULUS				
	Hankow	Yochow	Changsha	Total	Hankow	Yochow	Changsha		Total
							Crude	Regulus	
1900	73,135§								
1901	55,107§	11		11					
1902	60,880	3,360		64,240	113,220	30,156			143,376
1903	1,369	40,957		42,326	7,436	76,515			83,951
1904	8,969	23,016	3,759	35,744	3,034	54,852	11,297		72,183
1905	1,637	5,704	29,806	37,146	907	24,982	28,208		54,097
1906	2,647	20,144	38,159	60,950	857	12,314	39,902		53,073
1907	1,176	46,332	51,948	99,456	18,737	11,195	29,411		59,313
1908	50	18,946	14,330	33,326	31	81,967	100,060		132,058
1909	316	32,995	18,491	51,802	254	16,368	93,102	4,032	113,756
1910	1,076	36,852	21,655	59,583	2,418	15,624	120,060	13,490	151,592
1911		12,499	8,417	20,916	9,711	48,288	121,716	26,309	206,024
1912	2,091	20,395	11,424	33,910	2,524	111,773	90,485	33,802	238,584
1913	724	8,484	70,039	79,247	514	34,440	116,155	35,381	186,520
1914	5,095	6,720	156,979	168,794	—	7,560	247,585	45,948	301,093
1915	566	3,657	15,221	19,444	15,251	2,373	247,443	97,642	362,709
1916	337	—	4,519	4,856	49,199	9,190	213,888	106,315	378,592
1917	1	—	1,512	1,513	17,348	2,537	319,993	222,062	561,940
1918	—	—	5,376	5,376	2,915	13,709	15,893	248,897	281,414
1919	—	—	40	40	840	—	33,854	114,761	149,455

§ Ore and crude

TABLE III.

EXPORTS OF ANTIMONY ORE FROM CHINA.

Year	Original Export from Hunan and Hupei Ports		Original Export from Ports in other Provinces		Total Original Exports		Total Export to Foreign Countries	
	Piculs	Tons	Piculs	Tons	Piculs	Tons	Piculs	Tons
1900								
1901								
1902	64,240	3,835						
1903	42,326	2,527	9,478	565	51,804	3,092	53,815	3,214
1904	35,744	2,134	8,117	484	43,861	2,618	53,286	3,181
1905	37,146	2,218	4,566	273	41,712	2,491	38,887	2,322
1906	60,950	3,639	7,130	426	68,080	4,065	59,920	3,577
1907	99,456	5,938	11,710	699	111,166	6,637	39,384	2,351
1908	33,326	1,990	4,800	287	38,126	2,277	8,995	537
1909	51,802	3,093	2,247	134	54,049	3,227	12,844	667
1910	59,583	3,557	2,980	178	62,563	3,735	95,259	5,737
1911	20,916	1,249	19,266	1,151	40,182	2,400	112,631	6,724
1912	33,910	2,024	5,534	330	39,444	2,354	33,976	2,028
1913	79,217	4,731	3,428	205	82,675	4,936	71,924	4,294
1914	168,694	9,670	2,004	120	170,698	9,790	169,435	10,116
1915	19,444	1,160	35,763	2,135	55,207	3,295	27,638	1,650
1916	4,856	290	205,887	12,292	210,743	12,582	194,525	11,613
1917	1,513	90	61,308	3,660	62,821	3,750	63,813	1,409
1918	5,376	320	4,502	269	9,878	589	7,939	474
1919	5,040	300	644	38	5,684	338	9,584	572

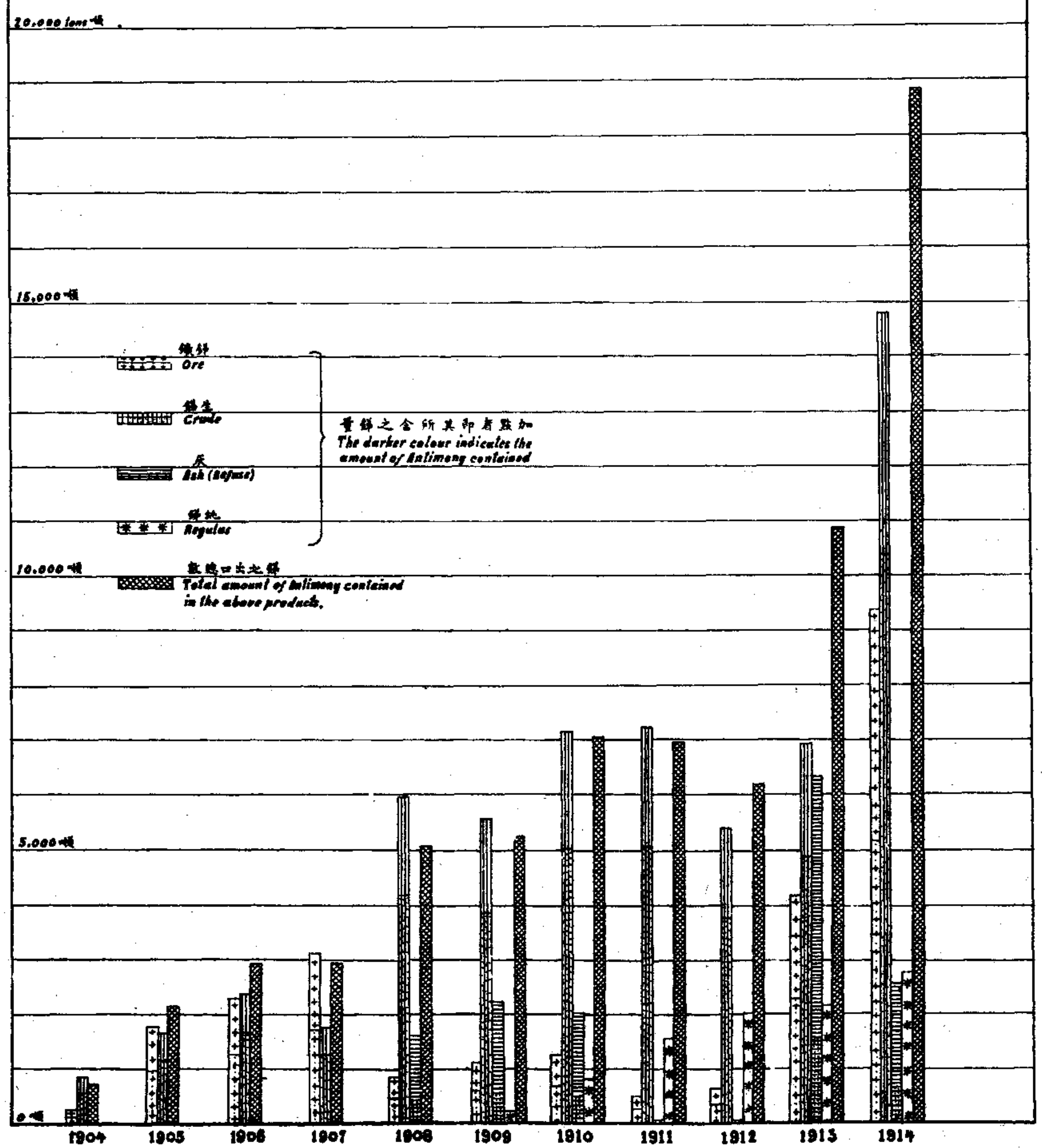
* The amount include antimony ore, crude antimony and regulus antimony

TABLE. IV.

EXPORTS OF ANTIMONY "CRUDE" AND REGULUS FROM CHINA.

Year	Original Export from Hunan and Hupei Ports		Original Export from Ports in other Provinces		Total Original Exports		Total Export to Foreign Countries	
	Piculs	Tons	Piculs	Tons	Piculs	Tons	Piculs	Tons
1902	143,376	8,559					87,246	5,209
1903	83,951	5,012			83,951	5,012	63,150	3,770
1904	72,183	4,348	8	0.5	72,191	4,348	55,440	3,309
1905	54,097	3,235	46	2.7	54,143	3,238	63,314	3,780
1906	53,073	3,168	7,212	431	60,285	3,599	38,298	2,286
1907	59,343	3,543	5	0.3	59,348	3,543	154,695	9,234
1908	132,058	7,883	63	4	132,121	7,887	131,245	7,835
1909	113,756	6,791	66	4	113,822	6,795	109,852	6,558
1910	151,592	9,050	485	29	152,077	9,079	116,520	6,927
1911	206,024	12,299	7,370	440	213,394	12,739	223,656	13,353
1912	238,584	14,045	4,059	242	242,635	14,287	215,406	12,860
1913	186,520	11,135	12,113	723	198,633	11,858	214,727	19,386
1914	301,093	17,976	7,562	451	308,655	18,427	358,966	21,430
1915	262,709	15,684	114,944	6,862	377,653	22,546	371,102	22,155
1916	378,492	22,596	19,543	1,167	398,035	23,763	371,102	22,155
1917	561,940	33,548	15,697	934	577,627	34,482	578,094	34,502
1918	281,414	16,800	905	54	282,419	16,854	265,989	15,880
1919	149,455	8,923	1,179	70	150,634	8,973	137,957	8,236

湖南長沙銻鑛出口比較表
EXPORTS OF ANTIMONY FROM CHANGSHA, HUNAN.



ON HISTORICAL RECORDS OF EARTHQUAKES IN KANSU.

BY W. H. WONG.

It was originally intended to translate the complete list* of earthquake records as well as this paper into English, but just as this was going to the press, Dr. Wong wrote from Kansu that he should like to make the list more complete by the new material collected by him before publishing it. Hence only the Chinese version which was already printed is inserted in this number. The paper itself however contains so many interesting facts and ideas that I consider it advisable to publish it at once. The author will no doubt reserve his new material for a future paper.

V. K. TING.

INTRODUCTION.

Ever since the beginning of history the Chinese records have been paying considerable attention to the occurrence of earthquakes in China. Whilst many of the earlier and even the later notices seem to be mixed up with various superstitions, there is no reason to doubt most of the facts recorded, because firstly, earthquakes, being a phenomenon felt by every one, could not have been manufactured, secondly, it was always regarded as a serious calamity bringing discredit to the rulers of the country, therefore no body would have dared to record an earthquake when none had occurred. For these reasons the Chinese records deserve careful study by all students of seismology.

In fact much has already been done by foreigners. Besides the works of Biot, Gaubil, Omori, Parker and Milne, the most complete study on earthquakes in China is the "Catalogue des Tremblements de Terre, signalés en Chine d'apres les sources chinoises", compiled by a Chinese Jesuit Father Huang, and supplimented and discussed jointly by Tobar and Gauthier. The material on which this catalogue was based, was quite extensive, but the part on Kansu was much less complete because few of the district records, which are most valuable, were accessible to the authors. Consequently in

* The list is attached at the end of the Chinese version of this paper.

comparison with the other provinces the occurrences in Kansu contained in the catalogue are far from being exhaustive, especially with regard to the modern period. In the new Geography of Kansu (甘肅新通志) published a few years before Father Huang's catalogue, there are no less than 75 earthquakes, most of which quite destructive, not noted in the latter. In the present paper an attempt will be made to combine the two lists and to discuss the possible conclusions that may be drawn from the new material.

FREQUENCY.

If we neglect the question of intensity, and consider only the frequency, we have the 240 cases in the combined list distributed in time as in table I.

TABLE 1.

Centuries		*Number of earthquake years.*
VIII	B. C.	1
VII	,,	0
VI	,,	0
V	,,	0
IV	,,	0
III	,,	0
II	,,	3
I	,,	3
I	A. D.	2
II	,,	5
III	,,	9
IV	,,	10
V	,,	11
VI	,,	9
VII	,,	3
VIII	,,	5
IX	,,	6
X	,,	2
XI	,,	5
XII	,,	7

XIII	A. D.	1
XIV	,, ...	29
XV	,, ...	12
XIV	,, ...	29
XVII	,, ...	35
XVIII	,, ...	18
XIX	,, ...	31
XX	,, ...	4

If we except the 6 centuries previous to 200 B.C. during which time the records were obviously defective, we have then from 200 B.C. to 1900 A.D. 21 centuries with 235 years in which earthquakes occurred. That is on the average 11 years in a century. On the other hand if we only take the period between 1400 A.D. and 1900; we will have 25 earthquake years in a century. It seems also that earthquakes were more frequent between the 2nd and the 6th century A.D. and since the 14th century A.D. with a comparatively quiet period between. This apparent *periodicity* is similar to the one emphasized by Tobar and Gauthier. According to these authors earthquake records in China indicate three periods. The first period lasted from the beginning of the Christian era to 633 A.D. during which time there were 413 occurrences. The 2nd period lasted from 634 A.D. to 1266 A.D. where only 375 were mentioned. The 3rd period is from 1267 A.D. to the end of 19th century with 2935 records. In other words they believe that there is an alternating period of 600 years each, and at present we are supposed to be entering upon a comparatively quiet phase. Applying this method to Kansu province we find:

TABLE 2.

1st period	2nd period	3rd period
(1–633)	(634–1266)	(1267–1899)
48	33	146

This seems to confirm the hypothesis of periodicity of earthquake occurrences. The confirmation is however more apparent than real, for in studying the earthquake records there are two disturbing factors which must be taken into account. Firstly, the completeness of a record depends largely on the importance of the locality, hence we find more earthquakes are recorded in capitals and important cities than in others. Secondly, it depends on the political condition at that time. For example in the 13th century only one earthquake was recorded for Kansu. This is obviously due to the fact that northern China was then occupied by the Tungus and the Mongols who cared nothing about earthquakes or historical records. In order to make this clear, we shall divide the records, not according to centuries, but according to Chinese dynasties.

TABLE 3.

Dynasty	*No of years*	*Earthquake years.*
Chou 1122 B.C.-247 B.C.	876	1
Ts'in 246 B.C.-207 B.C.	40	0
Han 206 B.C.-220 A.D.	426	13
Three Kingdoms 221-264 A.D.	44	4
Tsin 265–419 A.D.	155	19
Nanpeichao 420–580 A.D.	171	15
Sui 581–617 A.D.	37	3
T'ang 618–906 A.D.	289	11
Wutai 907–959 A.D.	53	0
Northern Sung 960–1126 A.D.	167	11
Southern Sung 1127–1263 A.D.	137	4
Yüan 1264–1367 A.D.	104	25
Ming 1368–1643 A.D.	276	64
Ts'ing 1644–1912	269	69

From this we can see that in the more disturbed dynasties fewer earthquakes were recorded. The exception to this rule is from 265 to 580 when even more earthquakes occurred than in the glorious T'ang dynasty. No clear periodicity can however be proved and it is a significant fact that from the 13th century onward when the historical records have become undoubtedly more complete, the distribution of earthquakes in time became remarkably even and constant. Take this period and group the number of earthquakes in divisions of 10 years we have table 4.

TABLE 4.

	Period	No. of earthquakes		Period	No. of earthquakes
14th Century	1301-1310	3	17th Century	1601-1610	3
	1311-1320	4		1611-1620	3
	1321-1330	4		1621-1630	5
	1331-1340	7		1631-1640	5
	1341-1350	4		1641-1650	4
	1351-1360	3		1651-1660	4
	1361-1370	0		1661-1670	2
	1371-1380	3		1671-1680	6
	1381-1390	1		1681-1690	2
	1391-1400	0		1691-1700	1
15th Century	1401-1410	2	18th Century	1701-1710	3
	1411-1420	0		1711-1720	3
	1421-1430	0		1721-1730	2
	1431-1440	0		1731-1740	3
	1441-1450	2		1741-1750	2
	1451-1460	0		1751-1760	1
	1461-1470	1		1761-1770	3
	1471-1480	2		1771-1780	0
	1481-1490	2		1781-1790	1
	1491-1500	3		1791-1800	0
16th Century	1501-1510	2	19th Century	1801-1810	1
	1511-1520	1		1811-1820	3
	1521-1530	3		1821-1830	1
	1531-1540	1		1831-1840	0
	1541-1550	4		1841-1850	2
	1551-1560	6		1851-1860	3
	1561-1570	4		1861-1870	2
	1571-1580	2		1871-1880	6
	1581-1590	2		1881-1890	7
	1591-1600	4		1891-1900	6

From this it is seen that the distribution in time is extremely irregular and no periodicity of any kind can be attributed to it. The general frequency is undoubtedly very high for Kansu, the greatest figure being 7 out 10. We have taken the year as a unit for the sake of convenience, but if the number of actual shocks be considered the frequency is certainly greater, for example, from 1879 to 1893 no less than 30 earthquakes were recorded, averaging thus 2 shocks per yeer.

Next let us consider the distribution from the point of view of space taking the district as our unit by adding new data to the Father Huang's table.

TABLE 5.

District	*No of earthquakes*	*District*	*No of earthquakes*
Kaolan (Lanchow)	13	P'ingliang	8
Titao	14	Chingning	3
Taoho (Hochow)	7	Lungtê	1
Chingytian	3	Kuyüan	6
Hungshui	1	Hsiho	9
Chingch'uan (Chingchow)	2	Lint'an (Taochow)	5
Cêhngywan	22	Minghsien (Minchow)	3
Lingtai	5	Wutu (Chiehchow)	8
Lunghsi (Kungch'ang)	19	Wênhsien	6
Tinghsi (Anting)	2	Ch'ênhsien	6
Huining	3	T'ienshui (Ch'ingchow)	65
Chuanglang	1	Ch'ingan	11
T'ungwei	13	Ch'ingshui	2
Wushan (Ningyüan)	6	Lihsien	9
Fuch'iang	5	Huihsien	2
Changhsien	1	Liangtang	1
Ch'ingyang	7	Hsining	19
Huanhsien	6	Nienpo	1
Hoshui	1	Wuwei (Liangchow)	11
Chênning	1	Yungch'ang	1
Ninghsia	27	Chênfan	1

District	*No of earthquakes*	*District*	*No of earthquakes*
Lingwu (Lingchow)	7	Changyeh (Kanchow)	10
Chungwei	3	Shantan	2
P'inglo	1	Chiuch'üan (Suchow)	4
Chênjung	1		

It is seen that Kaolan (Lanchow), Titao, Chênyüan, Lunghsi (Kungch'ang), T'ungwei, T'ienshui (Ch'ingchow), Ch'ingan, Ninghsia, Hsining, and Wuwei have all a frequency above 10; whilst Taoho (Hochow), P'ingliang, Wushan, Hsiho, Wutu (Chiehchow), Wênhsien, Ch'ênhsien, Lihsien, Ch'ingyang, Huanhsien, Lingwu (Lingchow) and Changyeh have all a frequency above 5. It seems that from the districts of T'ienshui and Ch'ingan to those of Titao and Kaolan (Lanchow) there is a belt of the greatest frequency corresponding to the mountain range of Lungshan. To the south we have the districts of Hsiho, Lihsien, Ch'ênhsien, Wênhsien and Wutu (Chiehchow). To its north are the districts of P'ingliang, Kuyüan, Chênyüan and Ch'ingyang with Ninghsia further north. In the west Hsining, Wuwei and Changyeh (Kansu) form other centres.

INTENSITY.

Montessus de Ballore maintains that the frequency of earthquakes in a given district may be taken to represent its seismicity, because historical records do not as a rule indicate the intensity of an earthquake with sufficient accuracy as to enable us to make scientific comparisons and by adopting the above supposition the problem is considerably simplified. It is however doubtful whether there is any real correspondence between frequency and intensity. That there is a close relation between the two is of course obvious; the question is rather how far they correspond. Another difficulty is that in historical records slight shocks are often omitted, especially in regions of no geographical importance or where destructive earthquakes are too frequent. It seems to me that if we rely entirely on frequency, quite erroneous conclusions may result. Whilst it is difficult to form a reliable judgement of the intensity of earthquakes from the Kansu records, an attempt is here made to differentiate the more obvious facts into different classes.

1. When the record simply mentions that an earthquake occurred in certain place without any further information, it is usually of a kind that was felt by everybody but not sufficiently destructive to cause much damage, consequently its intensity probably corresponds to 4 in the Rossi-Forel scale. Care has to be taken however in the case of important cities and provincial capitals to which more attention is generally paid by the records. This accounts for the usually larger frequency of all the prefectures in comparison with the districts.

2. When it is mentioned that "ground was broken and water poured out", its intensity is usually above 7 in the Rossi-Forel scale. But if only out flowing of water is mentioned without indicating any damage to property or life, the locality may not necessarily be within the epicentral area.

3. Landslide is often mentioned either in connection with earthquakes or by itself. In the former case it indicates of course a fairly high scale of intensity though the earthquake may not necessarily reach the destructive scale. In the latter case of course no conclusion can be drawn.

4. Strange noises sometimes like thunder, or stormy wind, or the fire of a cannon are often mentioned together with an earthquake. In the case of Kansu 37 mentions are made. No doubt omissions must have been fairly frequent as in destructive earthquakes the damage of property and life often overshadows all the other phenomena. It is interesting to notice also that in most cases of the earthquakes where noises are recorded damage to property and life or change in topography is not mentioned

5. The best indication of intensity is of course the destruction it causes. When it is said that city walls, houses, or palaces were destroyed, and men and animal killed in considerable numbers, there can be no doubt that the earthquake was above 9 or 10 in its intensity and that the locality in question must have been within the epicentral area. All these earthquakes can be safely classed as destructive.

In the Kansu records 68 earthquakes agree with the above definition, and it is interesting to consider their distribution both in space and in time apart from the other and less destructive occurrences.

TABLE 6.

Centuries		*No. of years with destructive earthquakes.*
VIII	B. C.	0
VII	,,	0
VI	,,	0
V	,,	0
IV	,,	0
III	,,	0
II	,,	3
I	,,	2
I	A.D.	0
II	,,	4
III	,,	0
IV	,,	1
V	,,	1
VI	,,	3
VII	,,	1
VIII	,,	2
IX		2
X	,,	1
XI	,,	1
XII	,,	2
XIII	,,	1
XIV	,,	3
XV	,,	4
XVI	,,	9
XVII	,,	14
XVIII	,,	5
XIX	,,	9

Compare this with the first table we at once realize that the uneven distribution seen in table 1 had disappeared, and that the great increase after the 16th century must evidently be due to the more complete records of modern times. Take the table as it is the number of destructive earthquakes amounts to three per century, but if only the modern period, say from 14th century onward, is taken, then we have 44 destructive earthquakes in 6 centuries, i. e. 7 per century.

Applying the method used by Tobar and Gauthier in dividing the frequency into three period (sec table 2) we have;–

TABLE 7.

First Period	*Second Period*	*Third Period*
(1-633)	(634–1266)	(1267–1899)
10	9	33

Obviously no definite periodicity can be seen.

Again dividing the time according to the Chinese dynasties:

TABLE 8.

Dynasty	*No. of earthquak years*	*No of destructive earthquake years.*
Chou 1122 B.C.-247 B.C.	876	0
Ts'in 246 B.C.-207 B.C.	40	0
Han 206 B.C.-220 A.D.	426	9
Three Kingdoms 221-264 A.D.	44	0
Tsin 265-419 A.D.	155	2
North and South Dynasties 420-580 A.D.	171	2
Sui 581-617 A.D.	37	2
T'ang 618-906 A.D.	289	4
Five Dynasties 907-959 A.D.	53	0
Northern Sung 960-1126 A.D.	167	4
Southern Sung 1127-1263 A.D.	137	1
Yüan 1264-1367 A.D.	104	2
Ming 1368-1643 A.D.	276	21
Ts'ing 1644-1912 A.D.	269	20

Compare this with table 3 we see clearly that intensity and frequency are by no means the same thing. For example from 265 to 580 A. D. earthquakes were very frequent but very few were destructive whilst in the Han, the T'ang, and the Sung dynasties the number recorded is by no means large yet nearly half of them come under our classification. It is also to be noted that the number of destructive earthquakes in the Ming and the Ts'ing dynasties which consisted of nearly an equal number of years, is practically equal. This tends to prove, in the case of Kansu at least, that the distribution in time of earthquakes is on the whole even and continuous.

The geographical distribution of destructive earthquakes is retabulated in table 9.

TABLE 9.

District	*No of destructive earthquakes.*	*District*	*No of destructive earthquakes.*
Lunghsi (Kungch'ang etc.)	11	Tinhsi (Anting)	1
Wutu (Chiehchow including Wênhsien.)	7	Chungwei	3
Wuwei (Liangchow)	4	Chuanglang	3
Changyeh (Kanchow)	2	Minghsien (Mingchow)	1
Hsining	5	Lint'an (Taochow)	4 (?)
T'ienshui (Ch'ingchow)	8	Shantan	1
Hohsi	2	Chiuch'üan (Suchow)	1
Lingwu (Lingchow)	4	Lungtê	1
Chênyüan	2	Chingning	2
Chênning	1	Ch'unghsin	1
Lingtai	2	Chinyüan	3
Yentzu (Huamatzu)	2	T'ungwei	1
Ninghsia	11	P'inglo	1
Huanhsien	3	Fuch'iang	1
Ch'ingyang	5	Wushan (Ningyüan)	1
P'ingliang	4	Lihsien	1
Chênjung	2	Kaolan (Lanchow)	3
Kuyüan	3	Hsiho	1

Owing to the difference in detail, it is difficult to find out some general rule about distribution. Broadly speaking however, 5 regions may be recognized which at one time or another have formed epicentral areas.

1. The region of Wutu including the districts of Wutu, Wênhsien, Chênhsien etc.

2. The region of Lunghsi, including the districts of T'ienshui, Lint'an and Kaolan etc.

3. The region of Chingyüan, including the districts of P'ingliang, Chênyüan, Kuyüan and Ch'ingyang etc.

4. The region of Ninghsia including the districts of P'inglo, Ninghsia, Lingwu, Yentzu and Chungwei etc.

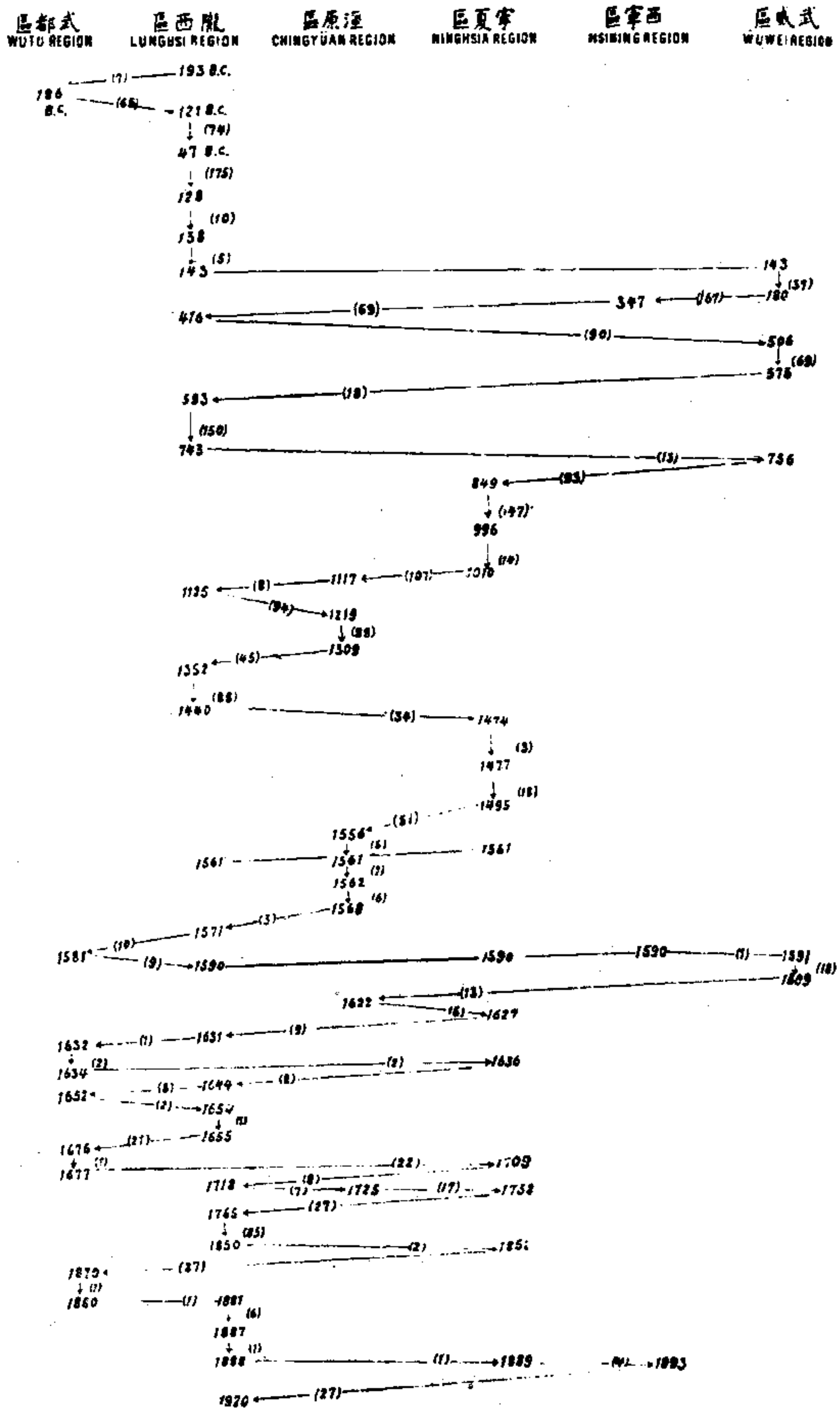
5. The region of Hsining.

6. The region of Wuwei, including the districts of Wuwei, Changyeh and Chiuch'üan.

For the last two regions the records are unfortunately incomplete.

In table 10 an attempt is made to represent in a graphical from the distribution of destructive earthquakes in Kansu both in space and in time. The numbers represent dates and those in brackets indicate the number of years between the successive earthquakes. It seems also that in eastern Kansu there has been a more or less regular migration of epicentral area in a north and south direction. This is more evident after the 17th century since which time the records have become more complete. For example since the great earthquake at Hsiho in 1632 the epicentrum shifted to the north but returned 20 years later to the south and we have the destructive earthquake of Wutu (Chiehchow) in 1656. Since that time the epicentrum migrated to the north again, but 24 years later Wutu was again destructively affected by the earthquake of 1676. The same process of migration seems to have taken place since, and it was only in 1718, 30 years later, that the southern area consisting of T'ienshui, Tungwei etc. was attacked. The next destructive earthquake was in Ninghsia showing the movement northward and, 47 years after, the great earthquake of Fuch'iang took place in 1765. From that

第十表
Table 10


武都區 WUTU REGION
隴西區 LUNGSI REGION
涇原區 CHINGYÜAN REGION
寧夏區 NINGHSIA REGION
西寧區 HSINING REGION
武威區 WUWEI REGION

date to 1854 there seemed to be a period of quiescence lasting for a time longer than usual. Whether this comparative absence of earthquakes was real or due to the incompleteness of the records is difficult to judge. In 1854 however a destructive earthquake broke out in Wushan in the south followed by the one in Chungwei in the north. In 1879 occurred the terrible earthquake of Wutu and Wênhsien the destructiveness of which was said to be desastrous. After this the epicentrum again migrated northward with earthquakes more or less severe occurring in succession in the districts of Hsiho, Lihsien, T'ienshui, Kaolan, Chingyüan and Lingwu. The 1920 earthquake occurred in the southern area and is 32 years after that of T'ienshui in 1888. If we suppose that the migratory movement is a periodic one oscillating from the south to the north and back again the above data seem to indicate that 30 years formed on the average a complete period. It is not maintained of course that the data at hand are sufficiently accurate to establish the theory, but the suggestion that the epicentrum has been migrating is tentatively put forth to explain the curious fact that the earthquakes in Kansu alternatively occur in the northern and the southern areas with apparent regularity.

AFTER-SHOCKS.

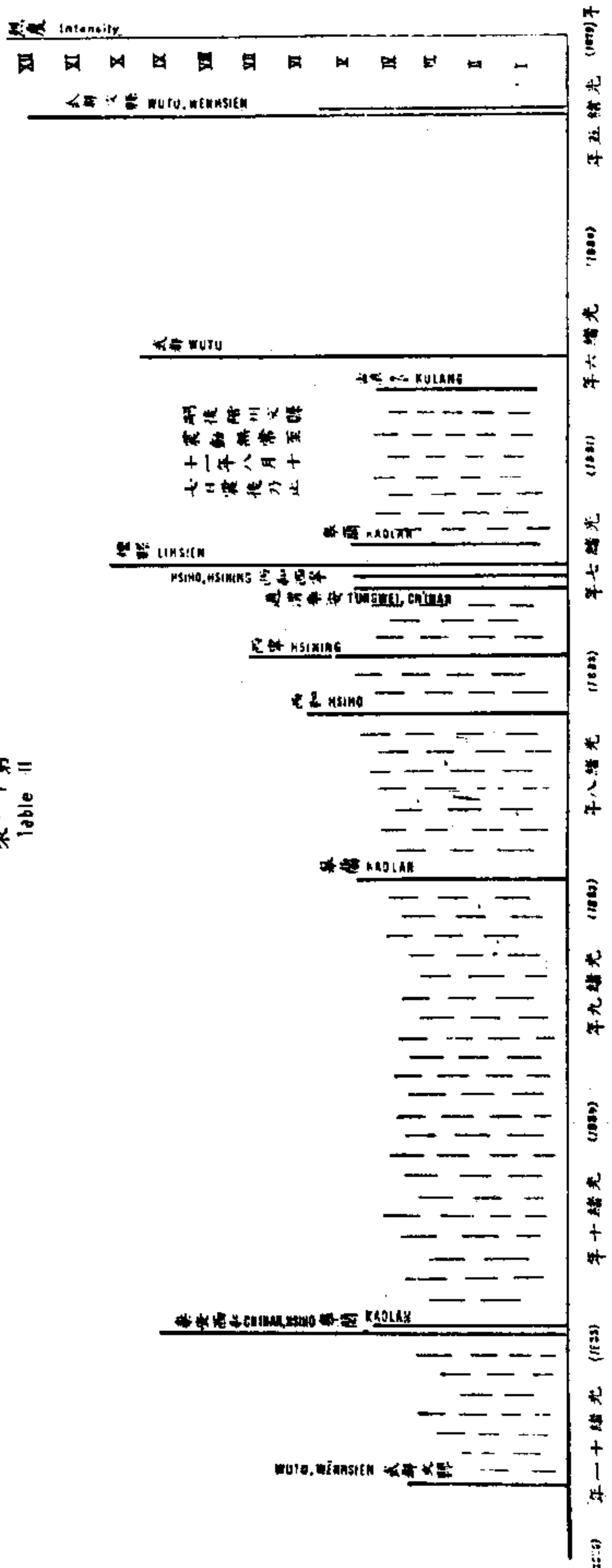
It is well known that after a big destructive earthquake the earth's crust often seems to have lost temporarily its stability, and shocks may be felt more or less continuously for sometime. These after-shocks may be quite serious and do considerable damage to life and property. Consequently the study of its nature is not only of purely scientific interest but may help the inhabitants of the affected area to predict and be prepared for the consequence.

Generally speaking, after-shocks may be divided into two classes. The first class consists of shocks which become weaker and with longer interval each time, just as after the passing of a big wave the water oscillates to and fro until it gradually comes to rest. In the second class the after-shocks may not regularly diminish in intensity nor in frequency; small shocks have hardly died away when greater ones come again and bring further destruction. It seems sometimes that once the earth's crust has lost its equilibrium, one disturbance causes another and these continue with irregular interval and variable intensity until a temporary state of equilibrium is again established. If we want to offer a theoritical explanation of the difference between these two classes of phenomena, it seems that the first kind of earthquake may be brought about by forces which may be considered as independent of the structure of the crust in the epicentral area. The alleged effect of atmospheric pressure, if true, may be one of these forces, but more likely such forces have their origin in the ascension of the liquid magma which may and may not cause volcanic eruption. In the second class the cause of the shocks is probably structural and the forces are identical with those which have caused strain in certain areas. When this strain has passed the critical point, the whole crust suddenly gives away without any need of further forces from without, and once given away, the process of readjustment would continue until it is temporarily complete. Of course there is no clear and sharp line to be drawn between these two classes, as volcanic action or ascension of igneous magma often chooses their point of attack in places of structural weakness, and the actmospheric cause would only be effectre where there is a preëxistent tendancy to movement in the earth structure. Still, in the more typical cases, it is possible to make a practical differentiation without much difficulty.

The earthquakes of Japan and their after-shocks so ably studied by Omori seem to belong to the first class mentioned above. For example, in the earthquakes occurred in the first year of Ansei and that of the 24th year of Meishi, the after-shocks became fewer and less intense as the time went on and their average mode of promulgation may be represented by a hypderbolic curve. The 300 earthquakes occurred in Italy from 1319 to 1920 studied by Cancanni are similar in nature; only 30% of them do not conform to this rule.

Of the earthquakes in Kansu only 30 about which the records are more or less detailed to enable us to make any study. In some cases continuous shocks may be felt in a given area not only for days or months but even for years. For example, in 143 A. D. there were earthquakes for 180 days; in the year 180 more than 80 shocks were felt in Chiuch'üan in about 6 months; in the T'ienshui earthquake in 995, that of Lingwu in 1474, that of Ninghsia in 1495, and that of Lunghsi (Kungch'ang) in 1604 more than 10 shocks were felt in one month. But the longest known earthquakes are those

表十一
Table 11



Intensity
WUTU, WENHSIEN
WUTU
KULANG
KAOLAN
LINSIEN
HSINING
HSINO
KAOLAN
KAOLAN
WUTU, WENHSIEN

of Chiuch'üan and Wutu. The former began in 1609 and continued till 1617, and the latter lasted from 1875 to the autumn of 1881. Another interesting phenomenon is that during the time when after-shocks were still continuing, the epicentrum gradually migrates so that one area comes after another in succession before the earthquake is completely died away in the whole region. The most clear case is that of 1875 which began on the 12th of the 5th moon. The worst area was the districts of Wutu and Wênhsien where more than 10,000 people were killed, and after-shocks continued to be felt until the middle of the next year. In the two years following the districts of Lihsien and Hsiho were successivelly affected. Its mode of promulgation is represented in table 11. Other examples are those of 1561, 1568, 1608, 1623, 1654, 1676, 1709, 1738 and 1765.

The conclusion to be drawn from these admittedly incomplete data seems to be that the earthquakes in Kansu belong to the 2nd class, i. e., their causes are usually internal and tectonic in origin. It is hoped that some of the theories tentatively put forward in this paper may have a chance to be tested more conclusively by the facts to be collected about the recent earthquake the study of which has just been entrusted to the writer by the Chinese Government.

TZU-CHIN-SHAN, AN ALKALI-SYENITE AREA IN WESTERN SHANSI, NORTHERN CHINA. (PRELIMINARY NOTES)

By Erik Norin

I have much pleasure in welcoming this interesting paper by Mr. Norin of the University of Stockholm, Sweden, who came out to China at the invitation of Prof E. T. Nyström of the Shansi University to study the Archaean rocks of that province.

V. K. Ting.

INTRODUCTION.

At 110°51'East and 38°14'North in Westernmost Shansi, 20 kilometres N.N.W. of Lin-Hsien (臨 縣) town, we find a mountain *Tzu-Chin-Shan* (紫金山) or the Purple Gold Mountain. It forms a small isolated mountain group which in numerous peaks rises alone and unexpectedly from the surrounding vast Mesozoic sandstone plateau. Already at a distance of several stages it can be observed and is bound to cause attention. This area is composed of alkali-syenitic rocks, which in the form of a laccolite have been intruded at shallow depth below an old land surface. The laccolite has formed a "reservoir" to a superimposed volcano of which part of the crater pipe and its rocks are still preserved, and in the shape of a neck form the second highest peak of the mountain.

To give an idea of the geological milieu in which these eruptives appear, it should be necessary lightly to touch upon the general geology ot Western Shansi.

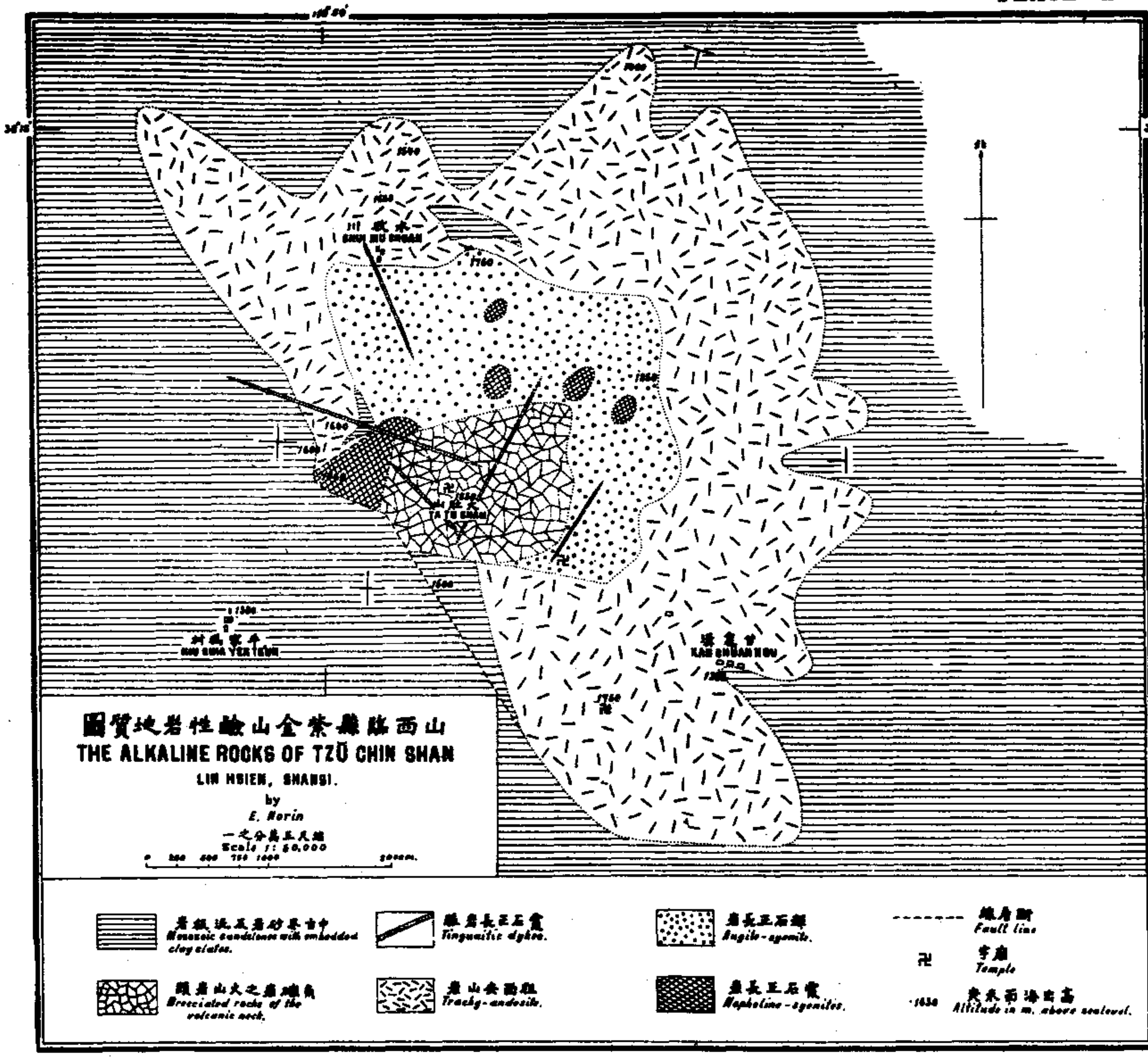
The regions studied by me stretches from Huang-Ho in the west to the Taiyuan basin in the east and is limited in the north and south by the parallels 38°20' and 37°40' respectively. The greatest part of this area forms a plateau land, furroughed by numerous long valleys and deep ravines; the loftiest point of this plateau does not exceed 2200 m. altitude. It is built up by the so-called Shansi-Formation, an extensive series of strata of largely continental sediments which extend over the whole eastern and central China; towards the west they continue in and across Shensi and Kansu. They should be equivalent to the Angara-series, which has such a vast distribution in Central Asia and Siberia.

In western Shansi it is mainly composed of red and greenish grey sandstones and greywackes; more subordinate is clayslate. They are not seldom strongly impregnated with lime. The sedimentation of the series covers a large time-interval; the deeper levels belong probably to Permian or Permo-Carboniferous; the upper may be of Jurassic age. This formation merges downwards, without marked frontier, into a series of interbedded, marine and continental, coal-bearing sediments, which according to Richthofen and Willis belong to the Carboniferous.

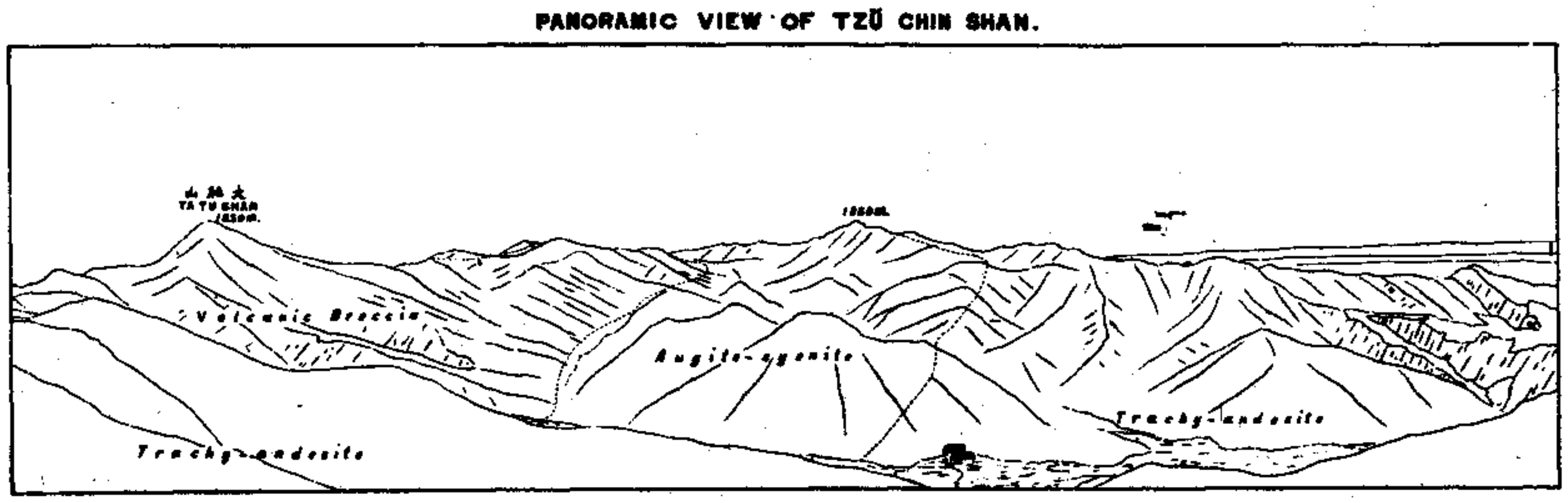
The stratification is generally horizontal; exceptional conditions are found along the marginal zone of a huge Archean horst, which cuts through the plateau; also along faultlines traversing the area in question. The dip of these dislocated strata is usually 10°—20°, sometimes more; the direction of dip is generally outwards from the central zone represented by the above-mentioned horst.

This late Paleozoic and Mesozoic sequence has, in all places where observation has been possible, been found to rest upon slightly undulating Cambro-Ordovician limestone. Below this at several places in Western Shansi we find a very thick series of Algonkian conglomeratic sandstones with embedded brown-red micaceous clay-slates, often strongly dislocated. This last formation is penetrated by diabases, which also, in the shape of beds of amygdaloid rocks, have in one locality been observed to cover the Precambrian land surface. They are covered by and enter into the bottom-conglomerate of the Cambrian quartzite. The above Precambrian formation is younger than the "Wu-T'ai" series of Bailey Willis because it rests upon an "Augen" granite which penetrates the Wu-T'ai schists.

Topographically as well as geologically in sharp contrast to the plateau land the above mentioned horst cuts through the Shansi formation in a direction N.N.E.-S.S.W. in the middle between Huang-Ho and Tai-Yuan-Fu (太原府). Its width, taken between the two largest fault systems, is about 50 km. The horst stretches, albeit with interruptions, from Fen-Chou-Fu (汾州府) in the South to Ning-Wu-Fu (寧武府) in the North, and rises in many high peaks. The highest point within my field of operations is Mo-Erh-Tung (莫兒棟) with an altitude of about 2850 m. above the sea.



PANORAMIC VIEW OF TZŪ CHIN SHAN.



The horst forms a partly afforested, sparsely populated territory, built up by Precambrian quartzites, sandstones, slates, veined gneisses, gneiss-granites and granites and scattered residues of Cambrian sediments, which latter mostly have a very flat northerly dip. The Precambrian rocks have generally a N.N.E. strike; this direction is also followed by the marginal faults of the horst. The vertical amount of displacement along the extension of the horst is not always the same. The greatest throw seems to lie near 37°50' N. where its minimum figure is 1600 m, plus the thickness of the Sinian limestone.

Towards NNE. the horst sinks slowly and continuously and disappears ultimately SE. of the town Lan-Hsien (嵐 縣) below a roof of Cambrian and younger sediments. Further North, in the direction of Ning-Wu-Fu, it reappears above the plateau. In the Western marginal zone between the horst and the Shansi-formation the foundation of the latter has been wrenched upwards and appears now as a mountain ridge of considerable altitude running parallel to the horst. At the eastern marginal zone the Cambro-Ordovican rocks, which here rest immediately on gneiss-granite, have become steeply raised and in many places pressed into isoclinal folds.

Igneous rocks accompany these dislocations only in the Eastern marginal zone of the horst and are here present only at the section where the displacement assumed its largest figure. They occur partly as broad, dyke-like bodies in Cambro-Ordovician limestone, partly as laccolites intruded between the Ordovician limestone and Carboniferous claystones and schists. They are accompanied by tinguaite veins, which shows that at least part of the igneous rocks belong to the alkali-family.

In the field work several circumstances have been encountered which indicate that the formation of this horst has originated through warping of the strip of country between the main faultlines. For example we find that in the sedimentary formations equivalent strata appear at approximately the same absolute altitude at both sides of the horst. Furthermore we may observe at several localities within the horst that the Precambrian land surface slopes slightly towards the north, whereas outside the horst the same surface dips to East or West. Both these facts can be explained by an unequal upheaval of the horst block in comparison to the more stable border-land;

but does not exclude the theory that the horst has been left standing when the border land subsided.

Concerning the time of formation of the horst I cannot at present give exact information. There is much to say for the theory that it has been formed at a relatively late period. The youngest sediments observed within the raised territory are of Cambrian age; the contact between Ordovician and Carboniferous is not developed along the marginal zone of the horst differently to the conditions prevailing within the plateau land; furthermore, when we approach from E. or W. the margin of the horst, we do not find any change in the facies of sedimentation of the Mesozoic series. It has already been pointed out, that the rocks of the Shansi formation on each side of the horst dip away from it, a condition which can be interpreted as "drag" of the adjoining strata, when the middle block was lifted up. Already these facts indicate that the dislocation has taken place in Mesozoic or post-Mesozoic age. Other circumstances point in the same direction.

The igneous rocks which appear in the eastern margin of the Archean region are in such a striking manner connected with the faultlines which limit the horst, that we cannot avoid the theory that their intrusion has taken place in connection with the forming of the horst. Tinguaites, pertaining to this igneous series, occur in the form of intrusive sheets in sediments of early Mesozoic age, which therefore is an approximative lower time limit of these intrusions. Also those alkali-syenitic rocks which westwards, in the middle of the plateau land, build up Tzu-Chin-Shan (see above) are of Mesozoic or post-Mesozoic age. It is possible that both these eruptive areas belong to the same epoch of eruption.

THE ALKALINE ROCKS OF TZU-CHIN-SHAN

The igneous rocks belonging to *Tzu-Chin-Shan* which have been laid bare, occupy a triangular area of approximately 15 sq. km. Its largest dimension in length is nearly 8 km. and arranged NW. to SE. Its highest peak reaches 1850 m. above sea-level (measured with aneroid). The accompanying sketch-map gives an idea of the distribution of rocks and the morphology of the area. (Pl. VIII)

During the field-work I have been induced to consider this igneous body as a laccolitic intrusion in the sediments; this laccolite has become, through denudation, partly uncovered and ressembles now a large lenticular body of igneous rocks resting on a sedimentary base which gently slopes towards SW. An interesting detail is the remnants of a volcanic neck containing lava material. This has evidently been the pipe of a volcano lying on the old land surface. To judge from the vesicular and porous nature of this lava, this land surface cannot have been situated very high above the present one.

The igneous rocks found within Tzu-Chin-Shan have in a preliminary way been divided in the following groups: trachy-andesite, augite-syenite, intermediary nepheline-syenites and nepheline-aegirine-syenite. This order of classification indicates also the sequence of eruption. The oldest of these rocks, viz. the trachy-andesite takes in certain sense a special position in relation to the younger. Through its high tenure of plagioclase it approaches the rocks of the alkali-lime-family, whereas the augite-syenite and the nepheline-syenites are typical alkaline rocks. Nor is the trachy-andesite so intimately associated with the syenites as these are connected with each others. The augite-syenite and the nephelinitic syenites must be considered as representing stages in a continuous process of differentiation, in which the nepheline-aegirine-syenite is the final product.

All the igneous rocks are usually quite fresh; the weathering has seldom penetrated deeply. The trachy-andesite is the only one of the rocks which shows a more far-reaching secondary transformation and this has here, at least partly, been caused by hydro-thermal action. This is indicated by an impregnation of opal which often accompanies the new mineral formations in this rock.

After the solidification the rocks have not been subjected to any considerable pressure. Only in the tinguaitic dykes we find occasionally that large nepheline individuals have disintegrated into a coarse aggregate of fragments; this can very well have been caused through tension within the rock during or shortly after its solidification. However, some of the rocks show distinct traces of having been, during their intrusion and crystallization, subjected to a considerable, one-sided pressure, which has given the rock a protoclastic structure. This is specially marked in the trachy-andesite which sometimes has a thoroughly gneissic appearance, but occurs also in the intermediary nepheline-syenites.

THE TRACHY-ANDESITE

The trachy-andesite is exclusively associated with the peripheric parts of the area; its contact with the sedimentary surroundings is well exposed along the western margin. Along the northern and eastern boundary the sedimentary rocks are visible in several places in the bottom of valleys which have been cut down through the igneous body. In the south the contact has nowhere been found on account of a covering of loess. Everywhere along the eastern and northern margin where the contact has been studied, the trachy-andesite rests on red-brown slate or a slaty series in the sandstone. This basal foundation dips often inwards under a flat angle of dip; but often it appears as if the sediments at the intrusion of magma have been strongly dislocated, broken up into blocks which have been pushed together and now dip in various directions and with different angles. The slates are strongly metamorphosed and impregnated with epidote; the levels rich in lime contain numerous nests of iron ore.

Along the western margin of the area the conditions are different. The trachy-andesite adjoins here with vertical contact the sedimentary formation. The contact is an intrusive one. The sandstone rests horizontally or has a very gentle dip towards E.: it attains here a much greater height than elsewhere along the boundary. In the east the contact plane lies at an altitude of about 1400 m. in the west the sandstone forms, on the contrary, the western slope of the mountain, and attains up to 1600 m.

In the neighbourhood of the eruptive boundary line appear in the sandstone several small dykes of trachy-andesite having a strike parallel to the main contact-line. A vertical dyke, 7 m. wide, running NW. to SE., occurs 2 km. west of the NW. corner of the igneous area. Further south about 2 km. WNW. of the village Niu-Chia-Yen-Tsun outside, Tzu-Chin-Shan, there occurs in the bottom of a valley a large outcrop of trachy-andesite; the rocks of the sedimentary formation are not exposed at this place. Probably this outcrop constitutes part of a large dyke.

The trachy-andesite resembles in hand specimens a grey, medium-grained monzonite with closely distributed white idiomorphous feldspars and small black prisms of bi-silicates. Against the contact of the basal schists and sandstones it becomes more plainly porphyric and fluxion-structured. Protoclastic streaks occur in several places, especially in the eastern and southern parts of the area, where the rock often assumes the appearance of a highly schistose gneiss. The similarity is emphasised by a frequent far-reaching decomposition of the mineral components and new formation of epidote and pyritic minerals. At a microscopic examination we found the following mineral association:

Phenocrysts of andesine, alkali-feldspar, a green hornblende, pyroxene (?), sphene, apatite, and oxygenated ore minerals, in a holocrystalline, fine-grained to compact groundmass of oligoclase, alkali feldspar, opaque ore grains and a little quartz, furthermore secondary mineral products: abundant epidote, chlorite, quartz, opal and pyritic minerals. The phenocrysts dominate distinctly in relation to the groundmass. (Pl. IX fig. 1)

The most important mineral is a *basic andesine* ($Ab_{56}An_{44}$) and this gives also the rock its characteristic appearance in hand specimens. It occurs as clearcut, white, rectangular prisms, like thick plates along (0 1 0) and with the surfaces (0 0 1) and ($\bar{1}$ 0 1) often well developed. They seldom exceed 2 to 3 m/m in length, at a width about half of this. It is twinned according to the Albite and Karlsbad-laws, but also not seldom according to the Pericline law. Primary mineral enclosures are rare. Zonar structure is not marked in the main body, but much developed nearer to the contact.

The alkali feldspar is subordinate. It is largely *a perthitic potassium-sodium-feldspar* in rectangular plates, but also sporadically crystals up to 1 cm. in size of sanidine-like *orthoclase* often with rounded edges and with a refused marginal zone. It carries numerous enclosed crystals of plagioclase and green hornblende.

Hornblende enters rather sparsely in the shape of long, slender, greenish black prisms delimited by the surfaces (110) and (010). They show in the microscope clearcut, transverse sections but often wedge-like longitudinal sections and are always surrounded by a sometimes thin, sometimes wider, opacite-like marginal zone. It is symmetrical hornblende; the elasticity z which lies nearest to the c-axis forms with it the angle $c:z=23°$. The absorption scale is:

x.................wine-yellow
y.................dark green-yellow
z.................leaf-green

therefore $z>y>x$. Probably it belongs to the part of the amphibole group, which is rich in alkali and ferric iron. The hornblende, especially in the contact type, is transformed into an aggregate of chlorite, epidote and a little quartz. Part of these pseudomorphoses have however not the crystallographic contour of hornblende; they originated probably from some pyroxene.

To the phenocrysts we must also count the *sphenes* entering often in microscopic crystals with long rhomboedric section and weak, but plainly observable pleochroism.

Apatite occurs in hexagonal prisms of various sizes.

These phenocryst-like minerals form the main part of the rock and lie, as has been mentioned before, fluidally arranged in a hypidiomorphous, very fine-grained groundmass, composed of an acid plagioclase potassium feldspar and a little quartz, which latter probably is secondary. Coloured, primary bi-silicates are lacking, but rounded grains of some oxygenated metal abound. In the groundmass we find irregular cavities and fissures, filled by secondary, coarse-crystalline epidote, fibrous chlorite, rock-crystal, and in most cases an isotropic mineral, evidently opal. Of secondary nature is probably also the pyrites, with which the rock is impregnated

The microscopic examination has shown that we have here a hypabyssic rock, poor in dark minerals, and characterized by the mineral combination: andesine & alkali feldspar. The existence of potassium-sodium-feldspar and alkali-amphibole indicates that the rock belongs to the alkali family. According to the association of minerals, the rock in a preliminary way may be classified as a trachy-andesite, although this name does not correspond to the geological position of this rock.

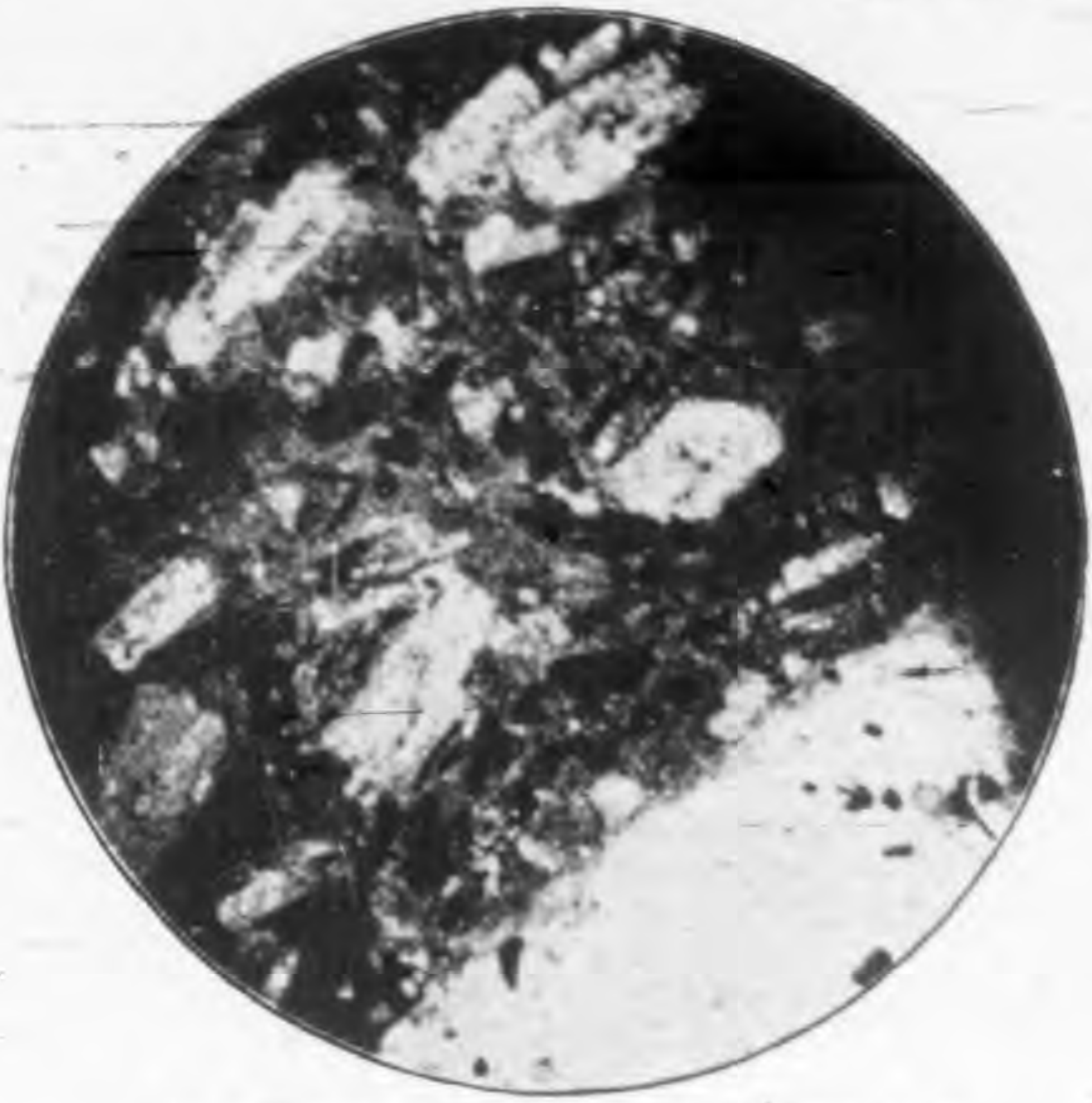


Fig. 1 Trachy-andesite. Parallel Nicols × 9.

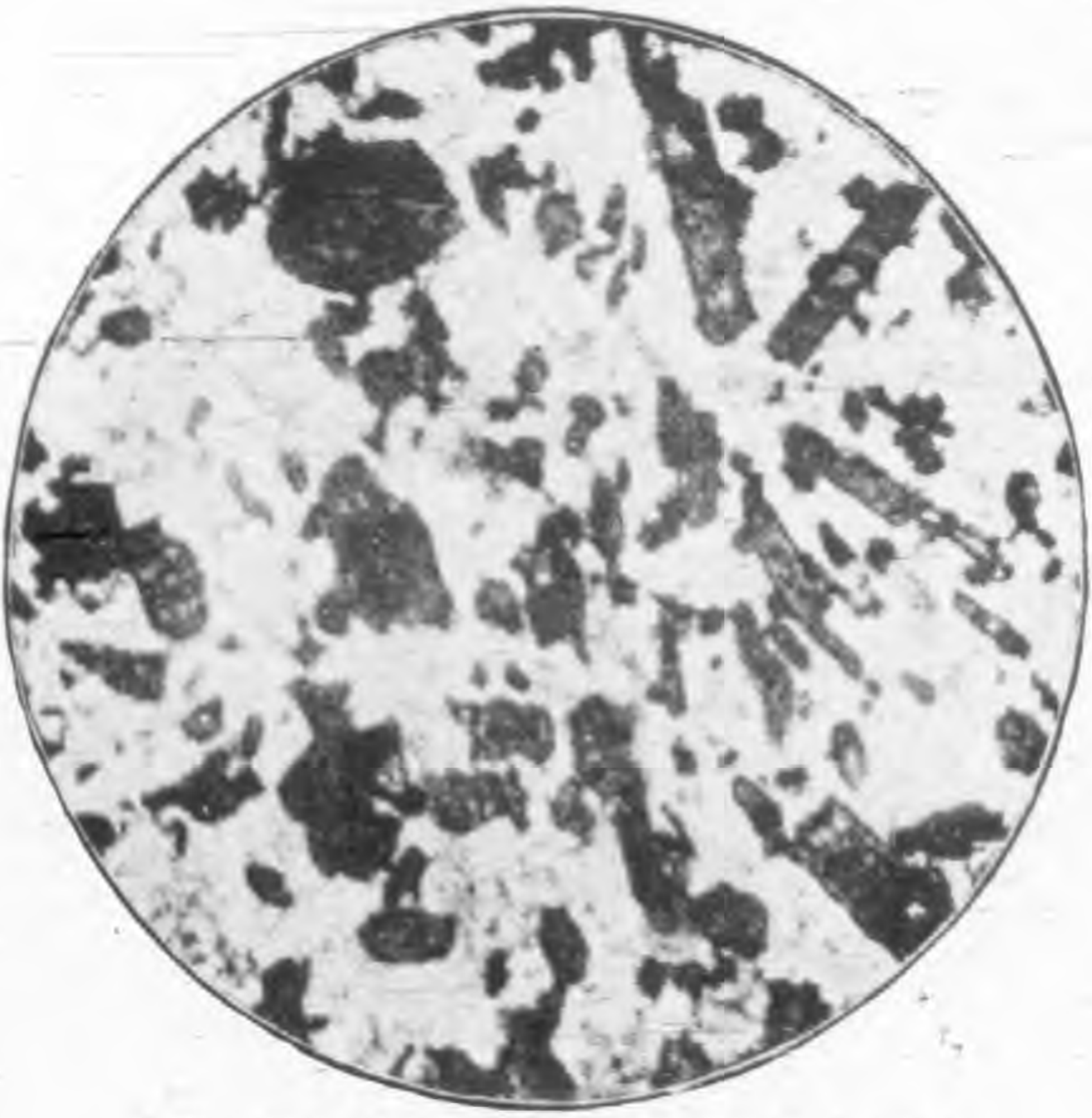


Fig. 2 Augite-syenite. Parallel Nicols × 9.

THE AUGITE SYENITE.

The augite-syenite is the most interesting rock in the massif, because with this is connected a number of types varying from alkali lamprophyre to pure nepheline syenite.

Contrary to the trachy-andesite the augite-syenite is a rock of abyssic character, nepheline-bearing and poor in lime. A glance at the sketch-map shows its distribution. It occupies the central part of the region and is surrounded on all sides by trachy-andesite, except in the S.W. where it borders on the sedimentary rocks. The contact between the augite-syenite and the trachy-andesite is on the whole well exposed. A study of the contact has shown, that any more considerable age-difference between the rocks scarcely exists; at all events the interior of the trachy-andesite had not completely solidified, when the augite-syenite magma was intruded. Along the entire contact line the frontier is more or less indistinct; sometimes the transition is completely gradual.

At the N.W. part of the contact line we notice that the trachy-andesite which is here less porphyric borders on a very fine-grained facies of the augite-syenite. The contact itself is indistinct. If we follow the contact-line eastwards up towards point 1760, we find similar conditions there. The marginal rock is a fluxion-structured, plainly *hybridic* rock. In the southern part of the contact line the conditions are slightly different in the manner that the augite-syenite there, without evident change in structure, merges into inhomogeneous transition-rocks.

There is scarcely any doubt that the augite-syenite magma has been intruded after the trachy-andesite and at a time when the latter had largely solidified. This is indicated already by the occurence of the rock and the fine-grained structure which the augite-syenite at several places assumes towards the contact and is moreover corroborated by the fact that an aplitic facies of the augite-syenite occasionally is seen to penetrate as veins into the trachy-andesite. On the other hand the difference in age cannot be very considerable because along the contact line we often observe fluxion-structure in the adjoining rocks; and this, combined with the noted absence of eruptive breccia and sharp fragments and the scarcity of apophysic veins, elucidates the fact that the solidification of the trachy-andesite was not completed, when the other magma became intruded.

In typical development the augite-syenite is a fine-grained to medium-grained rock, rich in dark minerals; it shows a glossy surface with peculiar bluish lustre. The bi-silicates appear as small bluish black prisms in a white scintillating mass of feldspar. The microscopic examination reveals a rock of hypidiomorphous, grainy structure built up of alkali-feldspar, nepheline, aegirine-augite, alkali-amphibole, titanite, opaque ore-minerals, apatite, and secondary zeolitic products (Pl. IX. fig. 2.)

The feldspar is *anorthoclase* and *albite*, often developed as long uneven prisms without crystallographic contour. Anorthoclase predominates. It is usually strongly turbid. Perthitic structure is rare and even under strong magnification the feldspar is homogeneous. Its nature of being anorthoclase is proved by following characteristics: A refraction slightly lower than the albite, small axial angle and optically negative character. The axial plane is perpendicular to M. Incomplete and cloudy extinction and anomalous refringence colours; in sections perpendicular to the optcially negative, acute bissectrix we obtain against the P-cleavage an angle of extinction of 8° to 10°. In sections nearly parallel with M we get 6° to 8°.

The *albite* is fresh and glass-clear and with even extinction; in composition it varies between albite and oligoclase-albite. Twinning according to the Karlsbad-law is common; polysynthetic twinning, on the contrary, has not been observed.

Nepheline occurs as rounded individuals; often as pocket-like indentations in the felspar, more rarely as plainly idiomorphous crystals. Quantitatively it is subordinate; it is to a large extent transformed to zeolitic products. To these belong possibly an isotropic, glass-like mineral which comparatively frequently occurs as small, irregular, independent grains with very low refraction. It may be analcime or a sodalitic mineral. Absence of plain cleavage does not allow closer determination.

Pyroxene. This is largely idiomorphous in relation to the other minerals; it is developed in broad strongly coloured prisms, in the composition varying between aegirine-augite and aegirine-bearing augite which latter often forms the lighter coloured central zone of zonary-built individuals. In the aegirine augite we have nearest to the c-axis the optical elasticity x, with the angle c: x=40° to 42°. The absorption-colours are x olivegreen; y light olive green; z light greenish yellow with x>y>z.

The other dark bi-silicate is probably a *barkevikitic amphibole* which enters partly grown together with pyroxene; partly in independent strongly corroded individuals. In relation to the pyroxene it is subordinate, but is never missing. It is a symmetical hornblende; the angle of extinction c: z=10°—14°. The absorption order is x honey yellow, y brown yellow (somewhat greenish) and z blue-green, almost opaque. z>y>x. The axial figure and refringence is uncertain, because of the strong self-colour of the mineral. Already through the placing of the axial plane, the angle of extinction and the absorption order, we can put the mineral amongst the barkevititic amphiboles.

Sphene occurs abundantly. It seems that some of the sphene individuals are idiomorphous, though more or less strongly corroded and have crystallized out at a relatively early stage of the consolidation of the rock. Others are allotriomorphous and contain enclosures of pyroxene, apatite and ore-grains. We have also observed cases when from larger, irregular sphene individuals there issue branches wedged in between the feldspars.

Apatite enters sparsely.

The crystallization of the magma has commenced with segregation of apatite and an oxygenated ore mineral; after this has followed amphibole, pyroxene and sphene more or less simultaneously. The amphibole has partly been resorbed, but later again segregated and is sometimes noticed as a marginal zone round the pyroxene.

The crystallization of the sphene covers a large interval which overlaps downwards the beginning of crystallization of feldspar. The nepheline is usually somewhat older than the feldspar.

The augite-yenite sometimes contains fragments of a medium-grained, more femic augite-syenite, probably en earlier consolidated local development of the main type, and which has been again broken up. In the S.E. part of the region at the small temple about 1 km. S.E. of point 1830 we find a very light-coloured, nephelinitic, medium-grained syenite facies. These light and dark types of syenite which, without change in structure, have developed from the main type by elimination or accumulation of the coloured bi-silicates, are to be considered as one of the first stages at the splitting-up of the augite-syenite magma. A further advanced differentiation has resulted in alkali-lamprophyres and light dykerocks with pegmatitic habitus; these can be considered as representing *the "Gang-Gefolge" of augite-syenite.*

Rocks with lamprophyric character occur either as a "paste" in a fissured, partly completely brecciated augite syenite, partly as dykes of varying, mostly inconsiderable thickness within the massif. They have also been observed in the sedimentary rocks outside the W. frontier of the massif. A specimen representative in the matter of occurrence and appearance, has been examined. It is in hand specimen a greyish black, mediumgrained, heavy rock, rich in dark mica. The mineral association is as follows: pyroxene, biotite, an oxygenated ore mineral, a little feldspar as paste and accessorily apatite. The structure is hypidiomorphous grainy with a tendency to parallel arrangement of the elements.

Pyroxene forms the main mass; it is coarsely idiomorphous and developed in short, light olive-green prisms, usually zonary built, with a weakly coloured central zone and a marginal zone richer in aegirine. In the augitic parts we find often agglomerates of crystallographically arranged, hair-like microlites. The angle of extinction is varying depending on the tenure of aegirine. Nearest the c-axis we have most often the elasticity z. In a homogenous individual which seems to represent the type, we obtained c: z=40°. In others it varied between 35° and 47°. The optical axes emerging on (001) and (100) are about equally dispersed. From this can be concluded that the pyroxene is an augite, rich in diopside.

The percentage of aegirine is evidently small. The pleochroism is rather strong with z and y light olive green, x straw-yellow. $z \gtrsim y > x$.

Biotite enters abundantly; it is the component which has crystallized last, and encloses therefor the other minerals or is infiltrated between them. The pleochroism is strong with x golden yellow. y and z deep brown. The axial angle rather near 0°

The feldspar forms like the biotite a "paste" between the pyroxene; part of the feldspar is acid plagioclase, part alkali feldspar; —

Rounded grains of an oxygenated ore mineral enters abundantly enclosed in the other minerals. *Apatite* is relatively scarce. Sphene has not been observed.

The augite syenite is also traversed by dykes of a rock rich in feldspar of pegmatitic appearance. It has not yet been microscopically examined and its mineral composition is therefor not known. It is pure white on the whole, mainly built up of feldspar with scattered, long-prismatic pyroxene. It contains in great quantity large well-developed *crystals of a wax-brown, sphene-like mineral.*

THE INTERMEDIARY NEPHELINE-SYENITES.

The coarse syenites which are rich in nepheline occur in numerous types of which one is a chemically and structurally fully developed nepheline-aegirine syenite; the others are transition-types between this and the medium-grained augite-syenites, and originating through a more or less advanced differentiation of the original magma. For these transitional rocks I have used the term *intermediary nepheline-syenites.* Characteristic for these rocks is their coarse grain, their usually light colour, high tenure of nepheline and their instability. Few of these types occur with any degree what-so-ever of uniformity over large surfaces; and at almost every outcrop we find a rich variety of rocks. This variation is caused not only by an increase or diminishing of the dark minerals, but is also induced by a variation in the structural development of the rock. Thus the grain varies between coarsely medium-grained to large-grained; the sequence of crystallization is not constant in the sense that in certain types, for example the ones rich in pyroxene, the dark minerals have on the whole been segregated earlier, in the felsparic rocks mainly later than the feldspar and nepheline. Between these two latter minerals the order of crystallization is also not constant; in the more basic rocks the nepheline seems as a rule to have crystallized earlier than the feldspar; in the nepheline-aegirine syenites later. Besides, in one of the intermediary types we observe micropegmatitic intergrowth between nepheline and feldspar which must be interpreted in the sense that both minerals have crystallized simultaneously. This inconstancy in the order of crystallization induces in the rock structural changes; thus porphyric types are not uncommon, where sometimes the feldspar appears porphyric and sometimes the pyroxene. Protoclastic structure occurs frequently, usually in the types which are more approaching dykes.

The intermediary syenites occur as mighty nodules or "Schlieren" like formations in the augite-syenite, with which they are either 1) connected by "Schlieren"-contacts or transitions, or 2) adjoin with them through a differently structured marginal zone, which often contains more or less completely resorbed fragments of the sidestone, or are 3) separated by distinct eruptive breccia.

These rocks do not represent independent eruptions but may be considered as differentiation-products from the augite-syenitic magma; they seem often to exist "in situ", sometimes they have intruded from a deeper lying source where reactions of separation have taken place to a large degree. It is remarkable that at the present surface we find nowhere the fully developed nepheline-syenite directly connected with these transition-rocks. Everything indicates that it has been, through dislocations, pressed up from lower levels against the roof of the laccolite. If we therefor consider the intermediary nepheline-syenites as the uttermost branches of a differentiation centre situated in the interior of the laccolite, then this breach in the consanguinity of the rocks may be explained.

Amongst this multitude of rocks I have for closer study chosen one type which through its wider distribution, its preferably dyke-like occurrence and a certain constancy in its macroscopic properties justifies the choosing of this as a representative type of the intermediary nephelinitic syenites.

It is a slightly protoclastic coarse-grained rock with a peculiar, oolitical structure which is caused by the arrangement of the dark minerals around and within the feldspar. By the weathering this rock is disintegrated in a gravel of fragments, the size of peas, which consist of rounded grains of minerals, which cover the hill slopes and through its light colour are sharply distinguished from the surroundings. This type is best studied along the main valley which from the pass W. of point 1850 runs towards N.W. Here we find a whole range of greater or smaller syenite well exposed.

The examined type shows the following mineral association: alkali feldspar, nepheline, aegirine-augite, biotite, magnesia-spinel, sphene, iron ore, pyritic minerals and apatite and the secondary minerals natrolite and analcime.

The feldspar, which is the dominating mineral has usually light blue-gray colour and occurs as isomeric often rounded individuals with overlapping marginal zones. They reach a size of 1 cm. or more; it is mainly *potassium sodium feldspar* developed as anorthoclase and krypto-perthite but not infrequently also pure *potassium feldspar*. Twinning is not observed in the microscopic slides examined. Its crystallization covers a rather wide interval which seems to stretch upwards into and over the pyroxene-period, whereas part of the same feldspar represents the last solidified residue of the magma. Thus the central parts of the feldspar are generally free from enclosed dark minerals which on the other hand, in the shape of connected stripes traverse its peripheric parts. Finally we find abundantly a strange micropegmatitic intergrowth of nepheline in feldspar; certain individuals consist of a compact eutectic mixture of both minerals, in others the structure is more scattered. It is now out of question that we see here a structure which has originated in crystallization of a nepheline-feldspar-flux which has been composed of both these minerals in eutectic proportions and which has itself been produced by resorption of earlier segregated nepheline and feldspar. This is all the more probable as reactions of resorption-as we shall find below-have to a large extent taken place during the solidification of the rock.

Nepheline enters largely but subordinate to the feldspar. Its main mass occurs as large crystals scattered within the feldspar and often showing sharp crystallographic definition. Elsewhere it occurs together with the dark minerals as rounded grains. A not inconsiderable quantity enters in the above-mentioned crystallographically arranged intergrowth with feldspar. This latter nepheline fraction is in colour light jade-green or colourless; sometimes reddish brown; the larger free nepheline crystals are colourless or brick-red. Usually the nepheline is fresh and glass-clear. However there occur individuals which have been thoroughly transformed into parallel-fibrous aggregates of *natrolite* in which the crystallographic contour and the cleavage along (0001) of the nepheline are plainly visible. The nepheline which is grown together with the feldspar seems to be especially subjected to easy decomposition. In this case also the feldspar seems to have given material to the secondary mineral formations in which besides natrolite also younger *analcime* forms a main constituent.

The characteristic dark bi-silicate is an *aegirine-augite* developed in broad prisms or individuals without crystallographic contour, with luscious green colour in through light. Pleochroism is strong with

x..................bright leaf-green
y........... ......yellowish green
z..................greenish yellow

therefor $x>y>z$

Nearest the longitudinal axis we have the largest elasticity x with the angle $c:x=30°-36°$. The tenure of aegirine is therefor not very high. Zonar structure exists.

The pyroxene is universally strongly corroded, the resorbed material has in many cases re-crystallized in situ, forming an aggregate of biotite, spinel and an oxydic mineral, probably magnetite, and often enclosing small residues of aegirine-augite. Thus we find strongly corroded slender pyroxene prisms of which one half consists of aegirine augite, the other of the above mentioned mineral associations; other individuals are completely transformed and consist occasionally of one complete biotite individual on which the spinel and ore grains seem to have grown. This reaction is remarkable in the sense that the forming of spinel is theoretically improbable if one only considers the relation base: sesqui-oxide in the pyroxene; furthermore, at the forming of biotite, an excess of silica ought to be obtained. The procedure can scarcely be explained otherwise than by the nepheline of the magma having also participated in the reaction.

The contents of *biotite* is unevenly distributed and seems to depend on the quantity of pyroxene; where the latter is abundant the biotite is subordinate; when it is scarce the biotite predimonates. It is almost universally accompanied by spinel and magnetite grains. Probably the biotite has to greater part originated from a new formation at the resorption of pyroxene. The biotite appears as allotriomorphous grains or surrounds not seldom the pyroxene as an irregular marginal zone. The axial angle is small (about 15°) its optical character is negative; pleochroism strong:

x..................light smoke-grey to greyish green
y..................bright brown-red
z..................opaque or deep greyish green.

$$z>y>x$$

Spinel occurs in rounded isotropic grains, seldom with plain crystallographic contour. The refraction is very high. It is violet in colour, often zonary built with an outer grey-green marginal zone. Optically it coincides most nearly with *magnesia-spinel* (pleonast).

Sphene enters abundantly; it is usually idiomorphous and then often in macroscopic, wax-yellow crystals with long-rhomboëdric setion and belongs then to the earliest segregated minerals. Not infrequently it is allotriomorphous and includes then pyroxene and ore grains.

Apatite enters sparsely and is developed in hexagonal prisms.

One of the most interesting features of this rock type is evidently its unusual structural development. Of this we may gain an impression by the microphotograph, Plate X. fig. 1. Macroscopically the structure is specially striking in the light-coloured types, which appear as if they were built up by close-lying, rounded or oval feldspar individuals of pea-size pasted together by dark minerals. Sometimes they show a rounded rhomboëdric, longitudinal section and the rock becomes then not unlike a nepheline rhomb-porphyry.

The structure is caused by the fact that the dark minerals are arranged in continuous, fluidal, often straight streaks which proceed to a certain extent independently of the contour lines of the feldspar individuals; they often follow the frontier between two feldspars but as often as not they penetrate the marginal parts of the feldspars. These streaks of dark minerals meet not infrequently with sharp angles and form often, but not always, closed compartments within which the dark minerals are missing or occur only sporadically. The compartments show often a tendency to assume rhombic shape (see Plate). Though the feldspar under the microscope appears thoroughly continuous from the centre to the margin, without any unconformity which could be interpreted as "Anwachszone", yet its occurrence and the distribution of the enclosures indicate that a difference of age exists between centre and marginal zone.

I have tried to interprete the phenomenon in the sense that in the magma at an early period have been segregated nepheline, pyroxene and numerous porphyric crystals of feldspar, which all of them at a later stage under different conditions have been unstable and thereby partly been resorbed. These resorption-phenomenons are specially marked with the pyroxene. Afterwards feldspar has again separated out and formed an optically uniformly arranged "Anwachszone" round the older feldspar phenocrysts, thereby enclosing the older dark minerals which have accumulated round these phenocrysts, and filling up the interstices. The not infrequent micropegmatitic intergrowth between nepheline and feldspar is interesting; through its nature as eutecticum this combination ought to represent the last residue of the magma. It should then be expected that it would occur as an infiltration between the other minerals. This is-as has been pointed out in the description of minerals-not the case. Probably we have here a case of resorption and re-crystallization of nepheline feldspar material.

This micropegmatitic structure occurs however sometimes also in the often narrow nephelinitic pegmatitic veins which intersect this rock. The eutectic structure can there be noticed even with the naked eye. These veins are genetically connected with the syenite and are probably to be interpreted as contraction fissures in the solidifying rock, which have been filled up with the residual liquid.

THE NEPHELINE-AEGIRINE-SYENITE

Typically and fully developed *nepheline-aegirine-syenite* occurs within a small area in a valley immediately west of Point 1830 Ta-Tu-Shan (大肚山). Its geological occurrence indicates that it is only a small outcrop of a larger mass existing at greater depths. On the surface it forms a small ridge which in a W. and N.W. direction is separated from the sedimentary area by eruptive breccias. In the East it adjoins the rock, to which it has also delivered material; its southern frontier is hidden by a covering of earth, but I have the impression that also here a brecciated zone exists. The roof, now removed by erosion, was sandstone. This type has probably originated by differentiation at a deeper level within the laccolitic body, and afterwards by tectonic movements forced upwards and solidified in contact with the sedimentary roof.

Against the roof which now has been eroded away, the syenite shows a typical cooling contact with gradually diminishing grain. The typical coarse nepheline-syenite which is found in the bottom of the valley, is imperceptibly transformed to medium-grained nepheline syenite porphyry with large rounded phenocrysts of nepheline and thin plates of potassium feldspar; at higher levels the phenocrysts mostly disappear except a few sporadic specimens; the darker minerals become more frequent and we find a small-grained nephelinitic rock of aplitic appearance. Uppermost probably just below the now removed covering of sediments is found a sugar-grained, dark grey-green, tinguaitic rock with solitary phenocrysts of potassium feldspar and red-brown nepheline.

The main coarse type of nepheline aegirine syenite is an often miarolitic rock with large reflecting prisms of pearl-grey feldspar, rounded crystals of greasy-looking redbrown nepheline which gives the rock a strange spotted appearance. Dark bi-silicates occur sparsely and are frequently accumulated to larger pitch-dark crystal aggregates of high lustre.

The weathering surface has the appearance so characteristic for nepheline rocks of having the nepheline crystals corroded largely away and leaving round cavities large as hazel nuts.

Apart from marginal facies the grain differs in size even within the main type inside certain limits. The thus-formed medium-grained varieties are in all other respects quite similar to the main type, into which they gradually merge.

The coarse type shows the following mineral association: alkali feldspar, nepheline, aegirine, biotite and apatite and small quantities of secondary minerals, mainly natrolite. sphene has not been observed. Undoubtedly this list will be enlarged when a larger number of slides from different parts of the massif will be examined. At all events the minerals above enumerated are the characteristic ones for the rock in question.

The feldspar is *orthoclase* with sanidine character and *potassium-sodium-feldspar* developed either as anorthoclase or krypto-perthite. Of these the potassium-feldspar occurs partly porphyric in large idiomorphous plates elongated along the clino-diagonal, partly allotriomorphous. Anorthoclase is abundant and shows generally a tendency to idiomorphous development. It is often twinned according to the Karlsbad-law sometimes according to the Bavenoe rule. It is mostly optically homogenous; but sometimes a partial separation has taken place and resulted in the feldspar assuming crypto-perthitic structure. The optical characteristics are as follows:

The axial angle is small; it is optically negative; the axial plane perpendicular to (0 1 0). In sections nearly parallel to (0 1 0) it shows a positive obtuse bissectrix. The angle of extinction was 6°—8°. A section along P shows the same angle to be 0°—2°, and perpendicular to the acute negative bissectrix 4°—5°, which observations indicate that an orthoclase rich in sodium is the feldspar present.

Nepheline is abundantly present in rounded individuals which not infrequently reach the size of 1 cm., coloured mostly brown-red, sometimes colourless. This is the constituent of the rock which was the last to crystallize and is therefor allotriomorphous and has sometimes the appearance of a connected mesostasis (paste) which fills the interstices between the other minerals. However, it may be possible that nepheline has segregated even at an earlier stage. In the feldspar occur scattered small fragments of a mineral which has been completely changed to natrolite from a substance which possibly has been nepheline.

The nepheline is on the whole thoroughly fresh and glasslike. Transformation into natrolite is seldom seen.

The pyroxene, judging from the optical properties, seems to be a tolerably pure aegirine (c: x=0°—8°). Generally it occurs in ragged and patched individuals without crystal-contour, enclosing or adjoining single

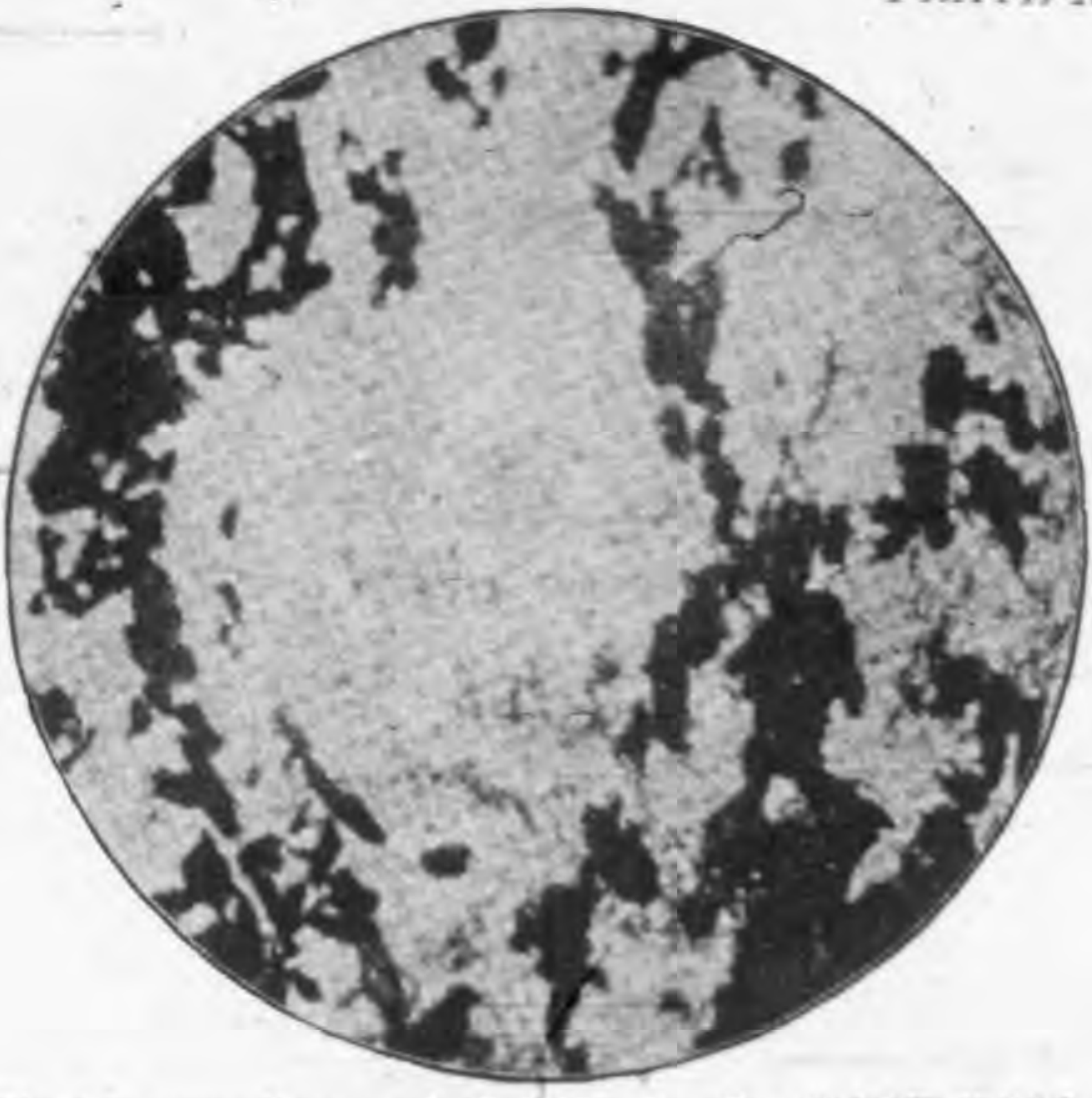


Fig. 1 Intermediary nepheline-Syenite Parallel Nicols × 9.

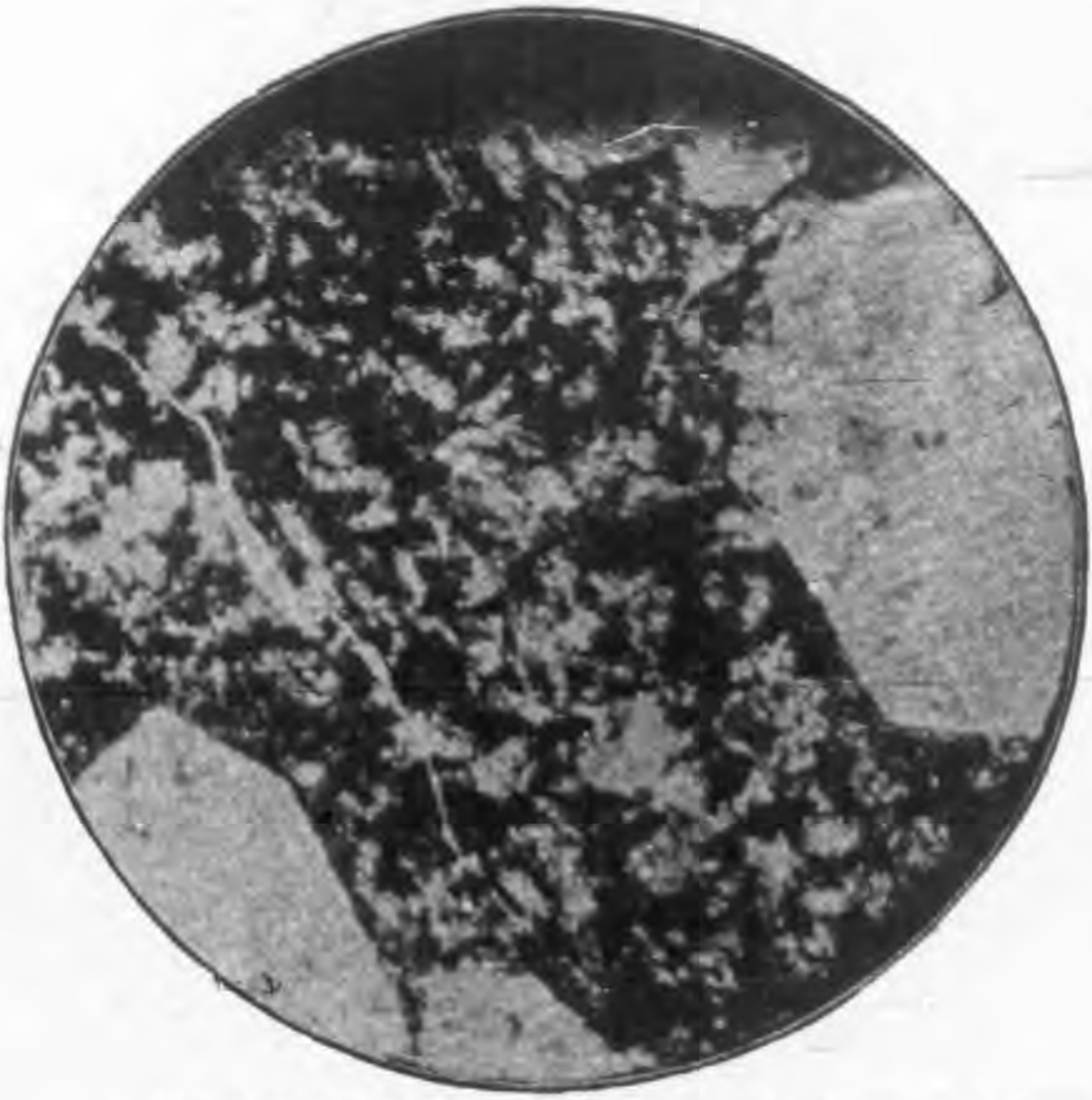


Fig. 2 Leucite-Tinguaite. Parallel Nicols × 9.

feldspar individuals. Sometimes however it is developed as larger, often strongly corroded prisms, which idiomorphously adjoin the feldspars.

Partly grown together with aegirine, partly in independent allotriomorphous individuals, a *dark mica* is found, sparsely but constantly, with strong pleochroism (Y brown red, Z black-brown). The dark aggregates of bi-silicates contain often a mica of another kind. It is a mica of the second order with small axial angle (2e estimated to about 15°) The foils of cleavage show slight or non-existent pleochroism. The colour smoky grey to light grey green; it has often zonar structure with light brown layers.

Apatite enters only sparsely as small prisms.

The above mentioned minerals have through the process of crystallization given the rock a hypidiomorphous, porphyric structure. Regarding the succession, we see here as in most other nepheline syenites, an overlapping of the different mineral fractions over each other. Apart from the apatite which was segregated at an early stage, the crystallization has begun with segregation of orthoclase, which is largely porphyric and idiomorphous. The nepheline has crystallized at a relatively late stage and is allotriomorphous in relation to the feldspar. It is already pointed out that part of the aegirine occurs in large prismatic individuals which, while maintaining the crystallographic contour, adjoin and penetrate into the feldspar. The aegirines however lack as a rule the crystallographic contour and are squeezed in between the feldspars.

Part of the above-mentioned dark aggregates formed of aegirine and mica may be interpreted as miarolitic cavities which during the pneumatolytic stage of the solidification have been filled. This applies specially to the aggregates in which the aegirine is accompanied by above mentioned light mica, which has not been observed elsewhere.

The association of the dyke-rocks of the nepheline syenites is exceedingly rich both as regards types and dyke-bodies. Melanocratic varieties belonging to these have not been ascertained with any degree of certainty. The leucocratic types are all the more frequent, even as rocks with pegmatitic characteristics. The connection between these dyke-rocks and the youngest eruptives of the laccolite is clearly revealed by their geological occurence. As can be seen by the sketch map, where only a few of the larger dykes are shown out of the innumerable present, they radiate from the central region of the massif, represented by the neck. This arrangement is striking and can be plainly observed from the top of Ta-Tu-Shan, from where the dykes in the neighbouring hills appear as prominent walls or are marked in contrast to the side rock through different colour. They also penetrate the sedimentary formations where they occur either as vertical veins or intrusive sheets. They are younger than the crater breccia. Their way of-radiating from a common centre would indicate that they have issued from a fixed point situated at inconsiderable depth.

Petrographically we may distinguish amongst the dyke rocks several types of which the most important are:

1) Fine grained to dense light-coloured tinguaites, free of phenocrysts.
2) Ditto with phenocrysts of sanidine.
3) Ditto with phenocrysts of nepheline and sanidine.
4) Ditto with phenocrysts of leucite.
5) Leucite syenite porphyry.
6) Finegrained dark dyke rocks of tinguaitic character.
7) Syenite pegmatites of several different types.

Of these we have only examined closely two petrographically important types, viz. Nepheline bearing tinguaite and leucite bearing tinguaite, representing the differentiation of the nepheline syenite into dyke rocks rich in sodium and such rich in potassium.

The *nepheline-bearing tinguaite* is a green to greyish green tinguaite with abundant phenocrysts of glass-clear sanidine and dark greasy-looking nepheline, in a small-grained holo-crystalline groundmass composed of alkali feldspar, nepheline and aegirine. Leucite is not present. The *nepheline* phenocrysts have through tension within the rock, probably at its consolidation, usually disintegrated in a coarse crystal aggregate. Sometimes they are largely changed to a bright yellow *cancrinite*. The *pyroxene* is a fairly pure aegirine. It occurs partly as large prismatic individuals without crystallographic contour partly as thin prisms, more seldom as slender needles. These surround in a fluidal manner to phenocrysts, but apart from this they are also distributed throughout the groundmass without visible order.

Leucite-tinguaite-porphyry occurs in two different types, the one carrying, in a blue green to grey-green, fine-grained groundmass, up to 3 cm. large, often bright red phenocrysts of rounded or plainly octagonal section. The other carries, in a leaden grey groundmass of smallish grain, large grey smoothfaced icositetrahedrons of pseudo-leucite, which can be easily removed from the groundmass. This latter type ought perhaps rather to be called *leucite-syenite-porphyry*.

The first-named typical *leucite-tinguaite-porphyry* is in hand specimens strikingly similar to a coarse-porpbyric eudialyte-bearing tinguaite. It is however possible to observe even with a magnifying glass that the phenocrysts are not homogeneous, but consist of two components, one coloured and one non-coloured. They are sharply defined against the groundmass and perfectly free of enclosed minerals of the groundmass. Their nature of being pseudomorphoses of leucite is evident because they consist of a mosaci of glassclear nepheline and orthoclase. Apart from these we find in most cases a large quantity of an isotropic mineral of very low refraction. A distinct system of cleavage is not developed. It has a tendency to occur in the central parts of the pseudomorphoses and form there often a large connected mass which penetrates as a wedge between the orthoclase-nepheline mosaic components. Without chemical examination it is clearly impossible to indicate the chemical nature of this mineral. Leucite pseudomorphoses from other localities have many times been found to contain considerable quantities of analcime. As an analogy we may be justified to presume that the observed mineral is analcime.

Pseudo-leucite is the only mineral which occurs as phenocrysts. The ordinary phenocrysts of tinguaite, potassium feldspar and nepheline are missing.

The groundmass is holo-crystalline, and consists of a panidiomorphous aggregate of clear alkali feldspar and nepheline, traversed by a network of fine aegirine needles, which have a tendency to accumulate to large felt-like masses.

Pegmatites belonging to the nepheline syenite occur abundantly. Also these can be classified in two groups, acid and basic. The former are pure white, cutting through the nepheline syenite in dykes up to one metre wide, and are often strongly weathered. A typical development is the following: the main mass is built up of white, glass-clear feldspar crystallized in thin idiomorphous plates. The sharply defined interstices between these are filled by blue-violet fluorspar and oxygenated iron-ore. In other types we have additionally pyroxene or amphibole and these form a transition to certain facies of the coarse nepheline syenite. The basic pegmatite veins are generally narrower; they are built up of long slender prisms of pyroxene which, as a dense crystal zone, grow out from the sides of the veins to their centre. These central parts are filled by younger feldspar.

THE VOLCANIC NECK.

In the panorama on Plate VIII we see on the left-hand side Ta-Tu-Shan, point 1830 on the map. Developed in steep rocks with numerous caves it rises above the low mountain slope towards the west. Ta-Tu-Shan represents the central part of the neck. On a wide circumference the surrounding syenite rocks are strongly brecciated, and intruding gases and solutions have caused an often far-reaching decomposition of the fragmental rocks and filled the crevices with newly formed minerals: Fluorspar, calcite and iron ore. A decided boundary between the real volcanic neck and the brecciated side-stone can not be traced; the limit depicted on the sketch-map includes also this brecciated and propylitized marginal zone within the region of the neck. This border zone has been marked by special easy erosion. Thus the eastern limit of the crater-breccia is marked by a deep valley coming from the north. In the same manner we find that the northern and southern breccia zones are eroded to valleys.

When we approach the neck from the outside, we first of all encounter a zone sometimes narrower, sometimes wider, within which the rocks as mentioned are strongly brecciated without the lava material having entered into them. Towards the more central part of the neck eruptive material begins to enter the breccia, filling up the fissures and cementing the fragments to a very solid and tough rock. The fragments are here in a better state of preservation.

The central part of the neck consists also of eruptive breccia, in which here and there the lava material predominates. The cementing matrix is rather differently developed in different locations. Usually it has the character of a hyp-abyssic, light-coloured, feldsparic rock. But on the northern and eastern slopes of Ta-Tu-Shan it has often the appearance of a very porous vesicular, sanidine-porphyric trachyte.

The neck and its brecciated neighbourhood is penetrated by swarms of tinguaitic dykes which run through the area in question in all directions. Many of these continue also outside the breccia into the syenites, but mostly they are bound to the neck.

The study of the petrography of this syenite body has led to results which may be summarized as follows:

All the rocks belong to the alkali-family. The earliest intrusion which appears as a trachy-andesite is, compared with the younger eruptives, remarkable through its high contents of lime, which has led to abundant forming of plagioclase. Its low tenure of coloured bi-silicates indicate that it is poor in magnesia and iron. A chemical analysis will probably characterize it as a rock of monzonitic composition. Possibly this rock is a hyp-abyssic facies of the deep-seated primary rock of which the augite syenite has been formed through differentiation.

Contrary to the treahy-andesite the succeeding augite-syenitic magma was poorer in silica and richer in alkalis and magnesia, which latter component together with almost all the lime, sesqui-oxides and a little alkali was mainly instrumental in forming pyroxene. Lime-sodium-feldspar is missing. Both rocks however are rich in sphene.

The petrological connection between these types will probably be elucidated by a study of the igneous rocks rich in alkali which occur in the Eastern marginal zone of the Mo-Erh-Tung horst. Amongst these we find abyssic eruptives probably of monzonitic composition accompanied amongst others by a hypabyssic rock, which in hand specimens strikingly reminds us of the above-mentioned rock which was called trachy-andesite. Nepheline syenites are not observed here, but all the same we find here dykes of tinguaite, indicating that also in this igneoues body alkali rocks are present.

The process of differentiation within the augite syenite magma is easier to follow. Towards the basic pole the differentiation has resulted in lamprophyric rocks rich in magnesia and lime poor in alkalis and free of sphene.

The intermediary nepheline syenite, which has possibly segregated from the augite syenite, is poorer in silica and dark bi-silicates than the mother rock. The tenure of alkali is relatively larger, which has found expression partly in more abundant production of nepheline, partly it has augmented the aegirine molecules of the pyroxene. The tenure of sphene is about unchanged. This rock is no constant type, but probably a stage fixed through intervening solidification.

A differentiation which has been carried still farther has led to a stage in which the relation of RO to R_2O has reached a minimum, whereas the relation R_2O to $Si\ O_2$ approaches its maximum if we assume the auigte syenite to be the mother rock. The differentiation has resulted in a nepheline syenite entirely built up by minerals rich in alkali.

Also within the nepheline syenite magma processes of differentiation have been active which have led to a partial separation of the alkali metals. This parting reveals itself in a development of sodium-predominant and potassium-predominant rocks represented by nepheline-bearing and leucite-bearing tinguaites.

In the petrographic series which is formed by alkali lamprophyre, augite syenite, intermediary nepheline syenite and nepheline aegirine syenite the pyroxene suffers a regular change consisting of an increase of the tenure of aegirine. This gains an expression in a change of angle of extinction and pleochroism. The following summary elucidates this:

	c:x	Pleochroism	
Alkali lamprophyre	50°	in light olive green colours	$z \geqq y > x$
Angite syenite	40°	in olive green colour	$x > y > z$
Interm. neph. syenite	35°	in luscious green	$x > y > z$
Neph. aeg. syenite	4°	in dark green colour	$x > y > z$

THE COAL FIELD OF TATUNG, SHANSI.

(Summary)

BY C. C. WANG

EXTENSION OF THE FIELD

The coal field extends from west of Ta-Tung (大 同) city south-west ward along a distance of more than 200 li (120 km.) as far as surveyed; it is known however that coal formation still occurs 100 li further south west till So-Hsien. The width of the field is about 100 li.

STRATIGRAPHY

The stratigraphic sequence represented in this field is as follows:

1. *Archaean gneiss:* South of Chi-Feng-Chan and north of Ching-Tzu-Yao the archaean gneiss forms barrier hills between the coal field and the alluvial plains. This barrier of gneiss is only interrupted near O-Mao-Kuo and Kou-Chüan.

2. *Cambrian red shale:* Man-T'o shale lies directly upon the gneiss. The shale is interbedded with thin limestone. The total thickness is about 100 m. (see fig 1 chinese text)

3. *Cambrian limestone:* Conglomeratic limestone is interbedded with oolitic limestone. The total thickness is about 260 m. (fig 1)

4. *Permo-Carboniferous coal series:* This series about 200 m. thick lies directly on the Cambrian formation. The Ordovician limestone so well developed in other parts of the Northern China is here totally absent. The lower part of the coal series contains limestone beds with fossil fusulina and corals. Coal seams occur in the upper part of the series (fig 1,2,3,); plant fossil as Pecopteris, Annularia, Sphenophyllum have been found. North of the village T'o-Ping, this series is rapidly thinning out north-west-ward; near Ching-Tzu-Yao, the Jurassic formation comes in direct contact with the Cambrian limestone and still further with the gneiss. This is explained by a pre-Jurassic unconformity.

The existence of this Paleozoic coal series was ignored by Von Richthofen; it was first discovered by the author in 1917.

5. *Triassic shale and sandstone:* The shale is usually red, the color of sandstone varies from red to green, gray or white. For the whole formation the red color is predominant (fig 2,4). The total thickness varies from less than 100 m. south west of Kou-Chüan to more than 350 m. in the region of Yao-Tzû-Tou and Chang-Chia-Pu

6. *Lower Jurassic coal series:* This series consists mostly of gray or white sandstone and blue or green and black shales (fig 2,5,6,7,8,). The sandy shale near the coal seams contains Baiera, Podozamites, Asplenium, Dichsonia, Pterophyllum (?) all well known Jurassic plant fossils. From Mei-Yü-Kou to Ya-Yai the total thickness increases from 260 to 480 m.; but from Tou-Yao-Kou north-ward it decreases until near Lü-Chüan where the whole series is only represented by thin sandstone and shale.

7. *Upper Jurassic red sandstone:* The lower Jurassic coal series is covered by a formation of red or green sandstone and shale. No fossil has been found. It is identified as upper jurassic by comparison with the Chiu-Lung-Shan series (ie. the violet and green series) in the Western Hills of Peking studied by L. F. Yih§. Hills of this formation has generally a rounded form.

8. *Basalt:* Outcrops north of To-Tzu-Yao and Kou-Chia-P'o. In a section visible at Hou-Yao-Tzu, the basalt is in contact will a limestone (fig 9). This limestone probably belongs to Cambrian. The contact is believed to be an igneous one.

9. *Conglomerate:* The largest occurrence is to be seen north of Kou-Chia-P'o and Hsin-Tsun. This conglomerate lies unformably above all the older formations (fig 10,11); pebbles of basalt are numerous.

STRUCTURAL GEOLOGY.

The Cambrian formation dips rather steeply toward north west. The dip angle gradually decreases from the older to the younger formations i. e. from the border to the center of the coal basin; the Triassic sandstone and

§ L. F. Yih Geology of Hsi-Shan or the Western Hills of Peking Mem. Geol-Surv. Series A No. 1.

the Jurassic coal series have generally a north west dip of 10-30°. In Wan-Chia-Tsui region, the strata are almost horizontal. At Tuan-Chia-Kou, Tu-Chia-Kou, Tiao-Lo-Siu, Kuo-Chia-Pu etc. the Jurassic coal series and the red sandstone dip gently toward the loess region south east of Tso-Yün-district. North west of Tso-Yün extends a gneiss range which must be separated from the coal field by a great fault line. The south east border seems also to be limited by fault. South east of Pai-T'o-Tsun there are two faults: one running from north to south with a horizontal displacemend of about 1,500 m., the other running in a NE-SW direction (fig 9). Between these faults the strata are strongly disturbed. Disturbance is also observed between Mei-Yü-Kou and T'o-Ping where the dip angle is steeper than usual and sometimes turned towards south east.

COAL RESOURCES.

As stated above, there are two coal series. The lower series, Permo-Carboniferous in age, has only one coal seam between Kou-Chuan and O-Mao-Kou with a thickness of 5-8 feet. But near T'o-Ping it is reduced to almost nothing but some black shale. South-west-ward from O-Mao-Kou two other seams may be worked below the one above referred to. Conditions of occurrence of these three seams may be summarized as follows:

Local name	Thickness of coal only	Thickness of coal together with interbedded rocks.	Thickness of rock separating the seam from the upper one.
Ts'ang-tan	3–4 feet	6–8 feet	
Hoang-ho	2 feet	4–5 feet	60 feet
Ssü-ssü	5 feet	8–10 feet	40 feet

The upper coal series, lower Jurassic in age, contains at Tou-Yao-Kou, Ta-Kou, Tien-Shang etc. three coal seams:

Local name	Thickness of coal seam	Thickness of separating rock
Hsiong-tsieh	1–4 feet	
Tsong-tsieh	3–6 feet	40–110 feet
Ti-tsieh	3–4 feet	20–50 feet

At Pai-T'o-Tsun a fourth seam is worked with a thickness of 8-30 feet, this is locally called Ta-Yao seam. All the coal seams become generally thicker and thicker south-west-ward from Pai-T'o-Tsun. The upper three seams attain each 7-10 feet at Ssü-Lao-Kou, Hu-Chia-Wan, Chin-Chia-Shan, Shao-Chia-Kou etc. The same thickness may be also encountered at Wan-Chia-Tsui, Ma-Ying-Wa etc. The figures stated above can be only taken as general rule, there are of course many local variations or accidents.

Of the particular facilities for working of the Ta-Tung coal field, we may chiefly mention: the horizontality of the coal series which makes the coal seams never too deep for mining, the solidness of roof and floor, and the quality of coal easily mined in great pieces.

The coal reserve is calculated as follows:

Area	Average thickness	Sp. gravity	Probale reserve
Lower series 388 sq. li	2 m.	1.3	252,000,000 tons
Upper series 650 sq. li S. W. Mei-Yü-Kou	5 m.	1.3	1,056,000,000 tons
Upper series 72 sq. li N. E. of Mei-Yü-Kou	2 m.	1.3	46,000,000 tons
Total			1,354,000,000 tons

Taking 354 millions as already extracted by old native mines, it remains still a considerable reserve of 1,000 million tons.

QUALITY OF THE COAL.

The coal is bituminous with an average moisture above 3% and volatile matter above 20%. The caking quality varies from seam to seam and according to different parts of one and the same seam. Analysis together with the result of coke making experiments by M. H. Li are given in details in the Chinese version.


山西大同煤田地質圖
GEOLOGICAL MAP OF THE TA TUNG COAL FIELD, SHANSI
縮尺二十萬分之一
Scale 1 : 200,000
5 4 3 2 1 0 5 10 Km.
左雲
Tso Yün
大同
Ta Tung
懷仁
Huai Jên
片麻岩 太古界
Gneiss Archaean
石灰岩及頁岩 寒武紀
Limestone & Shale Cambrian
下煤系 石炭紀
Lower Coal Series Carboniferous
頁岩及砂岩 二疊三疊紀
Sandstone & Shale Permo-Triassic
上煤系 下侏羅紀
Upper Coal Series Lower Jurassic
紅砂岩系 上侏羅紀
Red Sandstone Upper Jurassic
玄武岩
Basalt
礫岩
Conglomerate
黃土
Loess

GEOLOGY OF THE LEI-YANG COAL FIELD, HUNAN.

(Summary)

BY T. O. CHU

INTRODUCTION

A large coal field exists in the upper Siang valley at the east of Lei-yang district extending eastward into An-jen and southward into Yung-hsien districts. This field was surveyed in 1917 by the author together with Mr. C. Y. Shieh. The following is a summary of the main geological features of part of this field which has been studied by the author and as represented in the accompanying map.

STRATIGRAPHY

Five principal divisions are distinguished; they are in ascending order:

1. *Carboniferous limestone*-This is a thick formation commonly encountered in Hunan. Many quarries between the districts An-jen and Lei-yang are working the limestone for the purpose of lime burning and road building. Fusulina fossils have been collected near Tung-hu. This formation forms a E-W range to the south of which extends the coal field.

2. *Manganiferous and ferruginous sandstone*-This series immediately overlies the carboniferous limestone and extends from Ting-shui-p'u, Lao-hu-wo to south of Tang-ho-chüan. As a rule the lower part is more manganiferous while the upper part is more rich in iron. The manganiferous rock is typically dark colored with the manganese content ranging from 10–50 %. The ore seam is about 10 cm. thick. The iron bearing sandstone is usually red and thick bedded. The iron content is generally low but sometimes workable. Best ore is obtained from near Lao-hu-wo and smelted in the native furnaces situated between Lao-hu-wo and Tung-hu. The total thickness of the whole series is not less than 800–900 m.

3. *Permian coal series*-Three principal parts may be distinguished in this series:

   a. The lower part is constituted by a quartzic sandstone which overlies conformably the ferruginous sandstone and contrasting with it by its hardness. Outcrops are visible at N. of Kao-ma-tou, S. of Tang-shui-chüan, Yüan-fa-ch'ung and Shui-chi-ch'ung. Total thickness is about 300 m.

   b. The middle part consists of alternating sandstones and shales with thin calcareous intercalations. The dark colored shale contains plant remains.

   c. The upper part consists mostly of shales and several coal seams. Five coal seams are worked by numerous native pits in the syncline passing by Yü-shui-lung, Pan-chiao and Nan-chuang. The same number of coal seams is observed in the area extending from Lan-pan-chiao to Shui-chi-ch'ung. The average thickness is approximately as follows from below upward:

intercalating rock	40	24	100	60	30–80
coal	8	6	7	4	2–3

   All the five seams are anthracite. The lower three seams are qualitively as well as quantitatively more valuable than the upper ones.

The total thickness of b. and c. combined is roughly extimated at 1200–1700 m. The geological age of the coal bearing series is Permian according to Dr. Halle who was about the same time in the field for palaeobonical researches.

4. *Post-Permian (?) shale and thin limestone*-This is a thick formation unconformably overlying the Permian coal series. It is strongly folded between San-tu and Nan-chuang and clearly unconformable between the latter village and Ta-chin-tang. Light green shale predominates with intercalations of thin limestone, slate and sandstone. No fossil has been found. The post-Permian age is merely inferred from its position occurring south of the coal series which is as a whole dipping southward.

It is however not impossible that this series is of much older age (as would indicate the stronger folding etc.) and appears only here by faulting of great throw.

5. *Red sandstone with conglomeratic beds* probably of Tertiary age.

STRUCTURE

Broadly speaking the coal series has a E-W strike in the principal area from Liao-li-ch'ung to S. of Tang-ho-chüan. From Liao-li-ch'ung the strike turns to N-S with a markable thinning of the coal series.

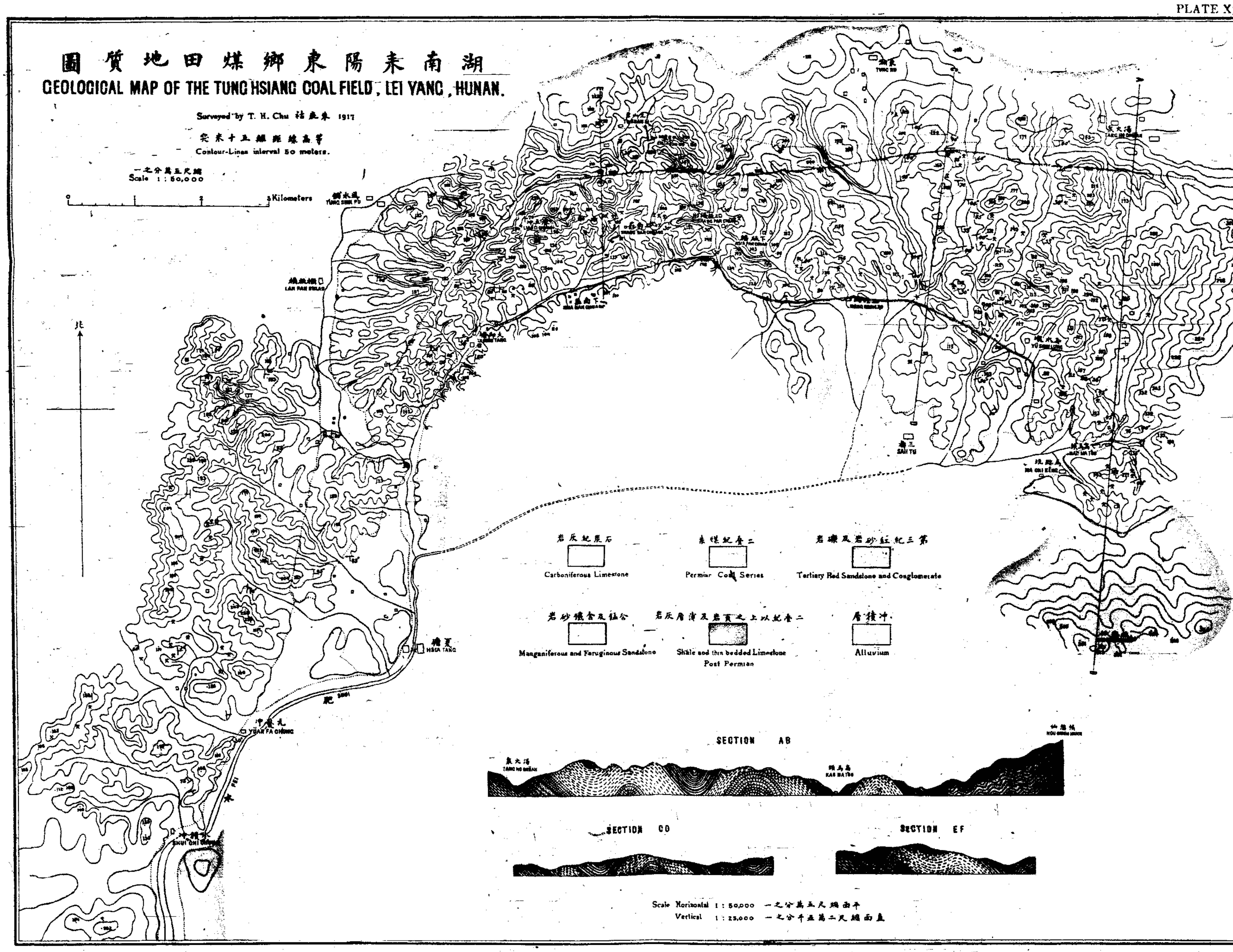
The coal field is limited to the south by the possible fault above mentioned which brought up the greenish shale formation. To the north and west it is bounded by the manganiferous and ferruginous sandstone. However the coal series reappears to the west of Lan-pan-chiao, Yüan-fa-ch'ung and Shui-chi-ch'ung; this is probably caused by a fault line passing by the named villages.

When more details of the coal field structure are taken into consideration, it will be seen that the strata are folded into a succession of synclines and anticlines. From Tang-ho-chüan to Kao-ma-tou and Hou-chieh-hsien there are three synclines (see section A B) of which the two deepest are situated near Yü-shui-lung and Kao-ma-tou where therefore the coal seams are most completely represented. To the west the folds are reduced to only one syncline and one anticline as may be seen from section C. D. Still further west the section E F shows foldings still more gentle and simple.

Between Liao-li-ch'ung and Ta-chiu-tang and further southward there seems to be also an anclinal folding complicated by other kinds of disturbance.

In the area west of Lan-pan-chiao and Shui-chi-ch'ung the coal series forms also an anticline of N-S trend.

The existence of the anticlinal foldings within the coal bearing area has of course the effect of decreasing the quantitative bearing of the anthracite which is very good in quality and largely used in Hunan.


湖南耒陽東鄉煤田地質圖
GEOLOGICAL MAP OF THE TUNG HSIANG COAL FIELD, LEI YANG, HUNAN.
Surveyed by T. H. Chu 1917
等高線距離五十米突
Contour-Lines interval 50 meters.
縮尺五萬分之一
Scale 1 : 50,000
Kilometers
石炭紀灰岩
Carboniferous Limestone
二叠紀煤系
Permian Coal Series
第三紀紅砂岩及礫岩
Tertiary Red Sandstone and Conglomerate
Manganiferous and Feruginous Sandstone
二叠紀以上之頁岩及薄層灰岩
Shale and thin bedded Limestone
Post Permian
沖積層
Alluvium
SECTION AB
SECTION CD
SECTION EF
Scale Horizontal 1 : 50,000
Vertical 1 : 25,000