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綏远及察哈尔西南部地質誌

孙健初著

中华民国二十三年八月

实業部地質調查所
国立北平研究院地質学研究所
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綏遠及察哈爾西南部地質誌

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第一章 緒言

察綏調查，前後凡三次。民國十九年春，奉派調查察哈爾西部地質礦產，先由張北調查向西而進，至土木路與和折而南行，經懷安而去陽原，後至山西之天鎮，小作勾留即遄返北平。民國二十一年春，本所翁詠霓所長應綏遠省政府之邀，派健初前往調查地質礦產。爰于四月二十八日由北平出發，次日抵歸綏，越四日向西北進行經察素齊入武川西部，勘察多日而返歸綏。復由歸綏東進，經集寧陶林，旋阻軍事，折向西行，經薩拉齊，包頭，安北，固陽，而返歸綏，由歸綏乘車回平。惟該省之陶林與和間因軍事發生未及考查，復于民國二十二年春，由北平前往以補所缺而竟全功。三次調查，計費時共四月餘，行程曲折可六千里。調查區域在北緯四十度三十分，至四十一度三十分，東經一百零八度，至一百十四度之間，幅員佔綏遠之本部及察哈爾之西南隅，亦即張垣以西五原以東歸綏以北白靈廟以南之地也。

本區地質，屢經中外學者考察足資導循。一千八百六十四年，有本拍里氏至豐鎮及岱哈，一千八百七十一年，李希霍芬氏勘察西營子及其迤南之小大青山，一千九百十五年，即民國四年翁所長調查大青山，兼涉四子王旗之一部。民國十二年，德日進氏經烏拉山入後套，而至鄂爾多斯之西端。民國十四年，大青山地質，復有本所王竹泉較詳之勘察（見地質彙報第十號）。各有專論圖說，散見于羣籍。其後歐美人士屢至邊地，所得結果時有發表，亦可參考。惟礦產，除大青山之煤礦已經翁所長及王竹泉詳細調查外，其他各礦見于前人之記載者甚鮮。至衆口所傳，西北爲天賦獨厚之區，礦產尤爲豐富，言之過甚，在學者一見即知其爲過實之譽，而疎于科學之研究。然一般人莫明眞像，徒滋疑義。玆幸得實地調查一探究竟，雖未遍歷兩省全境，而足跡所至已盡樺山，奎騰粱，大青山，烏拉山，色爾騰山，狼山等山脉，（爲兩省地質最顯著之區域）于地質方面，略得其梗概，藉糾前人觀察之所未盡。于礦產方面，亦務究悉其底蘊，冀破已往道聽途說之弊。惟限于時日未能到處勘察，遺誤之處自所難免，邦人君

予諒而教之則甚幸焉。

本書以中英兩文敍述，英文記地質較詳，多重學理，記礦產僅及其產狀之大概。而中文則言地質以簡明為主，論礦產則較為周詳，就所查各礦分別詳述，以定其價值及實業經濟之關係，不貶抑，不褒揚，惟求其確實而已。其在本區以內，曾經學者研究而此次未及考察者，亦摘要編入，以供參考。

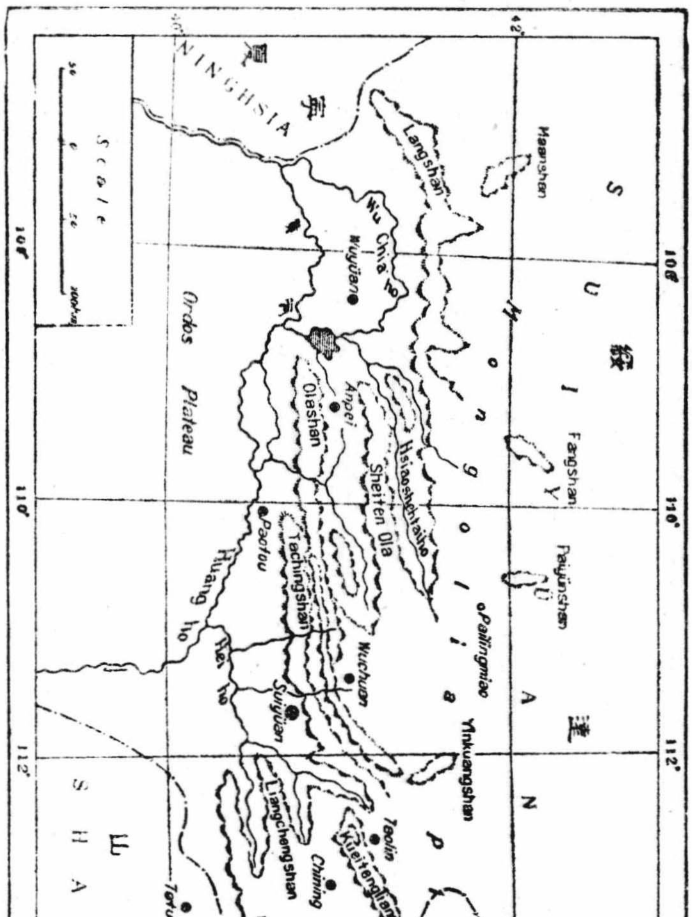
察綏調查，承省政府及各縣長之招待，及綏遠建設廳科長王如南技正馮壽垣兩同志之匡助，實地工作得以成功，書此以誌感謝焉。

第二章　地文

就各種地形圖觀察，則知察綏大部，為蒙古高原所佔，其地勢甚高，其上面頗平，惟至高原之南沿，始見崇峻之山嶺，如狠山，色爾騰山，烏拉山，大青山，涼城山，樺山諸山脉等（參閱第一圖），大致走向皆東西，實則曩昔，本為高原之一部，旋以河流侵蝕，而分離成為今日之蜿蜒嶺脊者也　此為調查範圍內最重要之嶺幹，亦內蒙著名之山脉也。此山脉之在東南者，南連叢山，而在西南者俯臨黃河平原，舊地理書所謂陰山山脉，即指此言，然詳察之，實可為若干不同之山脉也。

高原

蒙古高原位于察綏之北部，東起多倫以東，西逾居延海以西，南起歸綏縣，北越庫倫城，縱橫所及可達七百萬方里。穹然高起，勢若平台，測其海拔，約由一千餘公尺至二千餘公尺。其上面就作者所經察及者，自張北縣西至桃李壩，第三紀玄武岩流分布頗廣（皆成平層），雖微有低岡起伏，而地勢大致平綏　惟自桃李壩而西形勢迴異，地面多山，或為峻嶺（如小大青山銀礦山等），或似邱巒（如谷騰梁腦包壩等），蜿蜒綿亘，盆地中陷（如武川陶林興和等平地），盆地多在片麻岩之中，內滿紅土，山嶺半為玄武岩所組成，高出盆地二三百公尺。大概玄武岩流噴發之後，繼以地殼之斷陷，使地又成隆窪不平之形狀，於是侵蝕因之而復活，造成溝谷及山嶺。其後溝谷變寬，山嶺漸低，侵蝕堆積同時並進，因是有盆地紅土之生成，一如今日所見之情形也。



第一圖　綏遠及察哈爾西南部地形圖

山脈

山脈中之在察綏高原西南者，就圖書所載，總名之曰陰山山脈或大青山脈，如此名稱殊嫌籠統。就蒙人所稱另立名目，則可別爲大青山，烏拉山，色爾騰山，及狼山　高原東南之山脈，如涼城山，本無定名，茲以其密邇涼城縣故創畀此名。又如樺山，枝脈四出，隨地異稱，惟其正幹峯巔向稱樺山，姑以此爲全部之總名，此本區重要山脈名稱之所由來也。

狼山山脈　狼山山脈，自安北縣小佘太之附近起，沿高原而西亘，至于五原臨河，嶄巖峭壁，俯臨平原，一若天設屏幛，以為蒙漢之界限者。但入山北行百餘里，即見山勢漸平無復崇山峻嶺，蓋狼山與蒙古高原本為一連亘不絕之高原，自高原南向視之，初無所謂山脈，惟自地層拆斷，一部陷為平原，始有今日峻峭之形勢耳。測其海拔，約由一千五百公尺至一千九百公尺，其山頂大致齊平，高原之地固當如是也。

色爾騰山脈　色爾騰山與狼山之間僅有一平原（小佘平原）之隔，故近日地理學者誤認其為狼山之東部。其脈自安北縣綿亘而東，逾昆都崙河至固陽之正東，與蒙古高原相接連。大部為桑乾片麻岩所組成，峯巒聳立，山勢陡峻。其山頂，高出海面約由一千八百公尺至二千二百公尺。惟在固陽低地，環而峙者蜿蜒起伏似小邱巒，其高不過一千四百公尺左右也。

大青山脈　大青山脈，自祈下營子而西綿亘至于包頭，峯巒疊出，山勢險阻。實則一如狼山，其與蒙古高原為一連綿不斷之高原。惟自歸綏東北數十里起，西經薩拉齊以至包頭，地勢突然中斷，自陷落之平原北望高原，自覺懸崖絕壁形勢險峻，但賴巨溝急澗破山而出為北通蒙古之孔道，如翁所長言（參閱地質彙報第一號第十九頁）。大青山脈，為太古元古界之片麻岩，大理岩，石英岩，及古生中生代之砂岩頁岩，礫岩所組織，砂頁岩等以其質軟，常成圓而低緩之崗阜，但變質岩類，石質綦堅，故其所成之山，孤峯屹立，備極險惡，其峯嶺高出海面約在二千公尺以上也。

烏拉山脈　層巒疊幛，嵯峨叢生，巍立于安北包頭兩平地之間者，即所謂烏拉山是也。烏拉山脈東接大青山，西沒于原野，共長約二百里。其最高峯，位于哈德門溝之西，高于海面約一千九百餘公尺，與大青山最高點幾相齊平也。

涼城山脈　涼城山脈，位于涼城縣之東北，包有馬鞍山，油簍山等。此等山嶺，皆平緩起伏形似邱巒，然測其海拔，多足與烏拉山爭高焉。

樺山山脈　萬全以東之諸山，屏峙于平綏路之北，巍然自成一系，即樺山山脈也。此脈自漢諾壩之西起，蜿蜒而西經東西洋河，而止于豐鎮附近。東西延長數百里，悉為太古界片麻岩所組成。層巒疊幛，高入雲際，測其海拔，多在一千九百公尺以上

矣。

就上所述，可知本區之山脉走向大致皆東西，考其成因所在，則與地層之南北褶皺（詳于構造章）具有因果之關係也。

河流

本區面積幾達三十萬方里，地多高原，山脉明顯，而水系分布亦甚單簡，循流溯源可分二系。在集寧一帶山地以西者爲黃河系，在集寧一帶山地以東者爲洋河系，集寧一帶山地即其分水嶺也。

黃河自寧夏東來，經包頭之南至薩縣乃折而南行。狼山，色爾騰山，烏拉山，大青山，凉城山之水，南流或西流注于黃河，其重要者有三，即小佘太河，崑都崙河，黑水河是也。小佘太河，導源于狼山之東部，西南流經小佘太，至安北縣之西，合五加河，以入于烏梁蘇海，故烏梁蘇海實爲此二水瀦集之所。崑都崙河來自固陽縣，南流橫破烏拉山，至包頭之西南注于黃河。大黑水河小黑水河，源出于凉城山及大青山，在歸綏西南會合，西流至察蘇齊之南，受有黑牛溝，萬家溝之水，折而南向入于河。所謂歸綏平原者，實黑水系之冲積地也。至狼山，色爾騰山，烏拉山，大青山等以內之其他諸溝，多向南流，惟其導源不遠，故溝谷雖深，水量不多，一至平原或散爲細流，或沒爲潛水，無一定河床。夏季驟雨乍霽，或有山水奔騰湧成急湍，然易洩易盡，無餘力以自闢河床于平原，如翁所長言。洋河上源有三，東曰東洋河，西曰西洋河，南曰南洋河，皆源出于樺山脉。三流合于柴溝堡之東，始名洋河，蜿蜒東流出本區入宣化境，至下花園之東與桑乾河相會焉。

盆地

本區盆地之在高原以上者既如前述，本節所及，爲高原以下之盆地，其最要者爲黃河盆地，次爲柴溝堡盆地，懷安盆地等，茲分別述之如次。

黃河盆地　自歸綏以西沿黃河迄于五原，地勢平坦，長約八百里，寬約六十里至一百六十里，高出海面一千二三百公尺。南連鄂爾多斯平原。北界大青山，烏拉山，色爾騰山，狼山，嶄巖峭壁，勢如屏幛，高出盆地六七百公尺。東界凉城山脉亦高低

相差甚遠也。黃河盆地皆爲近代冲積層所成，土質肥沃，河流交錯，爲綏省富庶精華所寄之區也

黃河盆地初視之頗似黃河侵蝕所成之寬谷，然細察其與各大山嶺之關係，皆以東西斷層間之，由是可知其居各斷層之俯側，因地層陷落而爲盆地，黃河生成殆在地層陷落以後也。

柴溝堡盆地　柴溝堡盆地，爲東西洋河之冲積地　南北寬約二十里，東西長達四十里，更向東開展而爲部曇莊平地。南界龍王堂一帶之山脈，宛如屏幛，北界樺山山脈山勢尤峻。盆地內之冲積層，飛砂居多，不宜種植，惟東洋河村附近，地較肥美，爲農業上重要之區域也。

懷安盆地　懷安盆地，爲紅唐水溝侵蝕所成之河谷，長約二十里，寬僅十餘里，環而峙者，爲太古界片麻岩所成之山地。

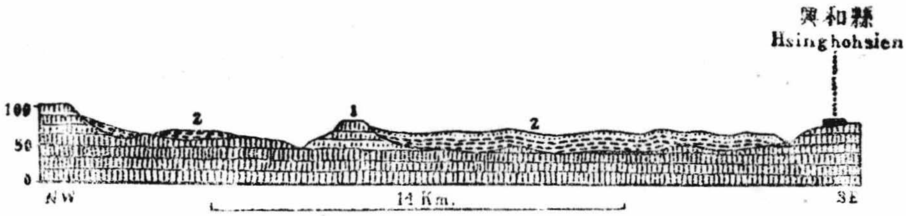
地文期

本區因地形之不同，概可分爲五個地文期，一北台期，二唐縣期，三汾河期，四清水期，五板橋期，試縷述如次。

北台期　北台期之侵蝕地面，爲一大平原，凡現在之高山頂，及玄武岩以下之地面皆屬之。玄武岩下之地面，大致平坦，惟其有時起伏綿延之形狀頗爲顯著，如在金騰梁一帶所見者，高下相差已達一二百公尺，頗可與中國北部其他各處之北台侵蝕平地相比擬。高山頂之侵蝕平原，亦頗明晰，雖已溝澗交錯，而原來之地形尚可辨識，故置身河谷，輒覺峰巒紆迴，山勢陡峻，及至山巔，一望瀰平，絕少峻峰，苟不俯視溝谷，恍若身在平原之上也。

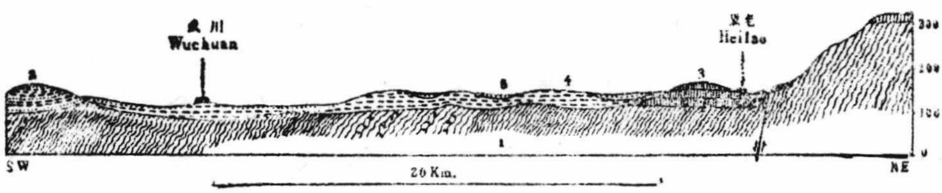
組成此侵蝕平原之岩層，自太古界以至上侏羅紀皆有之，蓋下白堊紀之地殼運動發生後，繼以侵蝕期，夷山填谷，使當時之地面成爲微有起伏之侵蝕平原。其時期，或係白堊紀之末期，及第三紀之初期也

唐縣期　唐縣期係中新統，爲壯年時代陸地造成之時期，所謂壯年期之陸地，即今平坦寬廣之溝谷，與起伏蜿蜒之低山而成者，例如蒙古高原上，山嶺綿亘盆地中陷（詳見前節），即唐縣期侵蝕所造成之地形也（參閱第二第三剖面圖）。台梁河之南岸，有第三紀末期之紅土上覆以礫岩層，散布于烏拉山北坡之梯地，厚約數公尺，高于河床六七十公尺。就紅土礫岩存在之情



第二圖　興和縣附近紅土以下之唐縣期地面

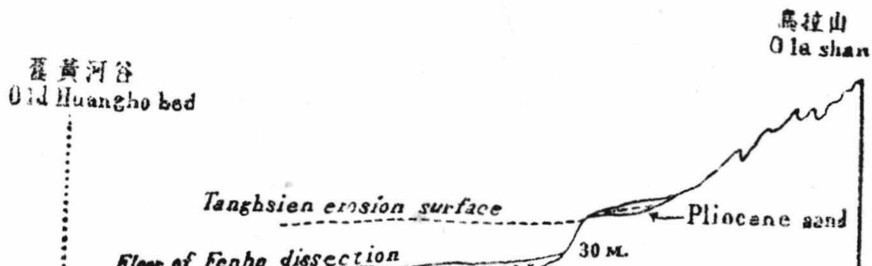
1. 第三紀玄武岩　2. 上新統紅土



第三圖　武川一帶紅土以下之唐縣期地面

1. 太古界片麻岩　2. 侏羅紀煤系　3. 第三紀玄武岩

4. 上新統紅土　5. 沖積層



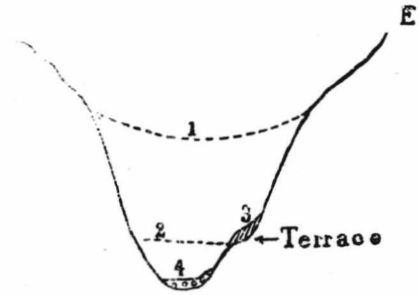
第四圖　烏拉山南坡之階級地形

形，可想其沈澱之際所佔地面必廣，或烏拉山北坡之梯地與色爾騰山南坡之梯地連續，成爲寬廣平坦之溝谷，而現在之河床其時尚未造成，此亦唐縣期之地面也。

汾河期　每于山谷河身仰視兩旁之山頂，其高低之可分爲三級者常能辨識。苟以三線，一聯最高頂，一聯次高頂，一聯最低頂，第一第二兩線可畫出北台平原及唐縣之地面，第三線則伏于第二線之下，似唐縣期復被侵蝕者，惟當時之地形，仍谷廣河寬成一半壯年之形狀。其時期似歷上新統之末期或更新統之初期，約與汾河期相當也。

清水期　汾河期之地面，深溝急澗，危崖矗立，為一險惡之地形，似汾河期之後，本區地面再行隆升，侵蝕復活，汾河期地面被其原有河流沿故道而深切者，在樺山（參閱第五剖面圖）大青山等處最為發育。其生成在更新統，約與清水期相當。本期溝澗內時有黃土之分佈，或即所謂馬蘭期之成績也。

板橋期　本期自更新統以迄于今，本區地面略受扭曲之影響，故河流之侵蝕復活，造成陡而淺者之河谷即最近之現象也。



第五圖　黃土窰子附近之谷形

1. 汾河期谷形　2. 清水期谷形

3. 黃土層　4. 板橋期谷形

與他區地文之比較　巴爾博氏（參閱地質專報甲種第六號）就張家口一帶之研究，曾將該區地文別為五大侵蝕期，其間恆隔以遞積期，頗與本區之地文情形相符合，茲臚列如次以資比擬。

（一）北台侵蝕

　　玄武岩流

（二）唐縣侵蝕

　　三趾馬層與礫石

（三）汾河侵蝕

　　三門遞積與礫石

（四）清水侵蝕

　　馬蘭遞積（黃土）

（五）板橋侵蝕

　　冲積與礫石

第三章　地質

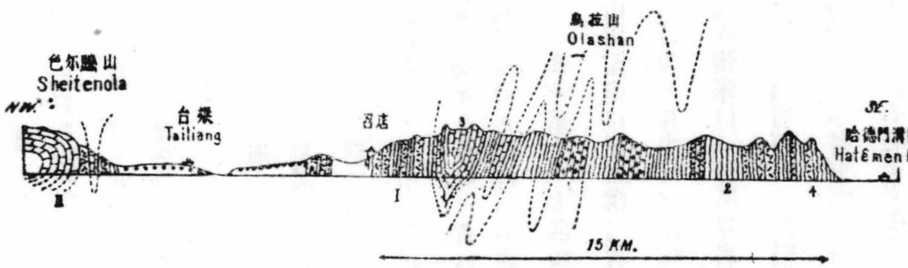
地質與礦產有密切之關係，各種礦質之貧富優劣，當由考察礦床生成情形以定。而礦床之形狀變化，分合聚散，以及分佈範圍儲量多寡，非深悉地質上之各種情形，不易推知其究竟。故欲知礦產之價值，非由研究地質入手不可。綏遠本部及察哈爾西南部地質，屢經前人勘察，各有圖說，已如上述，惟多係初步研究，記載簡略，尤關于礦產之地質情形，殊少詳細說明。茲特將層累構造及其他關于礦產之地質要點，分別敘述，以資參考

地層

綏遠本部及察哈爾西南部之地層，凡分十三系，卽桑乾系，屬太古界，五台系，屬元古界，南口石灰岩，屬下震旦紀，什那干石灰岩，屬上震旦紀，揑馬椿煤系，屬二疊石炭紀，薩拉齊砂頁岩系，屬二疊三疊紀及三疊紀，石拐煤系，屬下侏羅紀，小北嶺礫岩層，屬中侏羅紀，大青山砂頁岩系，屬中上侏羅紀，土木路系，屬上白堊紀及下第三紀，漢諾壩玄武岩，屬漸新統，紅土層，屬中上新統，黃砂層，屬上新統。就中片麻岩系分佈特廣，四方延展難盡其端。如二疊石炭紀及下侏羅紀等系，暴露零星，頗不發育，然此兩系與察綏兩省礦產，大有關係，其分佈情形，應特別注意而詳述之。

桑乾系

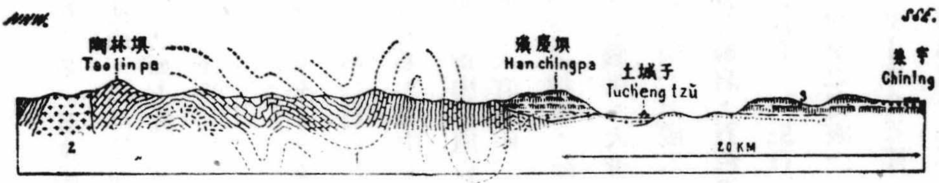
本系爲本區最古且最下之地層，分佈之廣殆遍地皆是，而其暴露顯著，足以供吾人研究之材料者，則在樺山（樺山以南南口嶺之露出者亦頗清晰），金騰梁，大青山，烏拉山，色爾騰山等處。岩石全系以片麻岩爲主，雲母片岩，大理岩，亦常目擊，其中常有火成岩之侵入體及細脈（其侵入情形詳于火成岩章）。片麻岩又可分酸性片麻岩基性片麻岩兩種，頗與巴爾博氏在張家口一帶所見者相類似。酸性片麻岩，石色黑灰或灰白，組織多中粒及細粒，惟在燈籠樹溝所見者，其組織較粗。造岩礦物，普通有石英，鉀微斜長石，條紋長石，斜長石，黑雲母，磁鐵礦，磷灰石，綠泥石等，石英長石雲母三者，常成白黑相間之條帶，以示片麻岩之特徵，雖有時作複雜之褶皺（如第十四版圖所示），然其原來之層面，尚能辨識，其方向常與層理相平行，大抵由長石石英岩深受變質而成者。其中常含石榴子石及石墨，如在哈德門溝及黃土窰子所見者是也。基性片麻岩，組織緻密，石色暗黑，惟其風化面多呈綠色，常爲角閃石及輝石所組成，而少矽鋁養化物，似由火成岩變質而成者。其與酸性片麻岩之關係



第六圖　烏拉山及色爾騰山地質剖面圖

I. 太古界　II. 震旦石灰岩　1. 石榴子石片麻岩

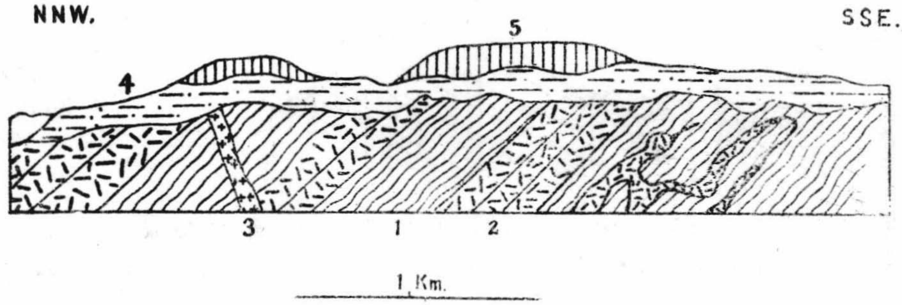
2. 片麻岩　3. 大理岩　4. 花崗岩



第七圖　集寧陶林間地質剖面圖

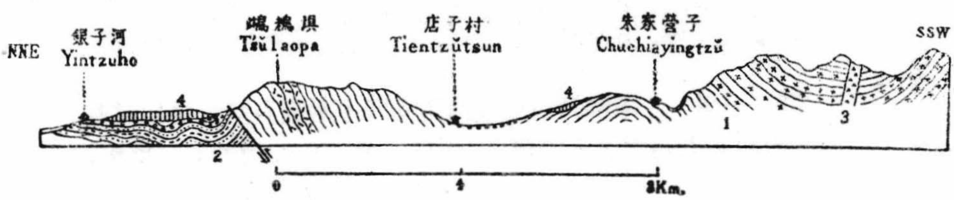
1. 片麻岩及大理岩　2. 花崗岩　3. 玄武岩及其底部頁岩

，不甚清楚，惟在沙壩子似沿其片理而侵入，且基性片麻岩，本身之片理亦頗清楚，大抵其生成，在酸性片麻岩變質以後，而在元古變質作用停止以前也。此岩有時富含鐵質，其與公義明之磁鐵礦有成因之關係。雲母片岩，大抵來自太古界之尼質，每與酸性片麻岩夾雜而生。大理岩，僅見于綏遠省，其中產石綿，常夾于酸性片麻岩內，或相間而生，　如第六第七剖面圖所示，此亦足証明酸性片麻岩來自水成岩，惟在基性片麻岩內尚未見有此情形也。由此可知此種片麻岩原由于火成岩變質而成，亦屬毫無疑義。大理岩多雪白，晶粒不粗，富含鎂質，其中常有蛇紋石與石棉共生（詳于礦產章）。此岩因受矽化而成矽化鈣，質頗堅硬，故常組成數百公尺（高于溝底）之高山，如半溝，石灰窰子，水間溝，　哈德門溝等處所見之嶄岩矗立者，皆為大理岩（如第十一版甲圖所示）。至本系之地質時代，最初李希霍芬氏，研究中國之地質，對震旦系以前之地層，曾分為泰山桑乾及五台三系。泰山系，屬太古界，五台系屬元古界，桑乾系介于二者之間，其中多水成片麻岩。其後維理氏就山東山西調查所得之經驗，僅謂中國有泰山系及五台系，而于桑乾系未曾提及。晚近燕京大學教授巴爾博氏，復倡三系之論，並謂其間應成不整合之接觸，就岩相言之，似當如是，惟作者迄未見其明確



第八圖　南口嶺南地質剖面圖

1. 桑乾片麻岩　2. 花崗岩　3. 偉晶花崗岩　4. 紅土　5. 黃土



第九圖　興和縣南銀子河朱家營子一帶地質剖面圖

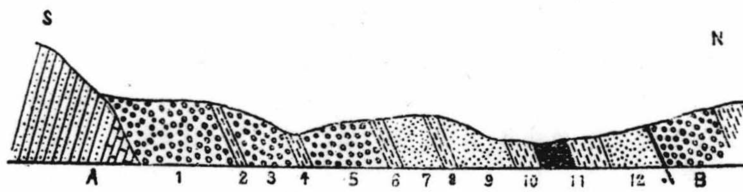
1. 含石榴子石片麻岩　2. 上侏羅紀砂岩及頁岩　3. 輝綠岩　4. 黃土

之界線耳。本區之片麻岩皆係桑乾片麻岩，而屬于新太古界，其理由如下，片麻岩大部原由水成岩變質而生成，片理清晰不似泰山，而其變質之劇烈，其中火成岩侵入之複雜，亦不近于五台，惟其中夾有大理岩，論者每疑其爲五台系，第桑乾系既多水成片麻岩，其中之有大理岩亦非不可能之事實。至大理岩生于綏遠而不見于察哈爾，大抵當時海水（或湖水）之分佈所及，僅至內蒙古之西部，而東部未曾受有海浸也，而余見如此，究竟是否如是，姑立此說以待証明。

五台系　本系僅見于綏遠，在固陽縣城北哈達山露出者頗爲清楚，直覆于片麻岩之上，惟其接觸之處，均被浮土掩覆無從觀察，是否相整合抑或有極大之不整一層，尙難確定，惟就觀察所得，石英岩大理岩大致平整，岩層傾向東北或西北，約由十五度至二十度，而附近片麻岩之片理傾斜，大致直立，頗似石英岩及大理岩蓋覆于片麻岩之上，成不整合之接觸者。岩石自下而上，（一）組織頗細之灰色雲母片岩，中產黃鐵礦，（二）大理岩，（三）暗灰色雲母片岩，（四）灰色或淺紅色石英岩（參閱第十剖面圖）。地層大部已被侵蝕，其總厚度無術測知，玆就侵餘者逐層計算，約有二百餘公尺。又大青山

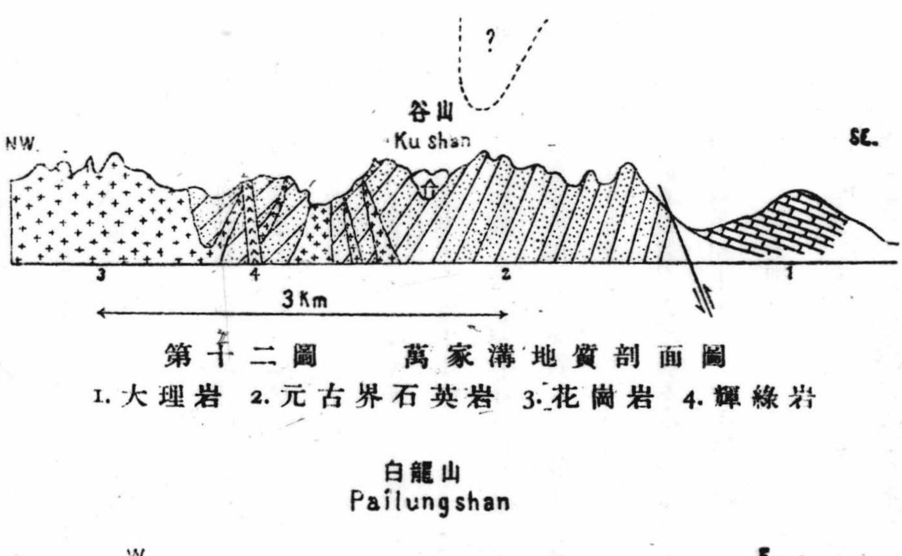
第十圖　固陽北哈達山地質剖面圖

I. 五台系石英岩及大理岩　2. 第三紀末期紅土　3. 礫石



第十一圖　薩縣童盛茂村南馬地灣子附近石炭二疊紀煤系

A. 五台系石英岩及石灰岩　　B. 二疊三疊紀礫岩及紅色頁岩



第十二圖　萬家溝地質剖面圖

I. 大理岩　2. 元古界石英岩　3. 花崗岩　4. 輝綠岩

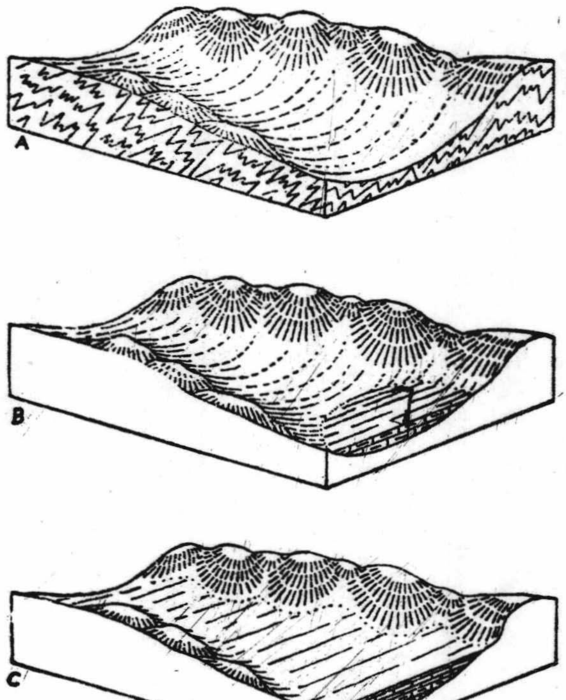
第十三圖　片麻岩及矽質石灰岩組成之白龍山

之巴兎溝，五達溝，萬家溝，蜈蚣壩等處，亦有片岩，大理岩，石英岩之分佈，惟巴兎溝，五達溝，作者未曾涉足，就王君之觀察（地質彙報第十號王竹泉大青山地質），石英岩連續于大理岩之上，而大理岩與片麻岩成不整合之接觸（參閱第十一剖面圖）

。由大青山東向至轉山子一帶，低岡起伏，其上均有頗厚之浮土，地層情形殊不易窺悉，惟山坡上時有大理岩之露出，且在河谷中亦檢有石英岩，大理岩，及灰色結晶石灰岩之碎塊，由此可見五台系沿大青山脈延展甚遠，此亦其之一分佈區域也。

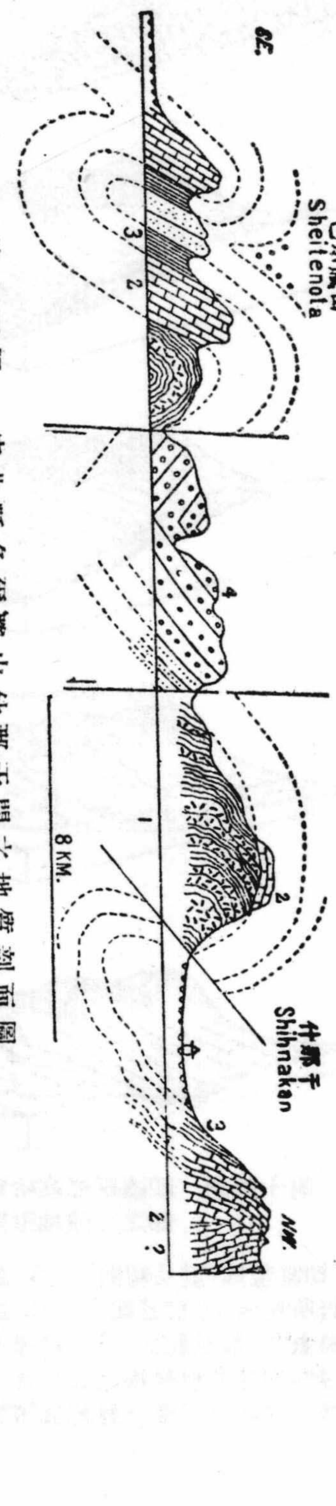
南口石灰岩　本層分佈于察哈爾，而見于白龍山（參閱第十三剖面圖），虎形山，陽原北山等處，往往組成平頂山。其岩性，恰如在南口所見之標準矽質石灰岩，極易認識。惟其下之石英岩極不發育，僅有薄層粘板岩與以下之片麻岩成不整合之接觸。

什那干石灰岩　本層分佈于綏遠之西部及中部，組成什那干以北以南及大灘以西以北之高山，直覆于片麻岩之上（參閱第十五剖面圖），而成不整合或斷層之接觸。全層厚度，就拴馬樁一帶露出者計算之，約有六百餘公尺。本層以石灰岩為主，兼有



第十四圖　綏遠東部察哈爾西部及山西北部之立體地形圖

A. 切割盆地(震旦紀前)　B. 盆地之一部為南口灰岩所覆蓋(下震旦紀)　C. 盆地為什那干灰岩所遮蓋(上震旦紀)　D. 什那干灰岩幾全被石炭紀侵蝕作用所剝蝕而造成河流　E. 河流盆地被二疊石炭紀及二疊三疊紀沉積物所覆蓋



第十五圖　安北縣色爾騰山什那干間之地質剖面圖

1. 桑乾片麻岩及花崗岩　2. 震旦紀石灰岩　3. 二疊石炭紀煤系　4. 二疊三疊紀礫岩

石灰質頁岩薄層，灰岩色黑灰，質勻密，內含燧石成層狀或卵形，爲震旦石灰岩之特徵，惟在拴馬樁什那干無燧石，而常夾方解石細脈，但其質仍不純潔，不宜燒灰（所燒之灰無粘着性），有別于奧陶紀石灰岩。本層屬于震旦紀，大概已無問題，惟其無絲毫之變質，其時代似較南口石灰岩爲新，震旦石灰岩之露出南口者，實不完全，就作者在河北密雲縣觀察所得之結果，南口石灰岩上，尙有甚厚之灰岩層，石色深灰，少矽質，然則本層與此石灰岩相當，而屬上震旦紀歟。

拴馬樁煤系　本系卽王竹泉所稱爲下煤系者，見于綏遠，分佈零星，面積不廣，大致論之凡分五區，（一）爲拴馬樁一帶之煤田，煤系位于什那干石灰岩之上，成平行不連續之接觸。岩石大抵下部爲灰色砂岩，灰綠色砂質頁岩，灰黑色泥質頁岩，及石英砂岩，中夾重要煤層，近煤層處，多爲黑色頁岩。上部爲灰白色石英粗砂岩，不夾煤層，石英粒微帶稜角爲較細之砂粒所粘合，本區煤系地層，分佈于沙蕨溝拴馬樁之間，以拴馬樁西南之露頭爲最清楚，其岩層自下而上次序如下（參閱第十七剖面圖）。

一　什那干石灰岩

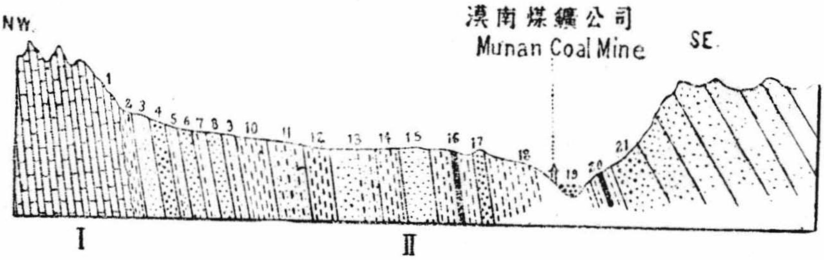
二　黑色泥質頁岩　　四公尺

三	含雲母之灰綠色細砂岩	五公尺
四	粗粒石英岩	三
五	含雲母之灰綠色砂質頁岩	一·五
六	粗粒石英砂岩	二
七	含雲母之灰綠色砂質頁岩	一
八	粗粒石英砂岩	二
九	含雲母之灰綠色砂質頁岩	三
十	灰色或黑色泥質頁岩	一〇
十一	含雲母之灰綠色砂質頁岩	一一
十二	黑色泥質頁岩	七
十三	含雲母之灰色細砂岩及頁岩	二〇
十四	灰綠色泥質頁岩	六
十五	含雲母灰色砂岩	一〇
十六	黑色泥質頁岩夾煤層	一五
十七	灰色粗粒石英砂岩	三
十八	深灰色泥質頁岩	二五
十九	河底礫石	二〇
二十	灰色泥質頁岩夾煤層	一〇〇
二十一	石英粗砂岩	一〇〇

第十六圖　武川甘溝子口一帶地質剖面圖

1. 桑乾片麻岩　2. 二疊石炭紀煤系　3. 二疊三疊紀礫岩

4. 花崗岩



第十七圖　漠南公司附近地質剖面圖

I. 震旦石灰岩　II. 二疊石炭紀煤系

以上各層之總厚，約達二百五十八公尺，似可代表本區煤系地層之總厚也。

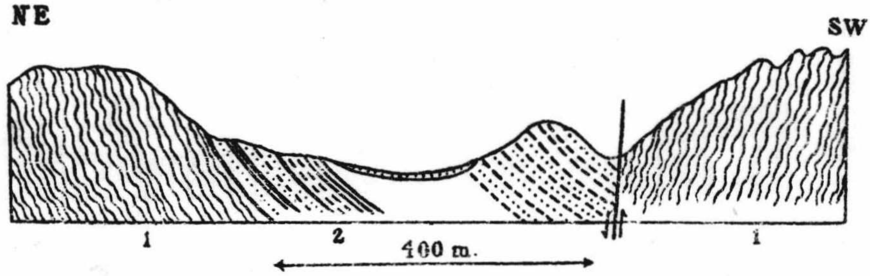
是役也，在拴馬樁附近之煤系內，曾採得植物化石，經健初粗略鑒定有左列三種。

一　Walchia piniformis.

二　Lepidodendron obtusum.

三　Calamites sp.

就上所列化石，Calamites sp. 屬於石炭紀及二疊紀，Lepidodendron obtusum 多見于上石炭紀，Walchia piniformis 之繁衍期自石炭紀至二疊紀，尤以屬下二疊紀者為多，大概本區之煤系，為二疊石炭紀之產物。至其上之石英粗砂岩，為白色石英砂粒所作成，石質堅硬，不易侵蝕，故成峻拔之小山。此種砂岩在中國北部最為常見，凡二疊石炭紀煤系之上多有此砂岩，其時代大抵屬于二疊紀。(二)露出于什那干北山之南麓，向西延展達猥山之西端，位于什那干石灰岩之上，成平行不連續之接觸。就其層位岩相觀察之，當屬古生代，而以歸諸二疊石炭紀為宜。岩石以泥砂質頁岩為主，間有砂岩之薄層，惟因深受變質之影響，全體已成千枚岩或片岩，其中夾有半成石墨之煤層，在葛紹溝一帶，黑色千枚岩內常有石英脈之侵入，迫擠錯亂極形褶曲之致，質硬者亦成山嶺峰巔立壁懸崖。其中之煤層隨地暴露，藉以確証其為煤系，惟已變質甚深，不值開採，僅其中之黑礬礦(詳于礦產章)，尚有一顧之價值也。(三)分佈于薩拉齊以北之水間溝，巴兔溝，五達溝等處，曾經王竹泉君研究，作者亦輪歷其地，藉知其勘查之確實，茲就王君之報告述之如下。本煤系為礫岩砂岩頁岩煤層所組成，或與片麻岩成斷層之關係，或覆元古代地層之上成不整合之接觸，例如在巴兔溝童盛茂村南所見之煤系，不整合于五台系淺灰色石灰岩及石英岩之上，如第十一剖面圖所示。其岩層自下而上為(1)石英礫岩，(2)黑色頁岩，(3)石英礫岩，(4)黑色頁岩，(5)石英礫岩，(6)黑色頁岩，(7)灰色礫岩狀砂岩，(8)黑色頁岩，(9)白色礫岩狀砂岩，(10)黑色砂質頁岩，富含植物化石，其種類為 Neuropteris flexuosa Brongniart, Sphenopteris sp. 及 Cordaites sp. 等，(11)黑色頁岩及煤層，共厚約十三公尺，(12)白色礫岩狀砂岩，以上共厚一百零六公尺，除少許黑色頁岩外大部為礫岩。(四)分佈于武川東北之甘溝子四號地一帶地方，不整合于片麻岩之上，惟其因花崗岩之壓擠焙烤，已深受變質，故砂岩頁岩煤層，大部變成石英片岩，千枚岩，石墨等，此類岩石，質頗堅硬不易風化，故組成四號地附近之山嶺，(五)出露武川以東之速力圖附近，成一條帶狀向西伸長頗遠。上繼以紅色砂頁



第十八圖　武川東速力圖二疊石炭紀煤系剖面圖

1. 太古界片麻岩　2. 二疊石炭紀砂岩頁岩及煤層

3. 二疊三疊紀紅砂岩及頁岩

岩，下覆于片麻岩之上，成不整合之接觸（參閱第十八剖面圖），岩石為黃灰色砂岩及頁岩，中夾煤層，並產 Walchia sp. 植物化石。層厚計達一百五十餘公尺。

以上各區之煤系地層，皆與山西系相當，惟在他處，山西系之下尚有所謂太原系本溪系者，其中夾有石灰岩之薄層。今在調查區域內，煤系地層，逕覆于震旦紀石灰岩或其以前地層之上，太原系及本溪系渺不可覩，足徵石炭紀之海面，向北似未侵入內蒙古，而二疊石炭紀之沼澤，已至內蒙之中部如王君之言也。

薩拉齊砂頁岩系　本系分佈于綏遠省，其產地有六，卽量盛茂，黑牛溝，溫家窰，拴馬樁，蘇力圖，平安村等是也。在拴馬樁量盛茂蘇力圖等處，本系地層皆連續拴馬樁煤系之上，惟在平安村一帶，則逕覆片麻岩之上，二者成不整合之接觸，大致當二疊紀石炭紀煤系沈積以前，地面曾經河流之侵蝕而成一平緩之寬谷，平安村約當其北邊，拴馬樁量盛茂等處，殆近于中底，二疊石炭紀煤系僅成于凹地，二疊三疊紀地層始延展至北岸，此二疊三疊紀砂頁岩系所以與片麻岩成直接之接觸也。本系岩石大致可分兩部，下部多紅色砂頁岩，中夾礫岩層（礫石為片麻岩石英岩等），上部多礫岩，中夾紅色砂岩層，有時下部之礫岩變富，上部之礫岩減少，二部殊少顯著之劃分。全系厚度約達六百餘公尺。其時代屬二疊三疊紀及三疊紀從王竹泉君言。

石拐煤系　本系卽王竹泉之上煤系。在察綏兩省均能見之。其分佈于綏遠則以在大青山者為最發育，曾經王竹泉君從事勘察，論述綦詳，作者雖一至其地，而所經目擊者不過其中一部份無從深述。玆就王君之報告採擇錄述而說明之，其言曰，本煤系（參閱第十九剖面圖），大部為綠色頁岩，砂岩，礫岩，煤層等，總厚計達四百公尺。在巴

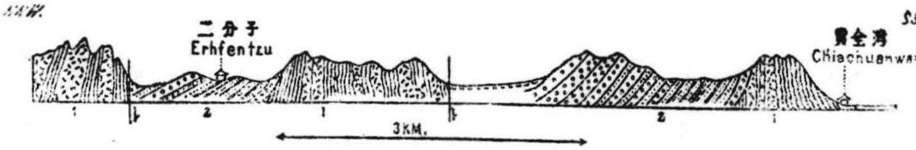
免溝本系地層平行于二疊三疊紀砂頁岩以上，其底層爲礫岩，礫石多石英岩。在毫賴溝子，亦有同樣之情形。在黑牛溝及壩口子者，因斷層之關係露頭多不完整。在東西溝內之柳樹灣一帶者，擠壓劇烈極形折曲之態，惟大青山西部露出之煤系，東始討子號以北之大溝，西達石拐鎮，分佈既廣，岩層亦多平整，在大溝及三道壩附近，本系含石灰岩數層，中產魚類化石，又于五達溝石拐鎮揚圪墶等處，採得植物化石多種，如 Cladophlebis cf. acutangula, Baiera sp. Czekanowskia rigida Heer. Podozamites lanceolatus Heer. Asplenium whitbyense Heer. Coniopteris sp. 等。

第十九圖　白石頭溝地質剖面圖

1. 桑乾系　2. 二疊三疊紀及三疊紀紅色頁岩及砂岩

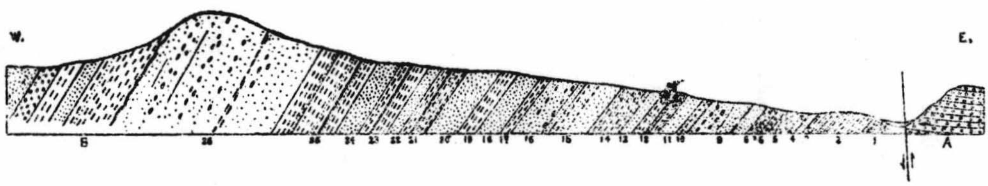
3. 下侏羅紀煤系　4. 中及上侏羅紀紅色頁岩及砂岩

就王君所述，石拐煤系多與薩拉齊砂頁岩系成平行接觸之關係。而此次作者在色爾騰山所經目擊者，本煤系皆逕覆太古界片麻岩之上，薩拉齊砂頁岩系則未之見。今試論露出于色爾騰山之石拐煤系。色爾騰山之石拐煤系分佈凡三處，一在安北縣東北之二十年地溝，一在安北縣東之官井溝（參閱第二十剖面圖），一在固陽縣西之窩沁壕。皆構造單簡，地層整齊。岩石全系自上而下變化頗微，純以灰綠色砂岩爲主，各部無顯明之差別。就岩石組織而論，大抵上部爲細砂岩，夾重要煤層，近煤層處多爲灰色黑色泥砂質頁岩。下部爲粗砂岩，常含礫石，夾重要煤層，其上下地層不爲頁岩，多細砂岩，與上部略有殊異。全系厚度各處無甚軒輊，就官井溝煤系之露出估計，約達五百公尺。地層暴露甚少，窰坑率多浮淺，岩石由坑內取出者亦尠，故化石頗不易得，惟在官井溝萬和窰附近接煤層之頁岩內，採集植物化石數種，數雖不多，然皆形狀清晰，頗足藉以証明煤系地層之時代，化石經健初粗略鑒定，有 Podozamites lanceolatus, Todites williamsoni Brongn., Cladophlebis denticulata Brongn., Coniopteris sp., Anomozamites schmidti Heer, Thyrsopteris sp. 諸種屬，約與北平西山之門頭溝煤系相當，蓋屬于下侏羅紀者也。武川之西，平岡起伏皆爲紅土，在炭窰村附近破土而見頗軟之灰色砂頁



第二十圖　賈全灣二分子間地質剖面圖（卽色爾騰山東部）

1. 太古界片麻岩及花崗岩　2. 下侏羅紀煤系



第二十一圖　土木路恆升煤礦附近之下侏羅紀煤系

A. 白堊紀礫石　B. 上侏羅紀頁岩砂岩及礫岩

岩（層近平行），中夾甚薄之褐性煙煤層。其時代因乏化石不易確定，惟其岩性煤質類似窩沁壕之煤系，姑歸之于下侏羅紀。

石拐煤系，分佈于察哈爾，而在西南部者，凡二處，一在土木路之西，一在馬蓮疙瘩附近，皆假連續于中上侏羅紀砂頁岩系之下，而底部不見。其露出之部份，厚由一百八十公尺至二百公尺。

本系岩石自下而上少變化，以灰色泥質頁岩及中粒砂岩爲多，夾重要煤層，已經各礦開採。玆將在土木路西北所見地層色性，自下而上述之如次（參閱第二十一剖面圖）。

一	粗粒黃白色砂岩	四五公尺
二	灰綠色或紫色泥質頁岩	二
三	棕色中粒砂岩	三．九
四	淺白色中粒砂岩夾煤層	一二
五	淺白色粗粒砂岩	二—七
六	灰色砂質頁岩夾煤層	○．三
七	粗粒灰色砂岩	一．二
八	深灰色頁岩	四○
九	白灰色礫質砂岩夾煤層	一．三
十	灰色砂質頁岩	十九

十一	中粒砂岩	七
十二	黃灰色泥質頁岩	七・一
十三	白棕色中粒砂岩	三
十四	灰色砂質頁岩	七・五
十五	黃棕色中粒砂岩	一七
十六	礫質砂岩	七・五
十七	灰綠色頁岩	一
十八	灰白色中粒砂岩	六・六
十九	灰色砂質頁岩	五
二十	中粒砂岩	一五
二十一	灰色泥質頁岩上部夾煤層	七
二十二	灰色中粒砂岩	八・二
二十三	灰色砂質頁岩夾煤層	一二
二十四	灰白色中粒砂岩	一一
二十五	灰色泥質頁岩夾煤層	三一
二十六	白棕色礫質砂岩	五五

馬蓮疙瘩西北三十里之西營子附近，亦有下侏羅紀煤系之露出，惟作者足跡未至，無由詳述，就李希霍芬之觀察（China, Vol. II, Part III. 1882），大致本系岩石以灰色泥質頁岩爲多，內夾砂岩層及煤層　地層平緩，向東北約十度(似與以北之震旦石灰

岩成斷層之接觸）其中富含植物化石，如 Asplenium whitbyense Brong. Anomozamites sp., Pterophyllum richthofeni Schenk. Podozamites gramineus Heer, Elatides chinensis Schenk. 等，皆下侏羅紀之產物也。

小北嶺礫岩層　本層爲在內蒙不多見之地層，其時代因乏化石尚難確定，但就其層位上論之，當屬中侏羅紀或下侏羅紀之末期。岩質，大抵底部多灰綠色粗砂岩，中上部皆爲礫岩所組成，礫岩中之礫石，多爲片麻岩，砂岩，石灰岩，或各種火成岩如花岡岩斑岩者，直徑皆由一尺至二寸不等。本層在綏遠之露頭，就今所知者僅有官井溝北之小北嶺一處，整合于下侏羅紀煤系之上，厚約二百五十公尺，二者成連續之關係者頗爲顯著也。

大青山頁岩砂岩系　本系出露于大青山之喇嘛溝，黑牛溝，白石頭溝，水間溝，水磨溝，孫爾溝，東西溝，得勝溝，及大青山東南之馬蓮疙瘩，閻家窰子等處。全系以紅色或綠色砂岩頁岩爲主，中夾礫岩層，礫石以片麻岩爲多。其中雖因乏化石，不易確定其時代，而王竹泉君以山陝兩省豐富之經驗，斷其屬之于中上侏羅紀，已屬至當。其在各處與下侏羅紀煤系之間，頗難得明確之界線，但在土木路一帶，石拐煤系之頂部爲硬砂岩，其上緊接以本系之疎鬆礫岩及紅綠色頁岩，二者之岩性截然不同，謂其間之關係爲不連續，亦或近諸事實也。全系總厚約達五百餘公尺。

土木路系　本系隱伏玄武岩流之下，賴以河流侵蝕而顯露，露出之地，在察省之土木路及其以東之大營盤，二者相距約八十里。

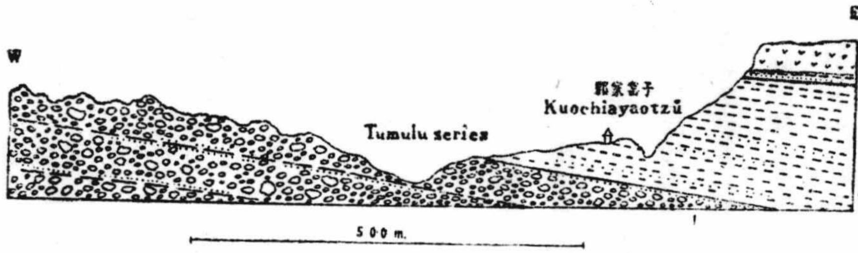
本系地層與以前地層不相整合，其情形在土木路一帶極爲明顯，蓋土木路附近本系之下，有上侏羅紀之砂礫岩及下侏羅紀之煤系，至桃李莊附近（至是底基較高，而本系變薄僅見其上部之岩層矣），則本系已直覆于太古界片麻岩之上，而侏羅紀地層皆缺而不見，以示極不整合之大觀也。

本系岩石凡分上下兩部，下部全由礫岩所組成，厚約二百餘公尺，礫石一部體積頗巨，稜角顯然，爲河流之漂礫，一部小而成圓形，其面已受一度之風化，係來自侏羅紀之礫岩，其質爲片麻岩花崗岩與深色之火成岩等，粘合物爲白色細砂及灰色粘土，

惟以細砂爲多。上部爲紅土，其中多石英長石之砂粒，厚約二三百公尺，大概當本系地層沈澱以前，土木路一帶爲廣闊之溝谷，由侏羅紀砂礫岩所組成，環而峙者，係太古界片麻岩之高山，山勢既高，侵蝕益速，始則山澗急流冲下漂礫，沈積于谷底，繼以風雨剝蝕，山巔之粗砂細泥移積于其上，夷山就谷，使當時之山溝，成爲一片平地也。

漢諾壩玄武岩　玄武岩多見于綏遠之東部及察哈爾之西部，自漢諾壩經興和縣以至集寧，再由集寧經奎騰梁而及陶林之西，沿途皆有玄武岩，繼續相連，覆掩于桑乾系，薩拉齊系，大青山系，土木路系等地層以上，其下爲一侵蝕平原如前所述（參閱第二十二第二十四第二十五等剖面圖），而組成嶺巔瀰平之高山。又集寧之南，豐鎮涼城一帶之山嶺亦多由玄武岩所組成，掩覆于片麻岩之上，位置雖低，而其底下之地形，極類興和等處玄武岩下北台平原之情形，其與漢諾壩玄武岩，實有血統之關係也（大同附近有零星分佈之玄武岩，其時代，已經地質學者証明較漢諾壩玄武岩爲新，其與豐鎮一帶之玄武岩，當然同時之產物矣）。漢諾壩玄武岩，大致色黑質堅，土人每取而用之爲建築石材，間有具氣孔者，惟孔多虛，其不虛者塡有瑪瑙質或方解石，如在張北之二台子，陽原之石寶莊，集寧之鹿角壩等處所見者是也。其柱狀構造頗不顯著，僅于下納嶺附近見之，如第一版乙圖所示者。漢諾壩玄武岩之下，常有疎鬆之砂礫及粘土或頁岩，中夾褐炭層，如大營盤，郭家窰子，劉家溝，馬蓮灘，莊馬台等處之煤系即是，皆似覆于片麻岩之上，而成不整合之接觸，惟在漢諾壩附近，此煤系夾于玄武岩之中間（參考地質專報甲種第三號及第六號），與上所述者略有殊異。大概漢諾壩一帶煤系以下之玄武岩向西漸次變薄，至綏東已失其踪跡矣。至玄武岩之時代，因其以下之煤系中未得化石，無由確定，惟在漢諾壩一帶，其玄武岩中之煤系，產有植物化石，如 *Pinus* sp., *Camptonia anderssoni* *Carpinus* sp., *Phyllites* sp. 屬第三紀之中期，撫順玄武岩，亦由其相間遞積岩內之植物化石，確定其屬于漸新統，本區之玄武岩與漢諾壩一帶之玄武岩本屬一體，其爲第三紀中期之岩流，已屬毫無疑義也。

紅土層　與各層均成不整合之接觸，多分佈懷安，陽原，興和，集寧，陶林，武川等處，尤以武川盆地之紅土最爲發育。本層內不含化石時代未能確定，惟就岩性觀之，頗似安特生氏在內蒙他處所見之中上新統之地層（參閱地質專報甲種第三號第四

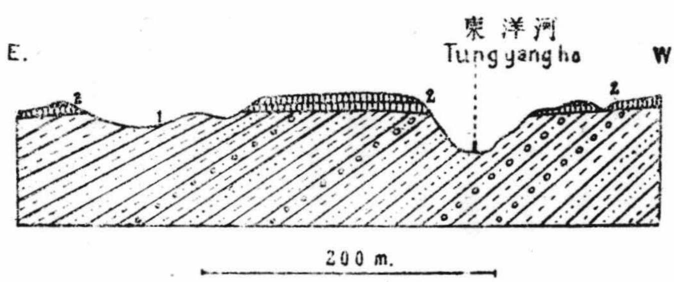


第二十二圖　土木路東郭家窰子附近地質剖面圖

1. 礫岩　2. 紅色粘土及頁岩　3. 玄武岩及底部砂頁岩

第二十三圖　集寧北烏得溝上部地質剖面圖

1. 桑乾片麻岩　2. 黃白色沙內含褐炭　3. 漢諾壩玄武岩

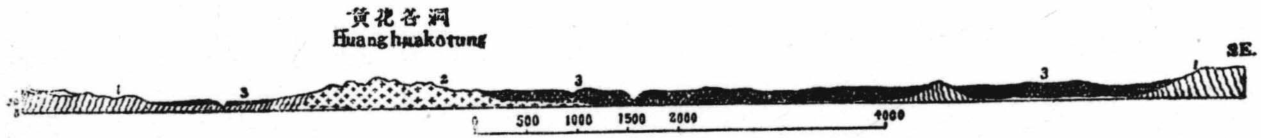


第二十四圖　閻家窰子地質剖面圖

1. 上侏羅紀紅色砂岩及頁岩　2. 玄武岩

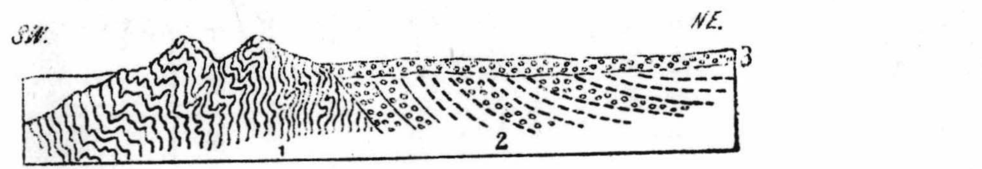
第二十五圖　三道營子附近地質剖面圖

1. 片麻岩　2. 玄武岩　3. 紅色粘土



第二十六圖　黃花各洞一帶玄武岩下之起伏地形

1. 片麻岩　2. 花崗岩　3. 玄武岩



第二十七圖　什那干東南十五里地質剖面圖

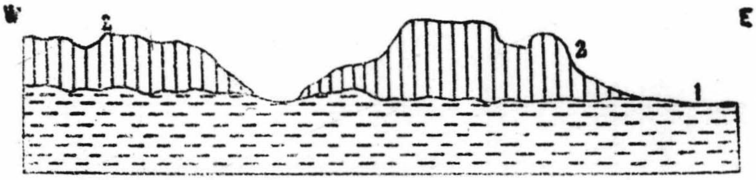
1. 片麻岩　2. 紅色或綠色粘土　3. 礫石

十七頁），故暫定其屬于第三紀之後期。岩石以紅色或綠色粘土爲主，有時夾有砂礫層，多呈傾斜狀（參閱第二十七剖面圖），似曾受一期動力之影響。全層厚度頗不一律，大約由三十公尺至六十公尺，常組成一帶岡阜及低地。

黃砂層　本層似不整合紅土層之上，分佈于陽原，包頭，台梁，什那干等處，岩質以黃白色細砂爲主，中有片麻岩之礫石層，其團結硬者而成砂岩及礫岩，傾斜頗緩，厚由二十餘公尺至四十公尺。德日進氏曾在鄂爾多斯西部，于中上新統紅土層以上，發見白砂層，並採有上新統之化石（參閱地質會誌第三卷第一期第四十頁），然則本層或與之相當而屬上新統歟。

礫石層　本層爲更鬆散之地層，約屬于第四紀，常常平舖于紅土層或黃砂層之上，最著爲固陽縣，什那干，安北縣等處（參閱第十第二十七剖面圖）　礫石膠粘不固，成層不顯，大都爲石英岩，石灰岩，片麻岩，中與砂土相混生。厚薄隨地而異，在固陽什那干附近，厚不過十公尺，而在安北據各處鑿井之結果，在五十公尺以下始見他層矣。

黃士層 本區除蒙古高原外，谷旁山坡上，恆有黃士層，農墾者多穴居于其中，如哈德門溝，白榮溝，水間溝，三道營子溝，陽原縣，懷安縣等處所見者均是。常常位于片麻之上或紅士或黃砂之上（參閱第二十八剖面圖），黃士雖有直立節理之可辨，有如風成層，然其中之平横石礫有時甚爲清楚，頗似藉賴水力而成者，蓋原生黃士生成之後，一部因水力之冲擊，而重行遞積也



第二十八圖　陽原縣八馬房附近地質剖面圖

1. 上新統黃色粘土　2. 黃士

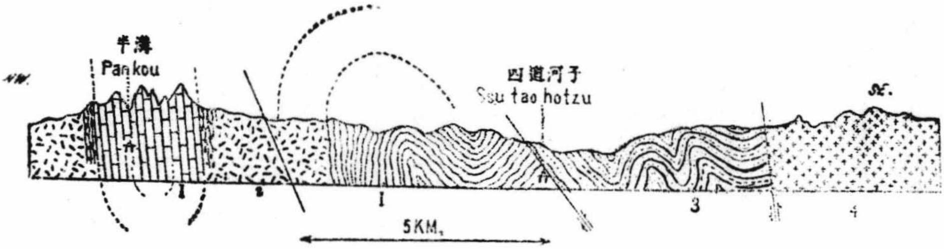
冲積層 本層爲最新之地層，凡寬谷高地之砂礫，及河流兩岸低地之淤士均屬之，厚度不一，顏色有殊，大部爲灰白色，有時呈棕色及黑色，厚度通常在五公尺至二十公尺之間，砂礫多見于洋河谷及高原上之平地，分佈所及概成磽地不利種植，淤士多分佈于黃河，黑水河之兩岸及高原之凹地，恆爲肥美之農田，如五原臨河一帶，已成綏遠重要農業之士地也

火成岩

水成岩，變質岩，火山岩，組成各種地層者既如前述，此外猶有侵入各層岩石中之火成岩，就觀察所知，種雖不多，然多于礦產之生成有密切之關係，故另分出，以便詳述 火成岩侵入各地層內，有時相交切，先後之序可尋，按其次序，考其成份，其岩漿，就大體論之，係由酸性而轉變爲基性也。

酸性岩類 酸性岩類，爲古花崗岩及新花崗岩兩種，此兩種岩石，驟視之似無大異，而其侵入之情形，變質之深淺，已確不同，試分論之

古花崗岩，侵入桑乾系片麻岩內，沿途調查，屢經目擊，其生成狀態，或乘隙迸出而成岩牆，或沿片理侵入，而成岩層，如在色爾騰山，大青山，奎騰梁，凉城山，南口嶺等處所見者，頗爲顯著，厚薄不等，由數百公尺至一二尺，惟與其接近之片麻岩，或受漫染或被交換，融合如一體，其界限不易畫分。此花崗岩，在桑乾系內雖極豐富，但侵入于五台系地層以內者尚未之見，故推其生成，似與五台系同時，而屬于早元古界，片麻組織不甚清楚，即或爲

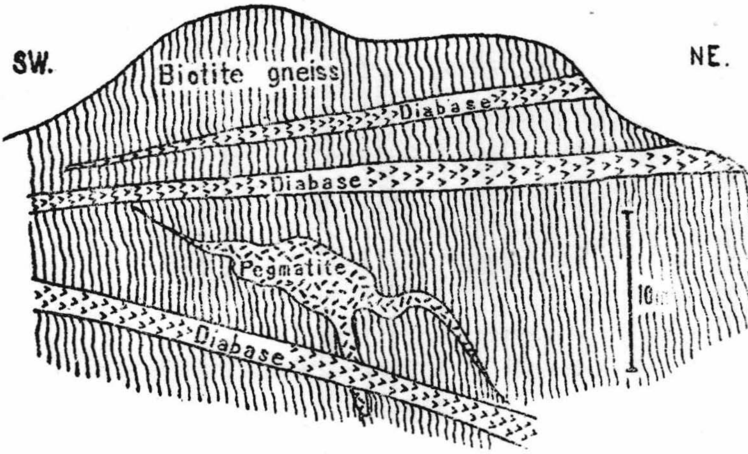


第二十九圖　武川四道河子榆樹店子半溝一帶之地質剖面圖

1. 桑乾片麻岩及大理岩　2. 元古界花崗岩　3. 上侏羅紀紅砂岩
4. 中生代花崗岩

後來侵入之岩體，其時代，亦必較震旦紀爲古，蓋什那干石灰岩分佈所在，即不整合于其上，並曾受動力之影響，礦物組織，已略具變質岩之觀，如石英破裂，消光不均，斜長石略呈灣曲之狀（第十六版丙圖），是皆似變質岩組織之証，而與普通花崗岩却不相侔也　此次採集之標本，而在顯微鏡下研究者，爲（一）大青山廟兒溝花崗岩侵入片麻岩內，界限未能畫分，色多淺紅，石質頗堅，所含石英不多，晶體不大，正長石量多，晶形大致整齊，斜長石較少，晶體大小不一，因受變動而常形灣曲，並經破裂，黑色礦物爲角閃石，形整而量多，呈綠色或黃綠色，一部變質分出磁鐵礦及赭鐵礦，赭鐵礦常與白色物質相伴生　（二）色爾騰山二十年地溝，花崗岩侵入基性片麻岩內，亦無清晰之界限，色紅質堅，略呈片麻組織，故組成色爾騰山之嶺脊　造岩礦物，以正斜長石及石英爲多，黑雲母次之，石英晶體頗大，晶形大致整齊，正長石晶形亦頗完整，一部變成高嶺土，時與鉀微斜長石伴生，其交紋構造，頗爲顯著，斜長石晶形大小不等，略形灣曲，消光不均，黑雲母呈淺黃綠色，一部變爲磁鐵礦

新花崗岩，出露于小大青山，黃花各洞筆架山，萬家溝，軍懷梁，賽林忽洞等處（參閱地質圖第一二三四五等幅），侵入各紀地層中，惟較新之地層，大部已被侵蝕以去，故現在所經目擊者，多在桑乾系內侵入而成岩基，冲斷圍岩，界限截然，其周圍細脈歧出，填充圍岩裂隙中，而成偉晶或微晶花崗岩脈，惟新花崗岩與古花崗岩之關係，尚未尋獲顯著事實，以証明之，但新花崗岩分佈所在，常有古花崗岩露出其附近，扭轉灣曲變動顯然，此種情形，實與新花崗岩侵入擠迫有關也　至新花崗岩生成之時代，其在筆架山南之甘溝子一帶，與拴馬樁煤系地層相接觸，岩石一部，變成黑色片岩或千枚岩，煤亦近于石墨質，固可謂其後于二疊石炭紀，然在萬家溝一帶，如翁所長所言，



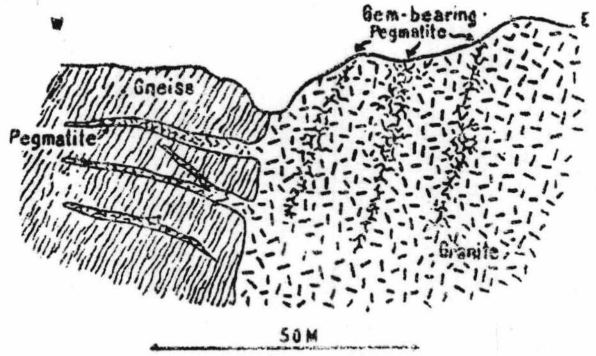
第三十圖　才腦包附近地質剖面圖

花崗岩雖與大溝西溝煤系成斷層之接觸，而砂頁岩呈黃紅色，未見何等之變質，且大青山侏羅紀之有烟煤至此乃悉成為無烟煤，顯然由于花崗岩侵入影響，而變質。又小大青山一帶地質構造，頗為簡單，故土木路之煤（下侏羅紀）皆屬有烟煤，惟至小大青山花崗岩附近，如馬蓮疙瘩之煤，乃忽成為無烟煤，此變質作用，似舍花崗岩侵入外，殆無他解之可能，由是可見花崗岩之生成，實應後于侏羅紀。惟漸新統之玄武岩流，往往蓋覆于花崗岩之上，可知花崗岩較古，其生成必在漸新統以前矣。大概本區新花崗岩之侵入，與褶皺運動同時，而屬白堊紀之初期　玆將各處花崗岩分論如下，（一）黃花各洞花崗岩，露出于黃花各洞及草多山之間，東西延長十餘里，其中有偉晶花崗岩脈　為各種寶石如水晶，藍晶，黃玉等，儲藏之所，而其脈旁出，侵入于片麻岩中，成為偉晶花崗岩者（參閱第三十一剖面圖），亦時見之。花崗岩分佈所在，多為浮土所蓋覆，或掩于玄武岩之下，故其與片麻岩之接觸情形，不易窺悉，惟黃花各洞西南有一河谷，沿花崗岩體南部而深切，故花崗岩得以顯露，而其與片麻岩之接觸面；亦得直接露出，供吾人之研究，接觸面近直立，極為清晰，近接觸面之片岩，富含雲母，中有偉晶花崗岩之侵入脈，近接觸面之花崗岩，晶粒較小，而片麻組織不甚顯著。

黃花各洞花崗岩，以粗花崗岩為主，中有文像花崗岩及偉晶花崗岩，各花崗岩之礦物成分，就此次觀察及顯微鏡研究所知者，大抵粗花崗岩之主要礦物，為正長石，鈉鈣長石，石英，黑雲母及角閃石，副礦物，為磁鐵礦，磷灰石。偉晶花崗岩之主要成分，為正長石，石英及黑雲母，副礦物，為藍晶及黃玉。文像花崗岩之礦物，為正

長石，及石英。茲將各種礦物，分別說明如次。

正長石，大致呈淺紅色，在各種花崗岩中均佔重要之位置，如在粗花崗岩中，平均約佔百分之五十，在偉晶花崗岩中，平均約佔百分之四十，在文像花崗岩中，平均約佔百分之四十五　鈉鈣長石，爲量不多，僅于粗花崗岩內見之，約當正長石四分之一。



第三十一圖　花崗岩內之偉晶花崗岩脈其中產寶石

石英呈黑色或呈白色，亦爲各種花崗岩重要之成分，尤以在偉晶花崗岩內者爲最多，常乘隙而成水晶礦，故探水晶者，每藉以爲探礦之指南。

黑雲母及角閃石，在粗花崗岩內時有所見，惟角閃石爲量甚微。

磁鐵礦置顯微鏡下呈黑色，在粗花崗岩內偶或見之

磷灰石在顯微鏡下呈柱狀，爲粗花崗岩內常見之礦物。

藍晶呈淺綠色，分透明與不透明兩種，皆生于偉晶花崗岩內（詳礦產章），惟爲量極少不易尋獲

黃玉多呈淺綠色，產狀與藍晶相同，在偉晶花崗岩中更屬少見。

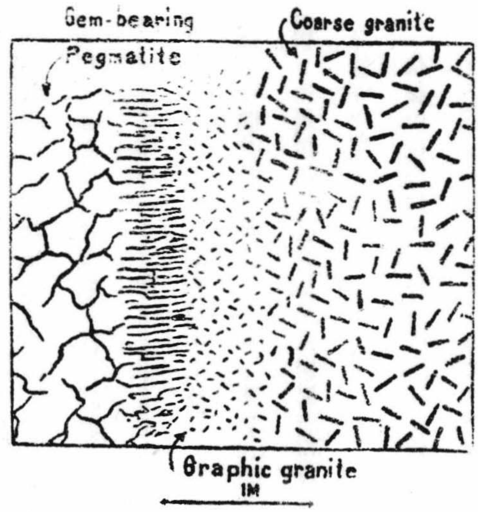
高嶺土常見于偉晶花崗岩之孔隙中，而附屬正長石之上，顯非原生之礦物

白雲母每夾于正長石之裂縫中，亦次生礦物也。

以上所述，不過就幾處岩石露頭所得之少數標本，研究說明其大概，如將來，此一帶之寶石礦從事大作，多採岩石標本，詳細研究，則各種造岩礦物之分配，當有變更，而其種類亦或有增加也

各種花崗岩之構造，就大體言之，其粗細之分頗爲顯著，就內部言之，其各種礦物之結構情形亦甚明晰，大抵粗花崗岩呈塊狀，易腐化，有極清楚之節理（參閱第八版甲乙圖），惟就大體而論，大致石質堅實，故成黃花各洞一帶之嶺脊　各種礦物，晶體

頗大，組織均勻，石英晶形大致整齊，直徑由二公釐至五公釐，正斜長石晶形更整而鉅，普通長達一公分，黑雲母角閃石形體較小，三者雜淆而生　偉晶花崗岩見于粗花崗岩內，惟與粗花崗岩共生，其界限不易分劃，故推其生成，實與粗花崗岩有關，而爲其晶體較大之一部，其中石英及正長石均形整而體鉅，最大者直徑常達十公分，二者混淆而生，有時中夾雲母片，惟石英往往侵入正長石之微隙中，示石英生成于正長石結晶以後之徵象　文像花崗岩所見不多，皆生于粗花崗岩及偉晶花崗岩之中間，爲二者之過度岩（參閱第三十二剖面圖），其中石英生于正長石內，二者俱爲柱狀放射之給合體，長由二公分至四公分，顏色深淡相映，



第二十二圖　花崗岩偉晶花崗岩及紋像花崗岩三者之關係

頗爲美觀　此外尚有類似文像花崗岩而缺少石英者，常生于花崗岩內孔隙懸壁上，長石爲扇形放射之結合體，其放射方向均與懸壁成直角，此類結構，美國地質學者博斯頓氏 (E. S. Bastin, Geology of the Pegmatite and associated Rocks of Maine. Bull. U. S. Geol. Survey, No. 445, PP. 23) 名之謂毛刷構造，蓋長石晶形隨放射而展寬，頗似扇形而亦類毛刷也。（二）賽林忽洞花崗岩，侵入桑乾系內而成岩基，其在西南，時分出細脉而入于片麻岩內，頗爲清晰，惟其東北兩面，浮土到處分佈致掩其跡，詳細情形不易窺悉。岩體露出地面者，東自十成子，經賽林忽洞，西至孔都崙，南始大窩兎，北抵保拉兎，縱橫所及約達百餘方公里，惟孔都崙之西南，復有花崗岩之出露，似仍向西南延長而至沙墕子，果爾，則花崗岩之露頭，長可達三十餘公里。

賽林忽洞花崗岩之組織成分，隨地而生變化，在水溝一帶，黑雲母頗多，而石英較少，呈中粒組織，在小窩兎賽林忽洞查沁等處，黑雲母減少，而石英變富，組織較細，但往往漸變而成偉晶花崗岩脉。此次所採標本，而作顯微鏡研究者，爲水溝附近富含雲母之花崗岩（以下簡稱甲），賽林忽洞附近富含石英之花崗岩（以下簡稱乙），及查沁附近之偉晶花崗岩脉（以下簡稱丙）

甲呈灰色或淺紅色；礦物爲石英，正長石，斜長石，鉀微斜長石及黑雲母，副礦物，則有磷灰石等，石英，正長石，斜長石及鉀微斜長石，均晶體不甚大，惟晶形頗整齊，黑雲母形整而體大，呈淺黃棕色，一部風化成綠泥石，一部變質而分出磁鐵礦。乙爲淺紅色，質堅，礦物以石英正長石爲最多，鉀微斜長石次之，斜長石又次之，黑雲母甚少，常變爲綠泥石，石英晶體大小不等，惟晶形完整，消光均勻，正長石形整體大，一部變成高嶺土，鉀微斜長石體大而整，其交紋構造極爲清楚，黑雲母晶形不甚完整，呈淺黃綠色，一部變成磁鐵礦。內之礦物成分爲石英，正長石，鉀微斜長石，雲母片嵌于長石裂縫中者亦常見之，石英乘隙而成各種水晶礦，如墨晶紫晶等（詳礦產章）。（三）小大青山花崗岩，露出于小大青山之西部，侵入太古界片麻岩內而爲岩基，其中有偉晶花崗岩脈，亦產墨晶藍晶等，本花崗岩同黃花各洞花崗岩，大部呈塊狀，石粒頗粗，組織均勻，僅近于邊際者略顯片麻之形狀。主要礦物爲石英，正長石，鈉鈣長石，黑雲母，石英甚富，或晶體頗大或成小粒，正長石形整體大，其量亦多，鈉鈣長石不過偶或見之而已。（四）筆架山花崗岩，出露于大灘及活佛灘之間，西北東南長約四十里，西南與桑乾系及拴馬樁煤系相接觸，拴馬樁煤系已受其侵入影響而變質，既如上述，其東北面尚未涉足，詳細情形無從紀述，惟度其位置，似與銀礦山一帶之片麻岩相接觸也。

筆架山花崗岩，大致石色淺紅，粗粒組織，惟時變粗，而成偉晶花崗岩脈，爲水晶礦儲藏之所。造岩礦物，極似黃花各洞花崗岩，富石英及長石，黝色礦物，爲黑雲母，長石中正長石多于斜長石　（五）萬家溝花崗岩，亦爲侵入之岩基，中夾片麻岩碎塊，其西北與侏羅紀地層成斷層之接觸，南與桑乾系五台系成侵入之接觸，東與侏羅紀地層相鄰接，其間之關係不甚清楚，王竹泉君曾謂其爲侵入之接觸，惟就作者一部之觀察，接觸帶內之岩層雖質地堅硬，而其色澤未常稍變，似在侵入接觸帶內不應有此事實也。

萬家溝花崗岩之岩石性質，隨地而異，在沙灣附近，石色淺紅，中粒組織，造岩礦物富長石石英，與黝色礦物量幾相等，長石中正長石多于斜長石，黝色礦物，角閃石多于黑雲母，二者變質分出磁鐵礦　海流素一帶，晶粒較粗，石英與長石量幾相若，

黝色礦物爲黑雲母，而少角閃石　（六）卯不亥附近軍懷粱花崗岩，暴露所在，南始東溝，北至紅沙墻，寬約八九里，西自卯不亥之北，東至各爾兒溝，相距十餘里，尙未盡其端。各面皆與片麻岩相接觸，接觸面頗爲淸晰，有時中有石英脈，石英脈中夾鏡面赤鐵礦，且其西南面有細脈歧出，侵入于片麻岩之裂隙中。岩石呈淺紅色，晶粒不粗，造岩礦物，以長石爲最多，石英及黑雲母次之，長石除正長石及鉀微斜長石外，尙有少許之斜長石，晶形皆頗整齊，石英及黑雲母，晶形不甚完整，黑雲母一部變成磁鐵礦。（七）近期花崗岩之重要岩體已如上述，此外尙有偉晶花崗岩脈或長英岩脈，侵入桑乾系內，而偉晶花崗岩脈，往往橫斷片麻岩之片理，就其岩石性質觀察之，頗似時代甚新，例如賽林包溝，苦洛圖溝（烏拉山），才腦包溝（大靑山），等處所見者，偉晶花崗岩脈富長石石英，黝色礦物爲黑雲母或角閃石，微晶花崗岩脈，長石與石英幾相等，而少黑雲母及角閃石，其中常夾鏡面赤鐵礦（詳于礦產章），二者常爲基性岩脈所切割，惟皆未經元古界之變質，其時代大抵在古花崗岩以後，而與新花崗岩同源同時也。

基性岩類

基性岩類，就此次所經目擊者有以下之二種，（一）輝綠岩生于桑乾系，成岩墻及岩脈，有時與偉晶花崗岩脈相切割，石色深淡交錯意態如畫，極侵入之美觀。岩石呈黑色，性質堅重，在顯微鏡下觀察，大致石岩組織顯明，礦物以斜長石及輝石爲主，斜長石大部爲鈉鈣長石，常生于輝石之中間，示輝綠岩組織之特徵，副礦物，有磁鐵礦。此岩既侵入桑乾系內，橫切偉晶花崗岩脈，而偉晶花崗岩脈之時代，約屬白堊紀之初期，前已言之，其生成當在中生代以後，大概與漢諾壩玄武岩之噴出同時，而屬第三紀之中期也　（二）安山岩露出于毋哈溝及東五素圖，侵入什那千石灰岩及薩拉齊砂頁岩系內，成岩牆，石色淺綠，風化甚烈，故其組織成分不易判別，其侵入最新之地層爲二疊三疊紀，就此，僅能謂其生成之時代晚于二疊三疊紀也。

構造

地質構造大致言之有二種，因橫壓力之推擠，而使地層褶曲錯裂者，其現象謂之褶皺。循直壓力之方向，使地層升降斷裂而不大褶曲者，謂之斷層。今日之地形卽簡接出于是，故地形構造有生成之關係。而礦產之成毀亦隨之而起，譬如一地層因斷裂而

深陷，岩汁得以侵入而生礦床，復經一次變動，則含礦之地層隆起露出，而予吾人以可採之寶藏。又如一煤田，煤層呈平整，向各方延長，因褶皺斷層致失煤田之價值，故研究礦產者之所以不可不知地質構造也。本區之山嶺平地，多與斷層有生成關係，而褶皺更為發育，多經王竹泉君研究，惟其足跡所至只限于大青山本部，茲則觀察他面較廣，或不妨總合紀述以補王君前勘所未及，其情形如次。

褶皺　褶皺影響所及之地層，可分兩組言之，一，為太古界及元古界之地層，二者之間隔以不整合。二，即震旦紀至上侏羅紀之各地層，不整合上述地層之上，而其彼此相平行，茲分論之。

太古界地層及元古界地層之褶皺，頗為顯著，沿途觀察屢經目擊，例如自哈德門溝口北行二十里，沿途露出之岩石悉為片麻岩，走向近東西，傾斜大致成直立　再北行至召店嶺，見有大理岩數層夾于片麻岩內，此項事實，驟視之似為一連續層，但苟為連續層，則所見片麻岩厚達數千公尺，其性質必不同，今自下而上變化甚微，純以雲母片麻岩為主，各部無顯著之差異，且與大理岩相間疊之片麻岩亦具同樣之性質，可知片麻岩及大理岩，必為一緊閉式的褶曲層，如第六剖面圖所示者。倘吾人假定大理岩為一背斜層，則片麻岩較大理岩為新，反是，則片麻岩較古，惟就岩性觀察之，似後說近乎是實也　山神廟至牛溝間所見之片麻岩，因花崗岩侵入之影響，構造頗不清楚，惟其中之大理岩，自南而北露出者凡三四次，且其傾斜，大致向南向北頗有一定（如山神廟附近大理岩傾向西北約五十度，牛溝一帶大理岩傾向東南約七十度，）其亦似經相當複雜之褶皺，而成許多東西走向之向斜層及背斜層　陶林東南討賴溝內，則有大理岩厚約五十公尺，夾于酸性片麻岩內，大致作東西走向，傾斜向北約六十五度，其北面露出之大理岩，因花崗岩之擠迫構造頗不清楚，惟南面尚有大理岩三層，露頭明顯，厚各四五十公尺，夾于酸性片麻岩內，皆作東西走向，傾斜近直立，各層大理岩之性質，厚薄既無二，其鄰接之岩層又從同，其為褶皺構造（參閱第七剖面圖），昭然無疑。又黃花各洞西南出露之片麻岩及大理岩，一致傾斜向東南。色爾騰山東部露出之片麻岩，大致傾斜向西北或東南，傾角由六十度至八十五度，其褶皺構造皆頗顯著。大青山南面，常常露出片麻岩及大理岩，其傾斜向南及東南，就王竹泉君之考察，

亦多褶皺之構造，如巴克兎溝馬劉村北之片麻岩，顯示背斜層之構造；黑牛溝老道村附近之大理岩，則成一急峻之背斜層。至元古界地層露出不多，既如前述，故可以供吾人研究之材料者甚少，惟就幾處露頭觀察之，其褶皺構造亦頗顯著，如因陽以北之元古界石英岩及大理岩，傾向東北及西北，傾角約二十度，在窩沁壕以北之石英岩，傾斜約三十度，而方向相反，適成一東北西南方向之向斜層。大青山萬家溝內所見之石英岩，露頭寬達五六里，傾斜向西北，傾角甚急在七八十度之間，岩性各部相同，無顯著之差異，按石英岩之厚度，就在他處所見者，僅有數百公尺，而此處據露頭距離計之，至少當有三千公尺，可知必有變動以致之，似又爲一緊閉式的向斜層也。

震旦紀至上侏羅紀各地層之褶皺劇烈，常成錯斷，其褶皺錯斷極好之模範區域，爲大青山，王竹泉君已詳言之，惟此次所歷各地之構造，已有褶曲錯斷之可見，而地層倒轉之形跡尤極褶皺構造之大觀，可知各地之地質構造，實皆互相關聯，彼此相証更爲明顯。茲先述大青山構造之大概，悉採自王君之報告，次言此次歷經各地之構造，覈實紀述以資互証焉。(一)壩口子温家溝一帶，二疊三疊紀及下侏羅紀岩層略成一向斜層，向斜軸爲東北西南向。(二)自水磨溝經黑牛溝珠爾溝至西溝長約四十餘里，再西逾花崗岩經大溝，以前賞，三道壩，胡同兎，童盛茂，以至石拐鎮長可一百一十里，則二疊石炭紀至中上侏羅紀，除地層局部略呈褶皺或經陷落外，大致傾斜向北，普通傾角由十度至六十度，惟其以南自白石頭溝至老窩鋪間，二疊三疊紀及下侏羅紀地層之傾斜相反，斜角爲三四十度。(三)白石頭溝逆掩褶斷，在石拐煤田之南界，自東至西經鷄毛窰子，前增場，中保圪素，至白石頭溝之東長約一百里，但褶斷線頗有向東延展經東西溝至老道溝之趨勢，果爾則其長可達百五十里。其南之片麻岩，常常與其北之二疊三疊紀岩層成直接之接觸，而二疊石炭紀煤系轉被覆掩于褶斷面之下，其褶斷距，逾東而愈增，似以老道溝附近爲最大。(四)陰山逆掩褶斷，在石拐煤田之北界，西起包頭東北之鷄毛窰子，中經缸房地，胡洞兎，後小壩子，老道溝，喇嘛洞，以至水磨溝之東南，褶斷綫長約二百里。在老道溝四道河子北，每于片麻岩之上露出中上侏羅紀之岩層，頗足爲逆掩褶斷之証據。惟在缸房地下侏羅紀煤系與片麻岩相接觸，而在胡同兎後小壩子喇嘛洞等處，皆以中上侏羅紀岩層與片麻岩相接觸，似亦可以正斷層

解說之。但在後小壩子西北石灰窰附近，見片麻岩與中上侏羅紀岩層接觸，而片麻岩之上常有中上侏羅紀之砂岩塊，其爲逆掩褶斷似已毫無疑義也。(五)在白石頭溝逆掩褶斷之東北端馬密哈達附近，有大理岩擠入中上侏羅紀岩層內，其褶斷線，東北經烏蘭板甲之北，西南經東西溝延長約三十里。(六)畢克齊西北，組成嶋𪃍山之大理岩及石英岩，向北逆掩于二疊三疊紀岩層之上。又察素齊西北古城附近，有大理岩向北倒覆于中上侏羅紀岩層之上，其南復爲上項岩層所掩覆，其褶斷綫，似向東北延長而與嶋𪃍山之褶斷相連續，惟中隔平地褶斷綫隱昧不顯，是否如此尙難確定也。(七)薩拉齊西北寬店子，種地窰子等處，則有下侏羅紀煤系地層，因逆掩褶斷之關係而夾于片麻岩內，呈東西延長之狹帶狀。在寬店子之南，片麻岩之一部因由南而北之迫擠，而覆掩于下侏羅紀煤系之上，其跡頗爲顯著。(八)在上述逆掩褶斷之北，復有下侏羅紀煤系及二疊石炭紀煤系之狹帶，出于二逆掩褶斷之中間，東自水間溝，西至海流素溝，中經沙鍋窰子，谷溝銀店，楊圪㙍，延長約四十里。又武川之西南土城子長太樓一帶，見有煤系似屬下侏羅紀，呈一狹帶狀，東西延長十餘里，其南北各爲片麻岩，因其質弱居于谷底，露頭不全·故其詳細不易窺知·其構造殆與上述構造相同，下侏羅紀煤系出于二逆掩褶斷之間歟。(九)官井溝之下侏羅紀煤系地層所在，頗似一向斜層，斜軸成西北東南向，由營盤灣之北經官井溝至鄧先生溝之西北，其西部之南翼地層傾斜較陡，而北翼地層似較平緩，成不對稱之向斜層，惟有浮土分佈多掩其跡，詳細情形不易考悉，其東部之北翼，地層因被斷層折斷，形體不全，今所存留者，地層傾斜向北偏東，斜角爲七十度，惟愈北而愈緩(由三十八度至三十度)，略具向斜層之觀(參閱第廿剖面圖)。(十)上述向斜層之西北二分子一帶，下侏羅紀煤系地層分佈所在，在東南兩面不整合片麻岩之上，而北與片麻岩成斷層之接觸，除近斷層處略呈褶曲外，大致東邊之地層傾斜向西，南邊之地層傾斜向北偏西，斜角緩者爲四十五度，陡者近直立，惟中部傾斜趨平緩，有似半盆形，大概從前原爲一向斜層，後被斷層折斷而失其本來面目也。(十一)固陽以西下侏羅紀煤系地層分佈頗廣，惟砂礫泥土到處分佈，致掩其跡，其地下情形不易窺悉，但就採煤者言，煤田西南部之煤層傾向東北近陡立，而在東北部卽窩沁濠附近，其煤層傾向西南斜角不過一二十度，又似成一不對稱之向斜層。惟其西北面之太古界片麻岩峭壁屹立，其東北面之元古界石英岩露出亦頗突如其來，可知向斜

層外必有斷層在也。（十二）拴馬樁一帶之高山，爲震旦紀石灰岩及二疊石炭紀砂岩頁岩等所組成，嶄岩矗立高出地表約數百公尺，來此地者，莫不注意。此山之露岩甚爲明顯，自南而北先爲石灰岩，次爲泥砂質頁岩，再次爲石英硬砂岩，再次復爲頁岩，最北復爲石灰岩，不整合于片麻岩之上，各岩層一致傾向東南，傾斜緩急一致，斜角由五十度至六十四度，大致此一帶石灰岩砂頁岩等，因橫壓力之推移迫擠而褶皺倒側，其爲向南倒側之緊閉式的向斜層，灼然可見（參閱第十五剖面圖）。更進步觀察，其南面之頁岩平覆于砂岩之上，而石灰岩又平覆于頁岩之上，以此又足証明石灰岩頁岩之露出，係岩層之疊覆，而非階級斷層也，其爲緊閉式的向傾層者，更無疑義。此一帶石灰岩之變質雖不甚顯，而頁岩之裂縫中富含白雲母，以示變質之徵象，此種情形，亦合橫壓力推移迫擠之意義　自拴馬樁而東至烏蘭忽洞之東北，山嶺起伏皆爲片麻岩，而震旦紀石灰岩又于片麻岩山之西部復行出現，大致作一半圓形（如第六剖面所示），其南與片麻岩成不整合之接觸，其北卽二疊石炭紀之煤系，亦爲一倒側向斜層，似爲拴馬樁向斜層之一部，惟因侵蝕形體不全。就上所述，拴馬樁與烏蘭忽洞之向斜層，雖其倒側程度有不同，然推其構造之來源，實同受自南而北之一橫壓力而使之向南倒側。德日進氏謂其爲一由北向南倒側之背斜層，殊非事實也。（十三）什那干平地北邊，山嶺綿亙，露出二疊石炭紀煤系，此煤系地層傾斜向南，在葛紹溝口及毋哈溝口，顯見其平行的不整合于震旦紀石灰岩之上。又平地之南相距不遠，突出屹立者卽什那干南山之片麻岩，上覆以未經變質之震旦石灰岩，其北面之懸崖，大致作東西方向，以在什那干村之南者較爲清顯，觀之者，必謂此處有一正斷層，但據作者詳細之觀察，並非有何上下錯斷之形跡，其構造實具有特殊性質也。

什那干附近之構造，倘假定爲一正斷層，南高北低，則俯仰兩側之升降，僅限于上下壓力之衝動，斷層附近，必不能有推移迫擠之情形，更不能有變質之景象，而今乃確有如此之事實，如毋哈葛紹二溝口之煤系地層，褶皺變質頗爲劇烈，而什那干南山頂之石灰岩亦略呈褶曲之形跡，凡此在正斷層發生之區域內，殊不多見之事實，足見什那干附近構造非爲正斷層，而上述之情形恰合逆掩褶斷之性質（參閱第十五剖面圖）。更試論變質岩之生成，其成因不外區域變質及接觸變質兩種，擴觀什那干以北之變

質岩，東西分佈延長百餘里，如係接觸變質，則附近必有極大之火成岩侵入體，而今地面上，除毋哈溝內有一二安山岩侵入墻外，並未見有何火成岩之侵入體，可知變質岩非因火成岩侵入而變質，實與橫逆變動有生成之關係。而此橫逆變動適生于斷層之前，則此斷層爲由南而北之逆掩褶斷，更爲明顯也。（十四）懷安縣附近，零星分佈之震旦紀石灰岩，皆蓋覆于片麻岩之上，而片麻岩之山嶺常環峙其四周，震旦石灰岩適居于盆地內，其從前必組成許多之小向傾層，由此可以想見也，不過所成之向斜層較爲平緩，在侵蝕之小面積內，不易見走向傾斜之差異耳。（十五）興和縣西南嶋鵝村之南，片麻岩成層狀，傾斜向南，組成嶋鵝壩，其北平崗起伏，皆上侏羅紀地層，褶皺劇烈傾斜極無一定，二者爲一斷層所隔，斷層面傾斜向南，此種情形，極合片麻岩由南向北移置侏羅紀地層以上之意義，其爲逆掩褶斷灼然可見也。自嶋鵝村而東至東洋河一帶，上侏羅紀地層與片麻岩又復出露，二者亦成斷層之關係，斷層面向南傾斜甚陡，似屬嶋鵝村斷綫之延長，就上所述，嶋鵝村與東洋河之褶斷面雖有陡緩之不同，然推其構造之來源，實受同一之橫壓力，仍帶逆掩褶斷之性質。此褶斷綫共長至少亦達八十里。

總上所述，可知震旦紀至上侏羅紀之褶皺軸向，一致近東西，顯係自南而北之橫壓力推移迫擠而生成，並其生成時代當在上侏羅紀之後，大概屬諸下白堊紀，英文篇已詳言之。惟太古界及元古界之褶皺，其軸向大致與上述褶皺軸相平行，是亦値得注意之事也。考太古界之地層，自古迄今至少經過四次之褶皺，桑乾片麻岩生成之後，地殼變動，而起急峻之褶皺，此其一。當五台紀之末，褶皺運動復生，此其二。至侏羅紀之末期，地動又起，殆所謂燕山期地殼運動，惟其褶皺平緩形跡不甚顯著，此其三。迨白堊紀，褶皺運動甚爲急烈，每使較古之地層斷移于較新地層之上，以致構造有今日之複雜，此其四。片麻岩經此四次褶皺而仍能保其平整（即其傾斜頗有一定）之態度者，蓋與各次褶皺方向有關也。除白堊紀褶皺運動係由南而北及燕山褶皺不關重要，已如上述外，設吾人假定桑乾系片麻岩之褶皺運動，自東而西或自西而東，而成南北軸向之褶皺，五台系地層之褶皺運動，自南而北或自北而南，而成東西軸向之褶皺，則片麻岩必呈極複雜之褶皺，更加白堊紀之橫逆運動，其複雜程度可想而知矣。更進一步推想，假定桑乾系片麻岩之褶皺軸向，近東西，五台系地層之褶皺軸向爲南北，則亦必呈極複雜之構造，而今事實上乃確未

見有如此之景象，可知桑乾系及五台系之褶皺運動，皆為由南而北或由北而南，故其所成之褶軸，大致與白堊紀之褶軸相平行，而未嘗正交也。

斷層　本區褶皺之發育既如上述，而正斷層亦常見之，試分論如下，（一）歸綏包頭間地形之變化，實為正斷層所生成，崛起于歸綏平原之北者為大青山，巉岩峭壁不可攀援，山地平原劃分明確，示東西延長之斷層綫。此斷綫西始包頭城東至歸綏以東計長約達二百五十里。其斷移以歸綏以西者為最大，頗有愈東愈小之趨勢，如王竹泉君之言也，故至祁下營子以上已不見其踪跡矣。（二）萬家溝內大溝附近之下侏羅紀煤系，東與花崗岩成斷層之接觸，此斷層線自大溝西南綿亙向東北經前小壩子，水神廟，而至徐泥板申之東南，似與陰山逆掩斷層相交割，計長約有五十里。其俯側之岩層，在大溝附近，為侏羅紀煤系，王君已詳言之，惟在水神廟一帶，悉為上侏羅紀之紅沙岩，其與花崗岩接觸之部份，未見變質之形跡，實帶斷層接觸之性質，而王君未曾提及也。（三）黑牛溝口附近，有斷層南高而北低，走向近東西，略向北作灣曲狀。其仰側之二疊三疊紀岩層在東部者，與下侏羅紀煤系相接觸，在西部者，與上侏羅紀岩層相接觸，顯示斷移之差異，其斷距由數公尺至四百餘公尺。察素齊北柳樹灣附近，下侏羅紀煤系呈一狹帶狀，長達十餘里，南北各以斷層關係而與上侏羅紀相接觸，煤系則為上升之部份，殆所謂地壘構造者是也。又溫家窰子附近，二疊三疊紀砂頁岩，傾斜向南，北與五台紀片岩大理岩相接觸，王君曾謂砂頁岩不整合于片岩大理岩之上，但細察接觸面附近之岩層，常呈迫擠之形跡，大概二者之間有一正斷層以隔之。（四）烏拉山嶄岩壁立，南臨低地，界限截然，則有窄谷急澗破山而出，示居斷層之仰側，其斷線東西延長二百八十里（東起包頭北之復合當，西經賽林包至烏拉山之西頭）。烏拉山皆為桑乾系岩層所組成，其山脊之高，出于低地，達六七百公尺，則此斷層移動之巨可想而知矣。（五）色爾騰山及狼山崛起于安北平原及五原平原之北，其中絕壁深谷破山而出，流入二平原內，示地面升降之特徵，可知此處必有一斷層。斷綫大致成西北東南方向，一部向正東，西自狼山西部起，經烏蘭腦包，烏蘭忽洞，貫全灣至營盤灣以東而失踪。仰側為太古界片麻岩，震旦紀石灰岩，二疊石炭紀煤系及侏羅紀煤系，組成色爾騰山及狼山，俯側之岩層，因被沖積砂礫所掩，致隱其跡，其斷移不易測知，惟二

山之嶺脊高出平地常達五六百公尺，可知移距至少在一千公尺以上矣。(六)拴馬椿以南之斷層，大致成西北東南方向，斜切拴馬椿倒側向斜層之斜軸，約與上述斷層相平行，西自七分子西北起，向東似達西梁之東南。其西部之仰側，居斷綫之南爲太古界之片麻岩，俯側則爲三疊紀之礫岩層。而東部仰側乃居斷綫之北，爲片麻岩，俯側多爲二疊石炭紀煤系，大抵爲捩轉斷層。其斷距以西部爲最大，約計則有九百餘公尺。(七)小佘太河中部之斷層，大致作西北東南方向，西起舊佘太召，東達劉太古之東南，向東北略呈灣曲狀，爲一正斷層。斷層面大致成直立，仰側爲片麻岩，組成劉太古一帶之岡阜，俯側爲三疊紀之礫岩層，組成小佘太河兩岸之峻嶺，其錯動之巨可想而知矣。此斷層與拴馬椿斷層之西部共一俯側，故二斷層可合稱槽形斷層，惟礫岩層石質堅硬不易侵蝕，故在地形上反成較高之地帶也。(八)官井溝東北之正斷層，大致作西北東南方向，橫切官井溝向斜層之東北部，西端以盡于二分子官井溝大道之西旁，東端蔽于沖積層之下，踪跡不明，就今測知者長達二十里。斷層面大致成直立，仰側居斷綫之北，爲片麻岩，組成官井溝煤田之北一帶山嶺，嶄岩立壁山勢陡峻，俯側爲下侏羅紀煤系，傾斜向北偏東，組成煤田之低岡，錯動不甚劇烈。(九)二分子向斜層以北之斷層大致成東西方向，橫割向斜層之北部，其向兩方斷切片麻岩者形跡不顯，就今測知者延長不過十餘里。斷層面近直立，仰側爲片麻岩，山嶺巍然突起，狀甚顯然，俯側爲下侏羅紀煤系，岡嶺起伏勢多平緩，其升降之跡顯然可見也。(十)窩沁濠一帶，下侏羅紀煤系地層大致傾斜向南，但甚平緩，組成低地，其北緣之片麻岩，山嶺巍然突起，峭壁屹立，其間必有一正斷層。此斷層大致成東西方向，自西而東延長十餘里。斷層面成直立，斷移不甚劇烈。(十一)大灘之南有一正斷層，作西北東南走向，西起麻米溝，東經平安溝至楊灣子更東延至陶林之南，長可一百四十里。南爲仰側，北爲俯側，致桑乾系片麻岩與二疊三疊紀礫岩相接觸，其跡極爲顯著。此斷層以南之速力圖及以北之平安村各有一東西走向之正斷層，一則使桑乾系片麻岩與二疊三疊紀紅砂岩相接觸，一則使二疊三疊紀紅砂岩與玄武岩相接觸，其跡亦極明顯也。(十二)張北縣西部小斷層甚多，其斷線或作南北或成東西，走向頗無一定，例如小大青山之高起，土木路馬蓮疙瘩一帶下侏羅紀煤系之露出，皆此斷陷所致也。又陽原縣東北東城羅家莊等處，各有正斷層，走向近南北，斷距皆不甚大，惟其錯動之跡頗爲明晰。

總上所述，本區主要斷層大致作東西走向，與褶皺軸或相平行或成斜割。其時代依王君所述，約屬第四紀，但就此次之觀察，大半漸新統之玄武岩流已受折斷，而中上新統以及較新之地層概未受其影響。復按諸地文，自唐縣期以後亦未見有地殼之運動，故察綏之地殼破裂運動，約與吾國北部各處之斷層同時而屬于中新統，如遼寧山東有許多大斷層，已証明于此時生成也。

第四章　礦產

察省西南部礦產無多，而綏遠礦產之富久為人所稱道，凡欲開發西北者，莫不引為快談，不曰煤，鐵，石墨，石棉，寶石各礦俱備，即謂石棉礦到處分佈，遍地可尋。今綏省府力謀礦業建設，大舉調查，該省礦產得悉梗概，至以為幸。察省西南部之礦產，皆位于小大青山之附近。綏遠礦產，多在其本部。狠山，色爾騰山，烏拉山，大青山，奎騰梁等山脉，皆有其分佈。省南多屬平地。惟產硝鹻，省北雖係高原，而浮土綦厚，牧草繁滋礦產不易發見，就今所知者，僅有白雲山之鐵礦一處，惟未經目擊，其價值究竟如何不得而詳。此次考查所及，為奎騰梁山脉之煤礦及寶石，大青山脉及烏拉山脉之石棉，鐵礦，煤礦及寶石，色爾騰山脉及狼山山脉之煤礦寶石及綠礬。惟大青山本部之煤礦，雖亦曾略勘察，乃王竹泉君已先詳測，著有專論，茲不妨就其所言，與此次所查各礦一併述之如次，合資參考。

煤

本區煤田，為二疊石炭紀侏羅紀及第三紀煤系所組成，此外尚有第四紀之泥炭。二疊石炭紀煤田分佈雖廣，而暴露零星，且煤層不多，煤質為烟煤及無烟煤，大部變化而成石墨質，狠山，拴馬樁，童盛茂，揚圪塄，速力圖等處煤田屬之，大抵無大作之價值。侏羅紀煤田之煤層已知者由三層至十層不等，煤質有烟煤無烟煤及半烟煤，烟煤一部可煉焦，無烟煤半烟煤質均不劣可供家用，官井溝，二分子，窩沁壕，石拐子，寬店子，柳樹灣，黑牛溝，壩口子，土城子，炭窰村，土木路，馬蓮疙瘩等處煤田屬之。第三紀煤田分佈于馬蓮灘，東窰溝，大營盤等處，產褐炭，銷路不廣，僅供附近住戶燃燒之用。至第四紀泥炭，于台格木討子號一帶見之，其儲量約計共有一千餘萬噸，亦頗有注意之價值也。

二疊石炭紀

(1)狼山煤田

二疊石炭紀煤系，出露于狼山山脉之南坡，自小佘太至烏蘭腦包斷續相連，延長約百餘里，惟至烏蘭腦包尚未盡其端，其西至臨河以北仍有煤系之暴露，似屬二疊石炭紀，果爾則二疊石炭紀煤系，東西綿亘共達三百里，寬窄不等，由數十公尺至五百公尺。地層傾斜向南頗陡，有時近直立，就以前在什那于烏蘭腦包等處，試探之結果，及地層之露頭觀察，至少有煤兩層，各厚二尺至四尺，惟其全經變質已失經濟上之價值，聞試探時所採之煤，色黑無光澤，塊少末多，雖置烈火中亦不燃燒，且有時略帶金屬光澤，滑膩如脂，頗近石墨，可知其變質之深矣。惟其西部之煤，就烏蘭腦包一帶試探之情形，似變質較輕，如將來能探出可燃之煤質，可由小窰擇地挖掘以供本地燃燒之用，否則本煤田已毫無經濟上之價值也。

(2)拴馬椿煤田

位置及交通　煤田在安北縣東北拴馬倖之南約一里，產煤地點在漠南礦場及拴馬椿溝等處，其東南約十五里之西梁，聞曾有人挖掘，確有煤層，惟未經開採，就煤系分佈觀察西梁漠南礦場之間，除一部被斷層折斷外，均應有煤，但未試探不悉底蘊也。煤田居近山邊，南臨平原，南至安北縣約十里，西至五原約百八十里，均地勢平坦，可通馬車，運輸卽賴以便，惟東北至小佘太一帶途次多山，交通不便，運輸賴于驢馱甚爲遲緩，故本煤田一年所產之煤，多銷于安北五原一帶平地焉。

煤層　拴馬椿煤田，惟漠南煤場附近向經開採，煤層情形知之稍詳。就地層暴露岩石性質觀察，煤層夾于二疊石炭紀煤系之中部，約有兩層，相距約三十公尺，上層據漠南煤礦所知，厚由五尺至三尺，近煤層者爲灰色泥質頁岩，下層成于黑色泥質頁岩中，尙未開採，但就其露出情形，其厚度似亦在四尺以上矣。拴馬椿溝一帶近亦有人探採，惟煤層到處暴露，傾斜極無一定，不惟初來此地者不易究悉其層數，卽在此探採者亦莫知其究竟。但就地質構造詳細觀察之，此一帶之煤亦不過兩層，露出于拴馬椿溝東岸者屬第一層，約與漠南礦場上層相當，據試探之結果，厚由五尺至半尺，中夾黑色頁岩薄層，露出于斷層附近者，約爲

漠南礦場下層之延長，褶曲中斷而成窩子狀，其寬常達丈餘，藏于黑色板岩內，已無大作之希望矣。拴馬樁溝以東至西梁未經探探，且地面多浮土，煤層情形不得而詳，惟其含煤地層與漠南礦場煤系本屬一系，又相距不遠，其煤層情形，當與漠南礦場之煤層無甚差異也。

煤質　漠南礦場附近產無烟煤，末多塊少，塊煤呈黑色，有光澤，耐燃燒，火力強，爲頗佳之無烟煤，拴馬樁溝一帶亦產無烟煤，惟因地層錯斷，煤層受其迫擠之影響，煤質自有變化，變質劇烈者揮發物逸散，固定炭增加，因之一部份不易燃燒，品質不佳，漠南礦場附近之煤，曾經分析，其結果如左。

產地	水份	揮發份	固定炭	灰份	粘性	發熱量(加洛利)
漠南礦場	二·三五	七·三五	八五·一○	五·一○	不團結	七九七五

煤量　煤量估計所應確知之要件有二，即地質構造及煤系分佈是也。茲所舉兩處產煤地點均爲內斜層之一部，漠南礦場煤區在其北翼，煤系地層傾斜大致一定，向東北西南延長各二里即爲斷層所阻。拴馬樁溝煤區在其南翼，煤系因斷層迫擠大部褶皺頗爲劇烈，向西南延長約二里即因斷陷而失其踪跡。漠南礦場煤區煤系雖延長不遠，而其中似皆有可採之煤層，地層傾斜頗陡可至六十度，向下採掘當不甚深，煤層兩層，厚約三公尺，茲假定以一千五百公尺爲煤層之長，五百公尺爲煤層之寬，二公尺爲煤層之厚，比重以一·三計，則煤量約爲一百九十五萬噸。拴馬樁溝煤區煤系中皆有可採之煤層，煤層延長約二里，地層傾斜方向雖隨地而異，然大致向東南約六十度，可採之煤層當不甚寬，煤層厚薄變化甚急，恆不相連續，最厚者達四公尺，茲假定可採煤層之長爲一千公尺，寬爲五百公尺（向斜層底似入地甚深，其兩翼煤層之寬當各在五百公尺以上矣），厚爲二公尺，比重以一·三計，則煤量約爲一百三十萬噸。以上爲產煤部份所有之煤量，其他如西梁一帶，煤層儲存情形所知不詳，不便估計，惟就煤系分佈觀察之，如將來探得相當之煤層，其煤量必在五百萬噸以上矣。

礦業　本煤田礦業不甚發達，只有小窰兩處開採　一即漠南礦場，爲孔庚所辦，已採十餘年，冬春開採夏秋停工，工人十

餘名，工資大工每日五角，小工三角，由窰主給食，平均二人一日可出煤二十筐（礦井沿煤層而進所入不深），一筐八十餘斤，一日出煤約五六噸，一年開採六個月，共出煤一千噸。煤價就地每噸可售洋一元五角至二元。一在拴馬樁溝，爲劉某所辦，自民國二十年冬季着手開採，有工八七八名，日出煤三四噸，一年共產煤約八百噸。煤價約與前相等，而工資亦與之相同也。

(3)童盛茂煤田

位置及交通　煤田位于薩拉齊之北境，中老窩鋪之正南。煤系露出于大炭壕，童盛茂，石匠窰，哈拉溝一帶，延長約三十餘里，地層傾斜平均各約六十度。由煤田至鐵路其道有二，一由石匠窰子沿水間溝至薩拉齊，一自大炭壕沿大斗林沁溝至公吉板，各約三十里，皆窄谷急澗僅通騾馱，煤之運轉卽利賴焉。

煤層煤質及煤量　煤層夾于砂岩頁岩內，僅有一層，在童盛茂南馬地灣子附近，厚達六公尺。茲以煤層平均厚度爲三公尺計之，則煤量約有三千七百八十萬噸。煤質係烟煤可煉焦，俗稱臭炭，茲將大炭壕煤之分析結果，列表如左以示一斑。

產地	水份	揮發份	焦炭	定炭	灰份	焦性	硫黃	發熱量(加洛利)
大炭壕	一·七六	三一·六八	六六·五六	五六·九四	九·六二	團結	〇·〇一六二	七六八五

礦業　礦業不甚發達，僅石匠窰子及大炭壕附近有小窰開採，作輟無常，約計每年產煤不過二千噸。

(4)楊圪塄煤田

位置及交通　煤田位于薩縣之北，東西綿亘約四十里。其東西兩部，爲二疊石炭紀煤系所組成，而中部屬于下侏羅紀煤系，楊圪塄適位其中心，煤田雖居近山邊，而山嶺崇峻交通不便，惟有河渠空谷可通騾馱，運輸夙賴以便。

煤層煤質及煤量　東部煤系分佈于水間溝，沙鍋窰子，谷滿銀店等處，東西延長約十五里，地層傾斜，由六十度至直立。含煤一層，厚約二公尺，係烟煤。茲假定二百五十公尺爲可採深度，其煤量約達四百五十萬噸。中部煤系分佈于谷滿銀店，楊圪塄之間，長約十二里，地層傾斜約二十度。煤層平均厚一公尺半，煤爲煙煤，俗名香煤，可煉焦，分析結果，含水份百分之〇·

八八，揮發份百分之一二・八六，固定炭百分之七六・○五，灰份百分之一○・二一，硫黃百分之○・五六，發熱量爲七八六九加洛利。茲假定可採煤層之寬爲五百公尺，其煤量爲五百八十萬噸。西部煤系分佈于五達溝內之恆義相房及海流素等處，計長約十里，地層傾斜約五十度。煤層平均厚約一公尺，係烟煤，茲以二百五十公尺爲可採煤層之寬，則其煤量約有一百六十萬噸。以上二疊石炭紀煤系儲煤六百一十萬噸，下侏羅紀煤系儲煤五百八十萬噸，總計共達一千一百九十萬噸。

礦業　各部中惟中部有較大之煤窰採辦，餘均係小窰，礦業極不發達，年產額共計不過二千噸。中部有煤窰兩處，一在本部之東區，爲劉俊耀所辦，工人百餘名，工價每日大洋五角，每人一日可出煤一千六百斤。一在本部之西區，其規模與劉俊耀窰相等。以上兩窰每年產煤約達六千噸，均經大小斗林沁溝，運于薩拉齊公吉板銷售。

(5)速力圖煤田

位置及交通　煤田位武川陶林兩縣之交界，據黑水河之上源，東距陶林縣凡六十里，西距武川縣可一百九十里，南距祁下營子車站約九十里。由煤田至陶林及祁下營子則沿河谷以進，地較平坦，可通馬車，惟至武川，山路崎嶇，交通不便。

煤層煤質及煤量　煤系沿斷層而分佈，長約三四里，寬約一里許，煤層夾于煤系之中下部，近煤層者爲灰色或黑色砂頁岩，頁岩內富含植物化石，僅見煤二層，一厚三尺，一厚五尺，傾斜向西南，傾角約二三十度。煤經分析結果，約含水份百分之○・九○，揮發份百分之一六・二五，固定炭百分之五九・七○，灰份百分之二三・一五，硫份百分之○・六一，發熱量爲六六三三加洛利，其儲量以長一千五百公尺，寬五百公尺，厚二公尺計之，約有一百九十五萬噸。聞速力圖之西流水溝附近亦產煤，舊日曾經小窰採取，惟久已停工，其地下情形無由而詳

礦業　煤田西部昔日開採頗盛，舊坑煤渣猶有存者。現在僅其東部有小窰一座　爲山東人所辦，有工人一二十名，冬春開採，夏秋停工，一年可出煤二千餘噸，多銷于陶林境，聞就地售價一噸約四元云

(6)其他煤田

其他尚有武川東北四號地煤田，屬于二疊石炭紀，曾有人就地層露頭試採，後以其深受變質不能燃燒，遂棄之而永無人注意也。

下侏羅紀

(1)官井溝煤田

位置　煤田位安北縣東官井溝地方，西距安北縣約一百里，東距固陽縣約一百二十里，南距包頭縣約一百六十里有奇，約佔北緯四十一度二十分，東經一百零九度五十分之地也。煤田東西長約三十里，南北寬約二里許。煤田居近山邊（色爾騰山之南坡），山勢平緩，惟其南北略有小嶺蜿蜒連亘，蓋為太古界片麻岩所組成也

交通　自煤田至安北固陽兩縣固屬平地，而南去包頭車站中經烏拉山，道路則沿空谷以進，轉運則惟駱駝是賴，運輸遲緩。現在綏省府對于包寧路之包五段，擬預定其路綫，由包頭經官井溝口，安北縣至五原，該段路綫長約四百三十里，大致西部全行于平原之上，東部多行于山嶺之中。自五原東行至官井溝口，長約二百八十里，全行于冲積層之上，地勢彌平，惟由官井溝口出哈德門溝至包頭，長約一百五十里，中經哈德門嶺，且哈德門溝，窄而多灣曲，敷設鐵路尚須開鑿之工，若由官井溝口東南四十里入崑都崙河谷，沿谷南進四十里出口至崑都崙召，由召東南進六十里至包頭，除崑都崙河谷一段外，餘皆行于平地之上，崑都崙河谷廣河寬，修築路基少須開鑿之工。總之路綫除在五加河及崑都崙河須設簡單橋梁外，在其他工程上，無特殊之困難也。

煤層　煤層夾于下侏羅紀之中部，而距下部較近，近煤層者多砂岩及砂質頁岩等，其層數雖未經特別鑽探，未能確悉，然小窰開採已久，煤層情形，大可得其梗概矣。官井溝一帶有小窰採取，煤系含煤九層，多不甚厚，最上層八尺，第二層六尺，第三層五尺，第四層二尺，第五層五尺，第六層三尺，第七層五尺，第八層二尺，最下層五尺，各層相距由十公尺至二十公尺不等。營盤灣一帶，曾有小窰開採，據云煤層亦達上述之數，惟其厚薄略有差異，由此可知煤層之數目厚度隨地變化甚微，大概今所知之煤層即足為全煤田之代表也。

煤質　本煤田就今所知者有煤九層已如前述，惟現正開採者，只最上層及第三層，其他七層，雖曾經掘其露頭，但近地面變化甚深，不足代表全層之性質，故可詳細考察，並經化驗而借以定其品質之優劣者，爲最上層及第三層。此兩層現在官井溝及營盤灣採掘所出之煤，均爲烟煤，惟不宜煉焦，色黑有光澤，易燃，火焰高，塊末均有，頗似察哈爾宣化玉帶山之烟煤，茲將一三兩層煤之分析結果，列表如左以示其性質。

產地	水份	揮發份	固定炭	灰份	焦性	發熱量(加洛利)
官井溝第一層	四·五三	三四·四〇	五四·三三	六·七七	不團結	七三二〇
官井溝第三層	三·二〇	三三·〇五	四三·二一	二〇·五四	仝上	五七六八
營盤灣	五·八〇	三七·一〇	四一·七九	一五·三一	仝上	五六七七

煤量　煤量可採之多寡，與地質構造有關係，今官井溝煤田，就前所述構造原來大致爲一向斜層，惟其北翼大部爲一斷層所截斷，遂失去本來之面目，並影響煤田之價値。現在其南翼煤系露出地表者，自陶賴溝以東起至營盤灣以東止，延長約三十里，而歷來產煤之區，由沙氣溝至營盤灣僅二十里，茲以一萬公尺爲煤層可採之長。地層傾斜大致向北，斜角由四十度至六十五度，向下採掘當不能甚深，惟其西部地層漸有向北趨于平緩之勢，茲假定距地面五百公尺以上之煤可以經濟方法採取，其煤層可採之寬或能達七百公尺。就上所述有煤九層，最薄者有半公尺，最厚者達二公尺半，茲以七公尺爲其平均總厚。煤爲烟煤，比重以一·二計，則全煤田煤量約有五千八百八十萬噸。此不過就已知之事實推算所得之煤量，如煤層之數目厚度有所增減，煤量亦因之變更也。

礦業　本煤田礦業極不發達，官井溝一帶有小煤窰名萬和窰，爲陳某所辦，係租自漠南公司者，有工八十餘名，由窰主給食，工資四角，冬春開採，夏秋停工，一日可出煤二萬斤，其年產額不過二千噸。營盤灣亦不時有小窰開採，一年出煤約二千噸

本煤田一年產煤共四千噸，悉售于色爾騰山山前山後，以供住戶燃燒之用，就地售價一噸約値二元左右。

(2)二分子煤田

位置及地形　煤田在官井溝煤田之西北凡十里，西距安北縣約一百一十里。其四圍山嶺環拱，煤田成爲盆地，向東北西南延長，西南有一山口爲陶賴溝出山之路。陶賴溝者煤田中之一水流也，源出煤田之東北，蜿蜒西南流經煤田之中部，迤而南出山口流入台梁平地以內，不惟羣山之水賴以宣洩于區外，即于交通上，亦爲由煤田至台梁平地惟一之孔道也(溝身較寬可通馬車)。

煤層煤質及煤量　本煤田採掘舊跡甚多，均停工已久，煤層情形不得而詳，觀此含煤地層與官井溝下侏羅紀煤系本屬一系其煤層位置數目當與官井溝煤田之煤層無大差異，據採煤者言，在二分子西南一里許曾見煤三層，皆相距不遠，最下層厚由九尺至一丈中夾岩石薄層，其上兩層各由二尺至三尺不等，惟就岩層性質觀察之，三層之外仍有煤層之存在，故所有煤層至少在四層以上也。煤質爲烟煤，因未開採不易採獲新鮮煤樣藉化驗以定其優劣，其露出地表者已受變化殊不足代表全層之性質，但據土人言，少末多大塊，易燃火焰高，可知其性質與官井溝之烟煤相仿也。煤量，煤系地層之構造略成一緩平之向斜層，既如前述．假定全部之煤皆可採，其面積爲五十萬方公尺，煤層就今所知者至少有四層，其中一層厚達三公尺，以四公尺爲煤層之平均總厚，煤爲烟煤，比重以一.二計，則全煤田之煤量爲三千六百萬噸，如日取千噸，足供百年之開採也。

礦業　本煤田在民國十四五年曾經採掘，二分子附近多見煤渣遺跡，但今小窰全未興工，無礦業可述。

(3)窩沁壕煤田

位置及交通　窩沁壕乃固陽縣西北十里之一小村，環其四圍皆有煤系之分佈，惟煤系全居低地，礫石浮土覆掩其跡，故煤系所在幾無露頭之可見。煤田僻處山塞，交通不便，惟有河渠空谷可通駱駝馬車，貨物運輸端賴于此。由煤田東至武川縣約三百里，道路雖多沿河谷以進，而途次隔山，駱駝馬車上下頗感困難。惟由煤田至安北縣道路約一百二十里，沿崑都崙河及台梁平地面西南進，全行于平地之上，運輸較爲便利也。

煤層煤質及煤量　本煤田之煤層數目厚度，因未經正式試採未能確悉，就窩沁壕附近各窰戶歷來開採所知者，約有四層

自上而下第一層厚約四尺，第二層厚約三尺，第三層厚約二尺，第四層厚約八尺。第一層之下約三公尺爲第二層，第二第三第四各層之間相距約達八九公尺。煤質，就窩沁壕一帶小窰所採者品格不高，土人皆知均爲烟煤，色黑少光澤，大塊易破爲碎片，燃燒時灰份多，火力弱，富含硫黃，惡臭迫人，一望而知爲劣品，但就煤系岩性及其中不完整之植物化石觀之，似爲下侏羅紀之產物也。玆將所採煤樣之分析結果列表如左。

產地	水份	揮發份	固定炭	灰份	焦性	發熱量(加洛利)
窩沁壕	八·四一	二九·九〇	三五·一五	二六·五四	不團結	四六三五

窩沁壕平地東西長約三十里，南北寬約八九里，似皆爲煤系所組成，其構造如前所述爲緩平之向斜層，換言之即平地之下皆有可採之煤層，果爾則本煤田之煤量至少可達六七千萬噸，但未經鑽探，此論尚難確定。今所計者，爲窩沁壕一帶之有煤層可以蹤跡者之煤量，除窩沁壕周圍歷經開採，煤層情形已頗明瞭外，其西北西南各六七里之地方及其東南十餘里之迦壩，均曾經土人挖掘確知有煤，假定煤系地層近水平，全區之煤皆可採，其面積爲二十方公里。煤層有四層，最厚者達二公尺半，以二公尺爲煤層平均總厚，煤爲烟煤，比重以一·二計，則全煤田之煤量約爲四千八百萬噸。

礦業　煤田內小窰頗多，然皆各人集股自採自售，作輟無常，既無組織之可言，採挖地點亦不一定，遇煤即採，至不利採取，便又他遷，故舊窰坑雖到處可見，而統計開採之窰戶不過五六家，每家一日平均出煤約三千餘斤，假定一年各開採六個月，則本煤田一年共出煤約二千噸，全銷于固陽境，就地售價一張綏遠票(大洋四角)可買煤六百斤，即一噸煤可值洋一元二角云。

(4)石拐煤田

位置及交通　煤田在薩拉齊之北，東始大溝經六道壩，胡盧斯太，中老窩鋪至石拐鎮共長一百二十里。居于大青山中，交通不甚便利，惟有巨谷急澗，如萬家溝，白石頭溝，水間溝，五達溝，大東溝等爲由煤田出山之孔道，可通騾馱，煤之轉運即賴于此。

煤層煤質及煤量　煤層夾于煤系之中部，其數目厚度隨地不同，在石拐鎮一帶有煤七層，自下而上述之如次・

一、腦節煤	厚約三尺		
二、薄煤層	一尺	五、花石節煤	四尺
三、中大節煤	六尺	六、底大節煤	七尺
四、四尺煤	四尺	七、底甘小節煤	二尺

在大溝中老窩鋪等處，就所採之一層煤皆厚約四尺，在六道壩厚由四尺至一丈。煤質亦因地而異，大溝六道壩一帶產無烟煤，胡蘆斯太，中老窩鋪，石拐鎮一帶產烟煤，皆可煉焦。無烟煤經分析含水份百分之一・四〇，揮發份百分之四・八〇，固定炭百分之八四・二六，灰份百分之九・五四，發熱量爲七三五〇加洛利，烟煤含水份百分之一・四四，揮發份百分之三三・〇二，固定炭百分之五六・六二，灰份百分之八・九二，發熱量爲七七五一加洛利。其儲量，大溝六道壩一帶煤系露頭計長三十二里，地層傾斜由四十度至六十度，茲以一・五公尺爲煤層之平均厚，直下開採深度以五百公尺計，其儲無烟煤約有二千零三十萬噸。胡蘆斯太中老窩鋪一帶，煤系露出長約四十三里，地層傾斜約五六十度，煤層平均厚度以一・五公尺計，其儲烟煤約有二千七百三十萬噸。中老窩鋪石拐一帶煤系露頭計長三十餘里，地層傾斜由五十度至十度，煤層平均厚度以三公尺計，約儲烟煤五千八百五十萬噸，本煤田共儲煤一萬萬零六百一十萬噸。

礦業　石拐煤田礦業較爲發達，石拐大溝，六道壩，胡蘆斯太，中老窩鋪等處均有煤層開採，日出煤約一百五六十噸。石拐有煤礦公司兩家，一名漠南公司，已開孔字，永益，三合，永順，德益，對合，益順，福壽等窰洞，工人約四百名，工價每日五角，由公司給食，日出煤約八十噸（一年採煤八個月），每噸售價約二元四角。一名冀昌公司，有洞二口，工人二百餘名，每日出煤四十噸。大溝有萬豐窰及萬隆窰，採煤工人各六七十名，日出煤共二十餘噸，售價每噸二元五角。六道壩，胡蘆斯太，中老窩鋪雖經開採而產煤甚微，共計一日不過二十餘噸云。

(5)寬店子煤田

位置　在楊圪塄之正南，距楊圪塄凡六里，距薩拉齊可二十五里，其交通大致與楊圪塄煤田相若，惟距離較近耳。

煤層煤質及煤量　煤系分佈于寬店子，種地窰子，韓同會，長達二十四里，地層傾斜約四十度，有煤三層，上層厚約二尺，中層一尺，下層三尺，均為烟煤可煉焦，玆以二公尺為煤層之平均厚，可採深度以五百公尺計，則本煤田煤量約為二千四百萬噸。歷經開採，每年約出煤三千噸。

(6)柳樹灣煤田

位置　位于歸綏縣察素齊北可二十里，東溝西溝均由是蜿蜒而南，以入平地，為自煤田出山之孔道。

煤層煤質及煤量　煤系分佈于柳樹灣，孫爾溝，東西延長約六千餘公尺，岩層褶皺錯亂甚為劇烈，就今所知者有煤兩層，各厚二尺至四尺，均屬無烟煤，其分析結果，含水份百分之一·四六，揮發份百分之三·四四，固定炭百分之七九·八六，灰份百分之一五·二四，發熱量為七〇四六加洛利。其煤量以煤層平均厚度為一公尺，則本煤田計儲煤一千一百七十萬噸。久經開採每年可出煤二千餘噸。

(7)黑牛溝煤田

黑牛溝煤田在歸綏縣畢克齊西北十餘里，煤系露出于蘇蓋營子一帶，東西延長約十四里，地層傾斜平均約五十度，見煤一層厚約一二尺，若以半公尺為煤層之平均厚，五百公尺為可採深度，則煤田之煤量計有二百餘萬噸。

(8)壩口子煤田

壩口子煤田位于歸綏縣北約二十里，煤系分佈不廣，縱橫所及不過三十餘方里，煤層甚薄僅由數寸至一尺，為半烟煤，昔者曾有人在溫家窰子一帶試採，終以煤層瘠薄採取不易而罷。

(9)土城子炭窰村煤田

土城子煤田在武川縣西南約一百五十里。煤系分佈于土城子長太樓一帶，東西延長約十里，其構造因逆掩折斷之關係而夾于片麻岩內，既如上述，惟其質軟常居谷底，多為冲積層所掩覆，全部情形不易窺悉，就露出之部份觀察，煤系地層頗形褶曲，且據土人從前探採所知者，煤層瘠薄，質近半烟煤，本煤田恐無大作之價值。炭窰村煤田位武川縣之西約十里，煤系地層近水平，分佈不廣縱橫所及不過三方公里，含煤三層各厚一尺許，為褐性烟炭及褐炭，（極似窩沁壕一帶之煤質）。其儲量多不過二百一十六萬噸。歷經小窰採取，一年出煤不過一千餘噸，全供武川附近居民燃燒之用。

(10)土木路煤田

位置及交通　土木路乃張北西部之一村鎮，其西北不遠有下侏羅紀煤系之出露，久經開採產煤頗盛，為察西頗著名之煤田。由煤田東至張北縣凡一百里，道路大部行于蒙古高原之上，地勢平坦（由煤田東經桃李壩登蒙古高原），可通馬車，交通頗便，惟自煤田而南約七十里至柴溝堡車站，途次隔山，道路僅循東洋河谷以進，至夏季驟雨乍霽山水奔騰則道路卽行斷絕矣。

煤層煤質及煤量　煤層夾于煤系之中下部，據在煤田北部一小溝內之觀察，約有煤八層，厚由幾寸至數尺（由露頭推算）不等（參閱第二十一剖面圖），就恆升煤礦所探之兩層，薄者僅四尺厚者常在八尺以上矣。其傾斜大致向西北，傾角由四十度至六十度。煤為烟煤大部可煉焦，曾經分析，水份佔百份之〇·八二，揮發份佔百分之二七·二六，固定炭佔百分之六二·七九，灰份佔九·一五，發熱量為七八一七加洛利。煤系分佈不廣，南北長約八里，東西寬約一里許，茲以四千公尺為煤層可採之長，煤層傾斜向西北頗陡，沿煤層下採當不能甚深，以五百公尺為煤層可採之寬，煤層平均厚或在二公尺以上，以二公尺為煤層可採之厚，比重以一·二計，約得煤量為四百八十萬噸。

礦業　本煤田舊日小窰甚多，均相繼歇業，今專採辦者為恆升煤礦公司，創自光緒三十二年，為遼寧昌圖人李耀山獨資所辦，沿用土法開採，有工人百餘人，在夏春兩季開採最盛時一日可出廿餘噸，一年共產煤約四五千噸，多銷于張北縣境，惟作者調

查時，內蒙災情綦重，人民逃避十室九空，該公司受此影響，幾行歇業，每日出煤僅足以維持公司人員之生活而已。

(11)馬蓮疙瘩煤田

位置及交通　煤田位小大青山之東麓，東距土木路煤田凡二十里。其交通大致與土木路煤田相若，其南以東洋河谷爲通柴溝堡車站之孔道，其東至張北縣路多平坦，運輸較爲便利。

煤層煤質及煤量　煤層亦夾于煤系之中下部，近煤層以黑色頁岩灰色砂岩爲多，據探採所知者僅有煤兩層（其與土木路煤田旣甚近，故其中所有之煤層數或較兩層爲多也），薄者四五尺，厚者六七尺，傾斜大致向東北，傾角約七十度。煤經分析含水份百分之〇·九八，揮發份百分之八·七八，固定炭百分之七四·六四，灰份百分之一五·六〇，發熱量七二六一加洛利，爲無烟煤，異于土木路之煤。其儲量，煤系南北延長約六里許，煤層傾斜幾近陡立，以三千公尺爲煤層可採之長，五百公尺爲煤層可採之寬，二公尺爲煤層可採之厚，比重以一·三計，則本煤田儲煤約三百九十萬噸。

礦業　本煤田有成平煤礦公司開採，該公司爲張虎臣所辦，資本一萬元，由股份集成，共計一百股，自開辦一來迄今已二十餘年，僅開有一斜坑，深約八十丈，其下有平巷十七，坑口高五尺，下寬五尺，上寬三尺，支柱用楊柳木，每棚約需洋七角，坑內運煤用條筐，提水用木斗，以人力轆轤提出，有工人百餘名，工資每日五角。採煤者不過八十名，共分二十組，每組一日可出煤一噸半，一年共產煤約六千噸（夏秋兩季出煤極少），成本一噸約三元，悉銷于張北興和南河蹔等處，就地售價一噸約四元左右云。

(12)其他各煤田

上述各處外，屬于本紀而調查未詳之煤田，尙有以下三處。

哈拉氣煤田，在歸綏東北二十里，據云煤質不佳，門斗溝煤田，在武川東約一百里，產烟煤。

佘太河在固陽北約五十里，產烟煤，其品質與窩沁壕之煤相若。

第三紀

(1)馬蓮灘煤田

位置及交通　據霸王河之左岸，位集寧之正北，土城子之東南，距集寧凡十五里，土城子可二十里。除漢慶壩嶺綿亘土城子以北外，餘皆平崗起伏，到處可行車馬，交通頗稱便利。

煤層煤質及煤量　煤系位于玄武岩之下，而露出于唐腦包，馬蓮灘一帶，地層近水平，煤層位于煤系之下部，各層相距不過一二丈，就小窰歷來所採已知者，在唐腦包有煤三層，第一層半尺，第二層二尺，第三層三尺，第一層之下二十丈為第二層，第二層與第三層相距約十尺，在馬蓮灘層則相等，而厚度增加，最厚者達五尺。均為褐炭，呈棕黑色，近經分析，水份佔百分之一八·四五，揮發份佔百分之三四·〇七，固定炭佔百分之三三·四一，灰份佔百分之一四·〇七，硫份佔百分之一·七九，發熱量為四七四九加洛利。其儲量，煤系之露出西北東南延長約四里，馬蓮灘東一里，農人鑿井時曾見褐炭層，其縱橫所及可達一方公里，茲假定褐炭層之平均厚度為二公尺半，比重為一·二，則本煤田約有褐炭二百五十萬噸。

礦業　本煤田歷經開採，小窰甚多，其礦業情形頗與窩沁壕煤田相似，採煤者三五一夥，到處採掘，作輟無常，其產額殊不易算計，惟窺其情形，全煤田一年出煤至多不過三千噸。

(2)東窰溝煤田

土木路以東，玄武岩分佈頗廣，其下有第三紀之煤系，露出于東窰溝及桃李壩，舊日有人就此露頭沿煤系開鑿平坑採取褐炭，坑口雖泯，炭渣猶存，據曾開採者言，褐炭層厚薄變化甚急，常由五尺至一尺或薄之無有，故開採者輒遭失敗。東窰溝桃李壩既有褐炭之可見，其間或亦有斷續相連之褐炭層，茲以一·二平方公里為褐炭層可採之面積，以一公尺為褐炭層可採之厚，比重以一·二計，則本煤田約有褐炭一、四四〇、〇〇〇噸。

(3)大營盤煤田

張北縣西大營盤附近，玄武岩下露出第三紀之煤系，當作者調查時，有小窰從事開採，據云有褐炭一層，厚由幾寸至五尺，呈棕色，木質組織極爲清楚，分析結果，水份佔百分之二一·四八，揮發份佔百分之三六·一八，固定炭佔百分之一七·九四，灰份佔百分之二四·四〇，發熱量爲四一六六加洛利。

(4)其他各煤田

除上述煤田外，尙有數處，據云均產褐炭，似屬于本紀，惟未經目擊，不知其詳細，玆僅記其位置如次。

莊馬台　在陶林西南，昔者曾經開採。

丹岱　在陶林東北約四十里，前經開採今已停工。

磨子山　在集寧東北約四十里，近經發現。

白腦包　在興和正北九十里。

劉家溝　在陽原正北，曾經開採(屬天鎮縣)。

第四紀　泥炭

歸綏平地產泥炭，其礦區凡三，一在台格木車站之西南，分佈于沙營子，栽生大小羊羔，霍拉哥氣及大里包一帶，東北西南延長約二十里，寬達一二里，泥炭層近于地面，厚由一尺至三尺，在台格木西南三里之處，已經開採，品質尙佳，分析結果，含水份百分之四·八二，揮發份百分之五三·九二，固定炭百分之一六·四四，灰份百分之二四·八二，發熱量六一九二加洛利。其泥炭量，若以半公尺爲泥炭層之平均厚度，則全區計儲泥炭一千五百萬噸。在討子號東南，面積狹小，縱橫所及不過四方里，泥炭層亦薄，厚僅一尺許，儲量甚微。一在討子號之東，聞其面積亦不甚寬廣也。

結論

統上所述，在察哈爾西南部，下侏羅紀煤系儲煤約有八、七〇〇、〇〇〇噸，第三紀煤系約有六、四四〇、〇〇〇噸，合計共有

一五、一四〇、〇〇〇噸，其中無烟煤佔三、九〇〇、〇〇〇噸，烟煤佔四、八〇〇、〇〇〇噸，褐炭佔六、四四〇、〇〇〇噸。在綏遠本部，二疊石炭紀煤系儲煤約有六九、一〇〇、〇〇〇噸，下侏羅紀煤系約有三一二、五六〇、〇〇〇噸，第三紀煤系約有一二、五〇〇、〇〇〇噸，第四紀泥炭約有一五、〇〇〇、〇〇〇噸，合計共達四〇九、一六〇、〇〇〇噸，其中無烟煤佔五五、二五〇、〇〇〇噸，烟煤佔三三六、四一〇、〇〇〇噸（可以煉焦者不過二分之一），褐炭佔一二、五〇〇、〇〇〇噸，泥炭佔一五、〇〇〇、〇〇〇噸，約成1o:5o:1:2之比。無烟煤之時代，自二疊石炭紀至下侏羅紀殆各代皆有，多與大地運動及花崗岩之侵入有生成之關係，烟煤之時代亦如之，其品質隨地而異，大青山一帶下侏羅紀及二疊石炭紀之烟煤，按翁所長之石炭分類法多爲中碳烟炭（Bm），適于煉焦，然色爾騰山下侏羅紀之烟煤，皆爲低碳烟炭（Bl）或褐性烟炭（Bc），極似宣化玉帶山一帶下侏羅紀之烟煤，同一時代，而品質之差乃如是，殆其本身性質原來有不同歟。

察哈爾西南部及綏遠本部之煤礦，皆係小窰開採，礦業極不發達，察哈爾西南部每年出煤不過一萬噸，多銷于張北與和境，售價每噸約四元左右。綏遠本部每年出煤約有六萬四千八百噸，其中二疊石炭紀之煤佔一萬四千三百噸，下侏羅紀之煤佔四萬七千五百噸，第三紀之煤佔三千噸，全銷于本省，售價每噸以兩元者爲多，所有煤產共值不過十三萬元，綏遠本部人口就最近統計約有一百七十九萬二千餘人，每人平均不及一角，其礦業之幼稚于此可以概見矣。

綏遠本部煤礦儲量表（以直深採五百公尺計算總儲量四〇九、一六〇、〇〇〇噸）

（一）二疊石炭紀

縣屬	煤田	面積（平方公里）	煤層數	煤層總厚（公尺）	煤質	煤量（噸）
安北	拴馬椿	一·八	二	二	(Am)無烟煤	三、二五〇、〇〇〇
薩拉齊	畫盛茂	一〇	一	三	(Bm)烟煤	三七、八〇〇、〇〇〇
仝上	楊圪墶	二	一	一—二	(Bm)烟煤	六、一〇〇、〇〇〇

武川速力圖	〇·七五	二	二	(Bh)烟煤	一、九五〇、〇〇〇
其他(如狼山四號地等處)				(A)無烟煤	二〇、〇〇〇、〇〇〇
共計					六九、一〇〇、〇〇〇
(二) 下侏羅紀					
安北官井溝	七	九	七	(Bl-Bc)烟煤	五八、八〇〇、〇〇〇
仝上二分子	七·五	四	四	(B)烟煤	三六、〇〇〇、〇〇〇
固陽窩沁壕	二〇	四	二	(Bc)烟煤	四八、〇〇〇、〇〇〇
仝上石拐	三九	七	·五—三	(Ah)無烟煤 (Bm)烟煤	一〇六、一〇〇、〇〇〇
薩拉齊寬店子	〇	三	二	(B)烟煤	二四、〇〇〇、〇〇〇
仝上楊圪塄	三	一	一·五	(Bm)烟煤	五、八〇〇、〇〇〇
歸綏柳樹灣	九	二	一	(Ah)無烟煤	一一、七〇〇、〇〇〇
武川炭窰村	三	三	〇·六	(Bc)烟煤	二、一六〇、〇〇〇
其他(如歸綏之哈拉氣壩口子黑牛溝武川之門斗溝土城子固陽之佘太河)				半烟煤	二〇、〇〇〇、〇〇〇
共計					三一二、五六〇、〇〇〇
(三) 第三紀					
集寧馬蓮灘		三	二·五	(C)褐炭	二、五〇〇、〇〇〇
其他(如莊馬台丹岱磨子山白腦包等處)					一〇、〇〇〇、〇〇〇

共計						一二、五〇〇、〇〇〇

（四）第四紀

歸綏	台格木討子號等處	一五	一	一	泥炭	一五、〇〇〇、〇〇〇

察哈爾西南部煤礦儲量表（總儲量一五、一四〇、〇〇〇噸）

（一）下侏羅紀

縣屬	煤田	面積（平方公里）	煤層數	煤層總厚（公尺）	煤質	煤量（噸）
張北	上木路	二	八?	二	(Bm)烟煤	四、八〇〇、〇〇〇
仝上	馬達疙瘩	一・五	二?	二	(Al)無烟煤	三、九〇〇、〇〇〇
共計						八、七〇〇、〇〇〇

（二）第三紀

張北	東窰溝	一・二	一	一	(C)褐炭	一、四四〇、〇〇〇
其他（如大營盤劉家溝等處）						五、〇〇〇、〇〇〇
共計						六、四四〇、〇〇〇

寶石

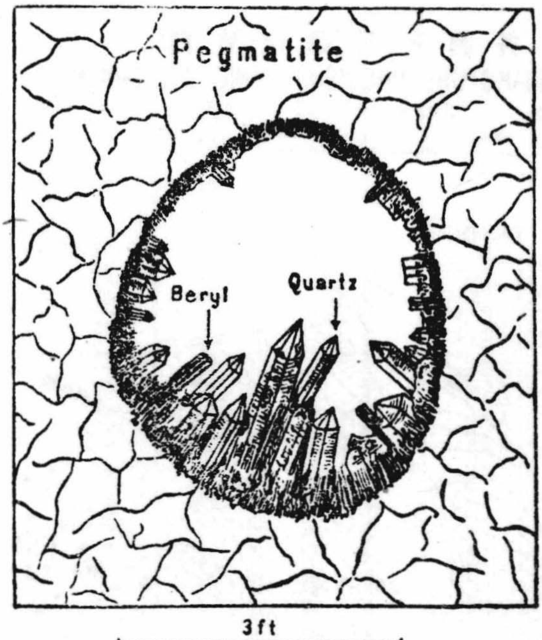
寶石者，乃硬度甚多，晶體透明，且具有美麗之色澤及光彩足供吾人玩好之礦物也。寶石種類甚多，總計不下數百種，然其中之名貴者，亦不過金剛石，紅寶石，綠寶石，碧璽，翡翠數種而已。綏遠寶石產地，古今頗有記載，然與實際情形完全不合，茲將此次考察所得者略述如左，以資參考。

黃花各洞寶石礦

位置　陶林縣西南三十里黃花各洞一帶，花崗岩分佈頗廣，既如前述，寶石礦之出產地點適在其西北部，由縣城西南行經平地至大西溝迤南上山，即見舊日開採寶石之遺跡，再南行五六里始出礦區之邊際。礦山雖高出陶林平地二三百公尺，然山頂漫平，坡勢極緩，可行馬車，交通尚稱便利

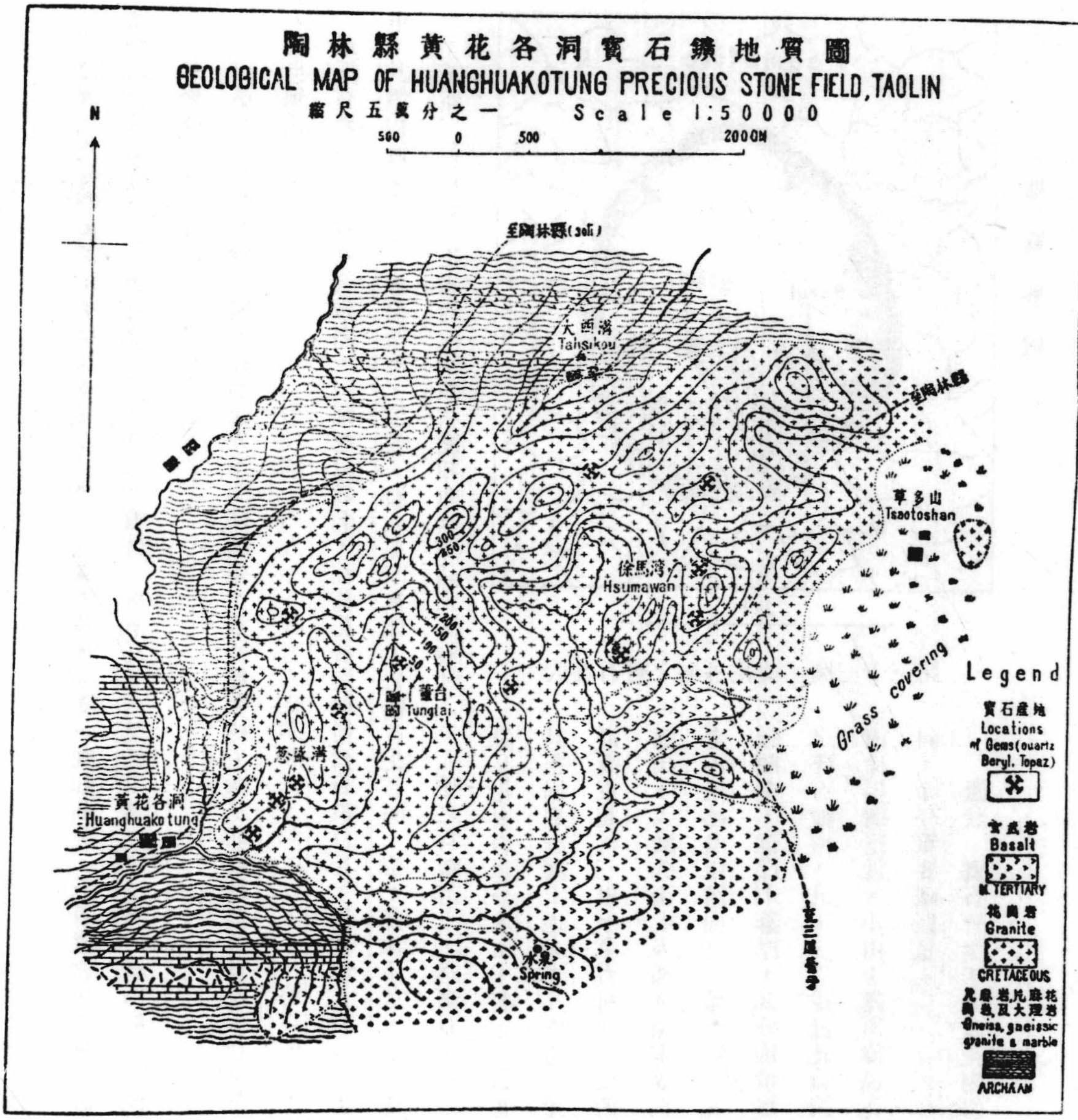
沿革　黃花各洞寶石礦，在前清末季開採頗盛，當時集寧縣土城子耶穌教堂各教友，在黃花各洞附近開採，得寶石甚多，每人曾得銀數百兩，其後全形停止。迨民國十四五年，復有人從事開採，到處挖掘，然終以結果不佳而罷，故官廳亦未嘗注意及之。最近有豐鎮之寶石商人數名，以採藥材為名，在黃花各洞取得寶石數百斤，後為他人所知，遂告于建設廳，謂其採得寶石數馬車，其價約值萬餘元，聲浪所播，遂致一般人莫明眞像，皆疑黃花各洞一帶，寶藏甚富，爭相設法開採者也。

礦區　黃花各洞花崗岩由細漸次變粗而成偉晶花崗岩脈（土人呼之為礦苗），為寶石儲藏之所，已如前述，礦區所在，即以偉晶花崗岩脈分佈所至而定。黃花各洞村東慈盛溝上部及西坡，偉晶花崗岩脈露出地表者凡四道，走向大致為西北東南及東北西南。沿溝東北行三里至董台村，村之西北及東北，皆有偉晶花崗岩脈之露出，大致作南北及西北東南走向，惟在西北者頗關重要，在東北者不過略具踪跡而已。董台村以北斯爾腦包一帶，據云偉晶花崗岩脈頗多，惟浮土甚厚，其分佈情形不易考悉，但就舊日開採所遺留之碎石觀察，其下之有偉晶花崗岩脈似屬毫無疑義也。斯爾腦包東南徐馬灣附近，小山上露出偉晶花崗岩脈數道，大致作東西南北走向，亦一重要礦區也。



第三十三圖　黃花各洞之寶石孔穴

產狀　寶石皆生于偉晶花崗岩脈以內之孔穴中（參閱第三十三



第三十四圖　陶林縣黃花各洞寶石礦地質圖

剖面圖），惟脉之鉅細、與孔穴之大小數目，寶石之品質儲量均有密切之關係。在慈盛溝（參閱第三十四圖）西岸有舊坑，偉晶花崗岩脉成囊狀，寬約六七尺，向地斜入頗深，脉石多石英，中有兩孔穴呈不規則之圓形，大小相若，口徑約三尺，烟晶即生于其中，完美之結晶體皆附着于孔壁，簇聚而作放射狀，惟其與孔壁接觸處，悉成塊狀之石英質，與組成孔壁之石英融合如一體，無顯著之分界，烟晶雖已採去而踪跡猶存，故得知其梗概也。

在董台村西北小溝中，偉晶花崗岩脉寬由二尺至六尺，方向大抵成南北，分向兩方，頗似延長甚遠，脉常成直立，下入甚深，中多填充烟晶之孔穴，烟晶雖亦近孔壁而生，而晶體簇聚方向極無一定，且其大小亦不一律，晶體大者多不透明，不過略具晶形而已，晶體小者皆成完好之結晶，有時其上附着綠寶石之柱狀體，舊日在此開採所得所謂貴重寶石者即指此也。在徐馬灣東北及東南所見之兩道偉晶花崗岩脉，曾經開採，一脉（南脉）向地深入，長可見者約十餘公尺，脉幅甚寬，據云其中之孔穴略呈圓形，徑長約由一尺至三四尺，內滿紅泥，惟所有寶石雖生于孔壁，然亦埋于紅泥中，就旁堆之碎石檢得之石塊，爲水晶黃玉及綠寶石，聞開採時曾得上項寶石千餘斤。一脉（北脉）方向近南北，分向兩方延長頗遠，孔穴鉅大，就坑旁堆積之碎石，知其中所產者爲烟晶。在董台村西北山頂上，偉晶花崗岩脉走向近東西，寬約一二尺，就此次炸探結果所見，孔穴不多，僅有極小之空隙內含不完美之烟晶結晶體，殊無開採之價值，其餘偉晶花崗岩脉雖有多處，然均未經炸探，且舊坑已泯其跡，其中有無寶石不易考悉，就露頭所在，脉幅多半甚窄，大半亦無採取之價值也。

寶石　黃花各洞寶石礦，就今所知者種類至爲簡單，僅有烟晶藍晶黃玉三種，其中以烟晶爲最多，約佔全量百分之八十，藍晶甚少，黃玉不過偶然見之而已，玆分述之。

烟晶多成一端或兩端尖銳之六方柱狀結晶體，大者長達一尺餘，徑長四五寸，小者長可四五寸，徑長二寸許，通常作灰黑色，然有時亦呈棕色及黑色，此種顏色遇火最易消失，如將烟晶置于火中，始而變黃，終成無色，故西人常依此法將烟晶變爲黃晶，而名(Spanish topaz)。

藍晶是藍綠色淺綠色及淺黃色，化學成分為 $BeAl_2(SiO_3)_6$，比重為 2.694，其結晶係六方柱狀體，惟其性脆，完整之結晶殊不易採獲，就此次可得者，直徑由一公分半至五公釐。

黃玉是淺綠色，晶體不大平行，底面之劈開甚為清楚，此與山西渾源縣所產之黃玉（色淵黃多透明）大不相侔。

開採狀況　黃花各洞一帶，偉晶花崗岩脈露頭頗多，舊日開採即以此為採礦之引線，就偉晶花崗岩露出之部份用鋼鑽鑿一豎洞（最深者達二丈），後沿脈之走向分向兩方探尋礦穴，如得礦穴即擴大挖掘，以免寶石之損壞。礦穴凡分水穴（穴中多水）泥穴（其中多泥）兩種，水穴中寶石結晶完好，便于採取，泥穴中寶石易于破碎，採取時須小心為之，如不得礦穴即遷往他處，另覓引線，故所有露出之偉晶花崗岩脈，幾經採探殆遍。嗣後又進而謀浮土以下偉晶花崗岩脈之發現，其試探以草色土性為標準，結果失敗者比比皆是也。

賽林忽洞寶石礦

賽林忽洞花崗岩中，有偉晶花崗岩脈，產烟晶及紫晶，已如前述，此項岩脈多分佈于賽林忽洞查沁一帶，其露出地表可經目擊者凡四處。一在賽林忽洞以南約六里許，有石英脈數道，寬窄不等，由二尺至五尺，長就可見者由五尺至十餘尺，惟皆入地不深，故其中寶石穴甚少，舊日開採者多遭失敗。一在賽林忽洞西南二里草山坡上，偉晶花崗岩脈寬由一尺至六尺成直立，向地深入，據云脈幅較寬者為寶石儲藏之所，舊日曾由此取得不少之烟晶及紫晶　一在查沁西南山頂上，有石英浮舖無根，而成扁平體，厚約三四尺，長寬各達一丈許，昔經開採，但無所得，頗似從前此處有一鉅大石英脈，後經侵蝕以去，今所見者僅其蝕餘之一部耳。一在查沁之西頭，偉晶花崗岩脈，就今所知者凡數道，方向大抵或南北或東西，分向兩方延長頗似甚遠，脈皆成直立，向下深入，脈幅寬由一尺至六尺，多產烟晶及紫晶，惟據開採寶石者言，舊日出烟晶及紫晶最多之岩脈不過二三道，烟晶之產狀與在黃花各洞所見者大致相同，皆生于圓形孔穴內，各晶體一端附着于孔壁，簇聚而成放射狀，其間夾有紫晶之結晶體，紫晶體恆小，烟晶體之大者直徑常達半尺許。此一帶寶石礦，在五十年前本無人知，迨光緒十六年，有山東人名孫文煥者採藥至此，見石

英脈露出者甚多，極似他處之寶石礦苗，遂着手採採，結果得烟晶甚多，因而附近居民皆知其爲寶石礦，爭相開採，不數年近于地面之礦採掘殆盡，甚深之礦難于施工，遂相繼歇業，聞統計所出烟晶約達四千斤，而紫晶爲量極微云云。

小大青山寶石礦

小大青山花崗岩中，亦有產烟晶及藍晶之偉晶花崗岩脈，前已提及，此類岩脈多見于小大青山之西坡，寬由一尺至五尺皆向地斜入頗深，脈石多石英，中有不規則之孔穴，大小不一，約由二尺至三尺，烟晶藍晶卽生于其中，或附着于孔壁，簇聚而作放射狀，或脫落而埋沒于穴內之紅泥中。該礦在前清末季開採頗盛，今已停工，據云藍晶常常與烟晶一處共生，但有時亦見其獨立之晶羣，由是可知小大青山之藍晶礦藏較爲豐富也。此次由舊洞內曾採得藍晶數塊，直徑由三公厘至三公分，係六方柱狀結晶，呈淺綠淺黃或深藍等色，極爲美觀。

甘溝子寶石礦

筆架山花崗岩中之偉晶花崗岩脈分佈散漫，脈幅亦窄，例如筆架山之偉晶花崗岩脈，寬約由幾寸至二三尺，而四五尺者殊爲少見，大概其中之寶石孔穴不能甚多也。惟甘溝子東十號附近，有一二偉晶花崗岩脈，脈幅較寬，舊日曾有人沿脈挖有深洞，據云所得烟晶等不少，其他偉晶花崗岩脈仍脈幅甚窄，且其分佈不遠，卽行散爲細脈，似無開採價值也。

成因

總觀以上所述，可知偉晶花崗岩脈或石英脈以內之孔穴，皆成不規則之圓形，且其中之寶石常附着于孔壁，中心尚遺留小空隙，其與美國 Maine 地方寶石礦之塡充偉晶花崗岩以內之孔穴者，頗有相仿之處，大抵本礦爲氣孔塡充之礦床也。其成因，係緣岩漿侵入地層，凝固遲速不均（凝固速者爲花崗岩，凝固遲者爲偉晶花崗岩脈或石英脈），其中含有石英，弗，鋁，鉑等質之氣液體，聚集于凝固較遲之一部，皷擊蕩動氣孔生焉。此時含礦質之氣液體遂乘隙而入于氣孔內，後乃物質分異，徐徐凝固，遂塡充于氣孔而成烟晶紫晶藍晶黃玉等。就上所述成因，可見粗鉅之偉晶花崗岩脈或石英脈內必有較大之孔穴，換言之，卽上項寶石必

產于粗鉅之偉晶花崗岩脈或石英脈中，細察昔日開採所得事實，亦大率如是，故將來開採時，或就露出之偉晶花崗岩脈及石英脈從事深探，或在礦區內浮土分佈地方開鑿長壕，另尋新脈，總宜擇脈幅較寬而向地深入者，爲開採之標準，萬不可誤認土性，迷信草色，到處亂掘，以致虛擲資本，空費周章也。

石棉

石棉係纖維組織，柔而能織，且可保溫避火，故爲近代工業上之要品。其在礦物學上言，凡分兩種，一、爲纖維狀之透角閃石或陽起石，其化學成分爲無水矽酸鈣，一、爲纖維蛇紋石，其化學成分爲含水之矽酸鎂。綏遠石棉二種俱備，惟屬于第一種者所見不多(如安北之卅哈溝石棉)，且其質脆量微，殊無一顧之價值，歷來開採者皆屬第二類，生于桑乾系大理岩，與蛇紋石或白雲石共生，考其分佈，均與侵入花崗岩(古花崗岩)有關，大概古代含白雲石灰岩先經區域變質而成大理岩，後因花崗岩侵入，復經接觸變質，其中之鎂質與矽酸化合而成石棉焉　其分佈之地，如歸綏之石灰窰子，武川之牢溝，六洲灣，安北之沙壩子，固陽之板申兎，邵不亥等處，均有之，惟皆絨短量少，難採易盡，故不宜大採，頗有小辦之價值也。

牢溝石棉礦

武川縣西南，楡樹店子西北十里牢溝附近，有桑乾系大理岩，東西延長十餘里，傾斜頗陡，幾近直立，與花崗岩相接觸，兩邊均見。大理岩中有蛇紋石脈凡三道，均沿大理岩層理而生，分向兩方頗似延長甚遠，石棉細脈卽生于此，就礦洞露出者觀察，或由一分而爲三，或由三合而爲二，皆成臥節，絨長由三公釐至三公分，質柔色白，屬纖維蛇紋石。前爲土人開採，有榮豐公司就地收買，每百斤(可製淨絨五十斤)給洋一元六角，每人一日可採石棉五十斤(皆就露頭挖掘)，惟礦量不豐，充分估計不過二萬噸。

六洲灣石棉礦

武川西南六洲灣北約五里梅姚根山，有大理岩出露于花崗岩內，長寬所及不過五百方公尺，其中之黃綠色蛇紋石或成囊狀或

成脈形，均含有臥節石棉細脈，惟蛇紋石脈內之石棉脈，較有採取之價值，其數由十合爲五，絨長由五公釐至二公分，質柔色白，有時呈棕色，其量至多不過六千噸，亦曾經土人開採，今已停工。

石灰窰子石棉礦

歸綏察素齊西北五十里石灰窰子東北，有桑乾系大理岩，中有花崗岩之侵入體，石棉生于二者之接觸帶內。就其性質產狀言之，凡分二種，一屬白色，產于大理岩內，與非纖維狀蛇紋石共生，脈數雖多，而絨（臥節）甚短，多不值開採，石灰窰東溝一帶之石棉屬之。一呈紅棕色，質細柔，而絨較長（長者達一公分半），多產于大理岩裂縫中，內夾白雲石，石灰窰子北溝上部之石棉屬之。本礦分佈雖廣，而其值以開採者，兩處共計不過一萬三千噸。

沙壩子石棉礦

包頭西北一百里沙壩子東北約三里崑都崙河兩岸，有石棉生于大理岩與花崗岩接觸帶內，石棉亦分兩種，一呈白色，其絨較長，由一公分至三公分半，一屬淺綠色，絨短而質脆，惟石棉脈均忽有忽無，探採維艱，其儲量約有八千噸。

其他各處石棉礦

固陽之邵不亥，板申兎，涼城之三道營子，包頭之雞毛窰子等處，大理岩均產石棉，聞皆儲量不豐，棉絨甚短，恐亦無大採之價值也。

石墨

黃土窰子石墨礦

興和縣南九十里黃土窰子附近石窰溝內，有灰色片麻岩（岩層傾斜成直立），夾于石榴子石及雲母片麻岩內，爲長石石英及微量雲母所組成，其中產石墨，質軟成小片，與長石石英雲母混雜而生，約佔全量百分之十，本礦所有石墨約計可達一千二百噸。曾經普晉公司以土法開採，現已停工。

喇嘛營子石墨礦

興和縣南六十里喇嘛營子東北之片麻岩內，有偉晶花崗岩脈，其中產石墨，質細性軟，品質頗佳，惟為量極微，不值開採。

紅山口石墨礦

歸綏城北二十里紅山口，有石墨質頗細柔，生于桑乾系片麻岩以內，成層狀厚薄不均，最厚者達二寸許，向西南傾入地下，其量不易揣測，惟就露出者觀察，其體積似不能甚大也。

狼山石墨礦

狼山南坡之二疊石炭紀煤系深受變質，已如前述，其中之無烟煤大部變成石墨，為量極豐，但其質粗性硬，富含雜質，殊無開採之價值。

鐵

公義明鐵礦

固陽縣西南二十里公義門村北半里，有低山高出地面凡七十公尺，長約一百公尺，寬可四十公尺，悉為角閃片麻岩所組成，此項岩石色黝黑，間有白色條帶，黑白相間示片麻岩之徵象，白色條帶富石英，黑色條帶多磁鐵礦及角閃石，磁鐵礦約佔全量三分之一，本礦所儲淨鐵量約有七十萬噸。

郜不亥鐵礦

固陽縣東南九十里郜不亥東，有鏡鐵礦生于花崗岩內之偉晶花崗岩脈中，此種岩石雲母極少，殆全為長石英及鏡鐵礦所組成，鏡鐵礦或成散片，或簇聚成大塊，惟不多見。

老窩舖鐵礦

薩拉齊北老窩舖附近，間產鐵礦，其中富礦不多，業經採掘殆盡，所餘者皆劣礦，已無開採之價值也。

其他鐵礦

包頭西北一百里，賽林包東苦連圖溝，有鏡鐵礦生于長英岩裂隙中，而成網狀之細脈，此不足稱爲礦床，僅名鐵礦之產地而已。

雲母

豐鎮之體勤莊，集寧之趙修溝等處，片痲岩內有偉晶花崗岩脉，寬由一公尺至四公尺，其中產雲母，與長石英雜淆而生，惟其片面太小，長寬至半尺者已屬罕見，故歷來開採者，多遭失敗停工。

硫礦

本區硫礦，無天然生成者，皆來自黃鐵礦，而黃鐵礦產地不多，僅于大青山一帶之下侏羅紀煤系內見之，分佈散漫，其量甚微，向未聞有人從事開採者也

綠礬

什那干北葛紹溝內，二疊石炭紀煤系中之煤層變質特甚，已成石墨質，其中裂隙內常夾有綠礬礦（其化學成分爲含水之硫酸鐵），露出于溝壁之高處，呈淺綠色或白色，係纖維組織，惟其遇水卽行消解，故在溝壁之低處不易保其結晶狀態也。

鹽

集寧東南之二蘇木海子，及涼城東之岱海灘，聞產食鹽，惟作者未曾涉足，無由而詳，內蒙所用之鹽，大半來自外蒙之諾爾湖，此項食鹽在興和等縣售價，每斤銅元十二枚云。

粘土

石拐鎮清水河等處之煤系內，有粘土層，可以取而製瓷器，如缸盆碗罐等，製法係將粘土侵于水內，壓之成漿，引入地坑，澄成粘泥，用以製各種瓷器之坏模，塗釉曬乾，燒之而成瓷器，綏遠所用之瓷器，皆來自此兩處。

石材

本區花崗岩大理岩石材雖多，而經開採者殊不常見，現在人民所取而用爲石材者，爲玄武岩，如各村之水槽，石滚，石柱等皆爲較粗之玄武岩所製成，且各處教堂所建築之西式大樓，其底基亦用較細之玄武岩砌起也。

CONTENTS

GEOLOGY OF SUIYUAN AND SOUTHWEST CHAHAR

BY C. C. SUN

I. INTRODUCTION

The geology of Suiyuan proper and Southwest Chahar has been studied by various geologists at different times. In 1864 the American geologist, R. Pumpelly[1] undertook a reconnaissance tour from Peking to Southwest Chahar. As a result of this trip he distinguished three principal geological divisions, viz. (1) Crystalline rocks, (2) Devonian limestone and (3) Volcanic rocks.

Pumpelly's reconnaissance was followed seven years later by von Richthofen[2] who made a route-survey from Changpeihsien to Hsiyingtzu and turned south through Hsinghohsien into N. Shansi. The following formations were recognized by him in Southwest Chahar :

a. Archæan gneiss
b. Sinian siliceous limestone
c. Jurassic coal series
d. Plateau basalt.

In 1915 Tachingshan was visited by Dr. W. H. Wong[3] at the request of Suiyuan Government. He first made a geological map of these mountain ranges.

The year 1923 was marked by the visit of two French geologists P. Teilhard de Chardin[4] and F. Licent in Western Suiyuan. Leaving from Paotouhsien, they crossed Olashan, took a rapid view of the Sheitenola and, moving southward, reached the Ordos desert near Santaoho. From this point, they went along the border of the Ordos, first southward up to Yinzeshan and Arbousola and then eastward into east Ordos.

The result of this journey appears as follows :

In this country there are five principal geological formations, viz. (1) Wutai crystalline rocks and marbles, (2) Palæozoic quartzite and limestones, (3) Ordovician slates, (4) Stephanian sandstoneo and conglomerates and (5) Mesozoic sandstones.

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1. Geological researches in China, Mongolia and Japan.
2. China Vol. 2, Part 3.
3. Report on the geology of Suiyuan. Bull. Geol. Surv. China No. 1, 1918.
4. On the geology of the N. W. and S. borders of the Ordos, China, Bull. Geol. Soc. China. Vol. III, No. 1, 1924.

As to the geologic structure, their interpretation may be summarised as below :

In the southern side of Sheitenola, the front of the Palæozoic limestone has the shape of a large "Pli Couché", stretched out towards the south and lying on the crystalline strata. Between the crystalline and Palæozoic rocks the contact is very sharp. It seems that there is an overthrust fault from the north southward thrusting the limestone over the crystalline series.

In the region of Arbousola and Yinzeshan the folding of the Palæozoic limestone towards the Ordos platform is very conspicuous. Both the Arbousola and Yinzeshan form anticlines, overturned eastward.

In about the same time G. B. Barbour[1] worked out in some detail the geology of the Kalgan area. His work is especially interesting for his summary of the physiographic stages studied by various geologists in North China.

After several years, since the visit of Dr. Wong, the Tachingshan range was restudied by my colleague, C. C. Wang[2]. A new geological map on the scale of 1 to 100,000 was made up by him in 1925. This map is so good that there is only a little to add to-day to it. The formations were classified by him as follows:

a. Wutai system—crystalline rock and marble
b. Permo-Carboniferous coal series
c. Permo-Triassic and Triassic red shale and sandstone
d. Lower Jurassic coal series
e. Middle and Upper Jurassic shale and sandstone.

With regard to the structure, C. C. Wang pointed out for the first time the importance of orogenic movement from south northward in this range which constitutes a most important region in the tectonic of N. China.

In the spring of 1930, the writer was instructed by Dr. Wong, Director of the Geological Survey, to pay a visit to Southwest Chahar. Leaving from Kalgan, the writer went through Hanoorpa pass to reach Changpeihsien and turned west to the edge of Mongolian Plateau taking a view of Hsiaotachingshan near Hsinghohsien on the west and Tumulu on the east. From this hill, he proceeded southward along the Tungyangho valley first up to Huaianhsien and then from Huaianhsien to Yangyuanhsien. A short trip was also made to Tienchenhsien in Shansi province. In the spring of 1931, the writer received instruction to explore the geology of Suiyuan proper in view

1. Geology of the Kalgan area. Mem. Geol. Surv. China Ser. A. No. 6, 1929.
2. Geology of Tachingshan, Bull. Geol. Surv. China No. 10, 1928.

of completing and extending the geological map of C. C. Wang. He left Peiping on the 28th of April and arrived at Kueisuihsien (Kuihua) on the 29th. After the rest of a few days he started for the West Tachingshan. He revisited the area mapped by C. C. Wang and returned to Kueisuihsien from the East Tachingshan. From Kueisuihsien, he proceeded northeastward to Chininghsien and Taolinhsien. Prevented by the bandits trouble from going southeastward to join the area previously mapped of West Chahar, he turned back westward to Salach'ihsien and to Paotouhsien. Thence the writer went further west across the Olashan following the route of Teilhard to Anpeihsien, and visited Sheitenola and Langshan, the geology of which is explored for the first time. Then he moved eastward through Kuyanghsien on to Sailinghutung, and again southward from Sailinhutung to Kueisuihsien at the end of June. In the autumn of 1932, continuing the geological survey in Suiyuan proper, the writer again made a reconnaissance in Wuchuan, Hsingho and Funchen districts. Thus the geology of Suiyuan proper and Southwest Chahar became gradually better known.

The result of the present survey proves that the strata of S. W. Chahar are really not so simple as indicated by the map of Richthofen. A modification which the writer suggests to the structural interpretation of Sheitenola is that the Palæozoic limestone clearly lies in a closed syncline which is overturned towards the northwest instead of to the south as thought by Teilhard and Licent.

C. C. Wang's work in Tachingshan laid down an excellent foundation on the geology of Suiyuan though his physiographic stages may need some revision. What he called Fenho canyon clearly corresponds to the Chingshui stage. The wide valleys in the range which were thought by C. C. Wang to belong to the Tanghsien stage are highly probably due to the Fenho erosion.

On the basis of the excellent topographical map on the scale of 1:100,000 by the military office and the sketch map by the local government corrected by my own field observations, the following map sheets on the scale of 1:250,000 have been made :

Sheet	I	Chaikoupao	Lat. 40° 30' — 41° 30', long. 114° 30'	— 113° 30'
,,	II	Hsingho	Lat. 40° 30' — 41° 30', long. 114°	— 113°
,,	III	Taolin	Lat. 40° 30' — 41° 30', long. 113°	— 112°
,,	IV	Suiyuan	Lat. 40° 30' — 41° 30', long. 112°	— 111°
,,	V	Paotou	Lat. 40° 30' — 41° 30', long. 111°	— 110°
,,	VI	Anpei	Lat. 40° 30' — 41° 30', long. 110°	— 109°
,,	VII	Wuyuan	Lat. 40° 30' — 41° 30', long. 109°	— 108°

These map sheets comprise the results of the present survey in Suiyuan and Southwest Chahar.

II. GEOMORPHOLOGY

A glance at any topographic map of North China reveals that Suiyuan and Chahar provinces are largely occupied by the Mongolian Plateau. Near its southwestern and southeastern margins this plateau has been sculptured out in precipitous-cliffed mountains which, when mentioned in the order from west to east, are Langshan, Sheitenola, Olashan, Tachingshan, Liangchengshan and Huashan, generally of east-west trend (see Fig. 1). The following is a description of plateau, mountains, basins and rivers in Suiyuan and southwest Chahar.

Plateau:—The Mongolian plateau stretches from Gobi region to Kalgan in the southeast and to Langshan in the southwest (see Fig. 1), the loftiest point of it, within my field of observations, does not exceed 2300 m. altitude above the sea. As pointed out above, from the SW and SE sides it is limited by mountain ranges. This plateau itself has an irregular surface due to the relief features resulting from faulting; and some of these features, like Yinkuangshan, Kueitengliangshan etc. are of mountainous nature, of which each one is a greatly uplifted fault-block. Many hill-masses mark regions of smaller vertical displacement. Besides these elevated masses there are flat surfaces or plains. They mark the location of enclosed basins of erosion origin which now received the sediments (chiefly red clay) washed down from hill-masses.

Mountain ranges:—(a) The Langshan range appears as the southwestern margin of the Mongolian plateau bordering the Wuyuan plain. The range has a E-W direction. It stretches, albeit with interruptions, from Ninghsia-Suiyuan border in the west to Hsiaoshiehtai in the east and rises in many high peaks. The highest point is in the western part having an altitude of about 1900 m. above the sea. The range is composed chiefly of Archæan gneisses and inliers of Palæozoic sediments, the latter have mostly been affected by metamorphism. Towards the east, the range sinks slowly but continuously and disappears SE. of Maominganchi.

(b) The Sheitenola range lies south of Langshan range and is only separated from it by a small plain. The range also approximately trends in a E-W direction, stretching from Anpeihsien to Kuyanghsien with a length of about 110 km. As shown in any topographic map, its eastern extension, however, really goes further east through Chanfangyaotzu to Tsienwulanpulang, W. of Wuchuanhsien. The altitude of the range reaches a figure between 1800 m and 2200 m.

(c) The Tachingshan range is situated not far N. of Kueisuihsien and Salachihsien trending in a ENE-WSW direction (from Tat'anchen to Paotouhsien). It has a steep escarpment on the south bordering the Kueisui plain which easily attracted the eyes of any one travelling on the Suiyuan-Paotou railway. The range is composed mainly of Pre-Sinian gneiss, marble and quartzite and scattered remnants

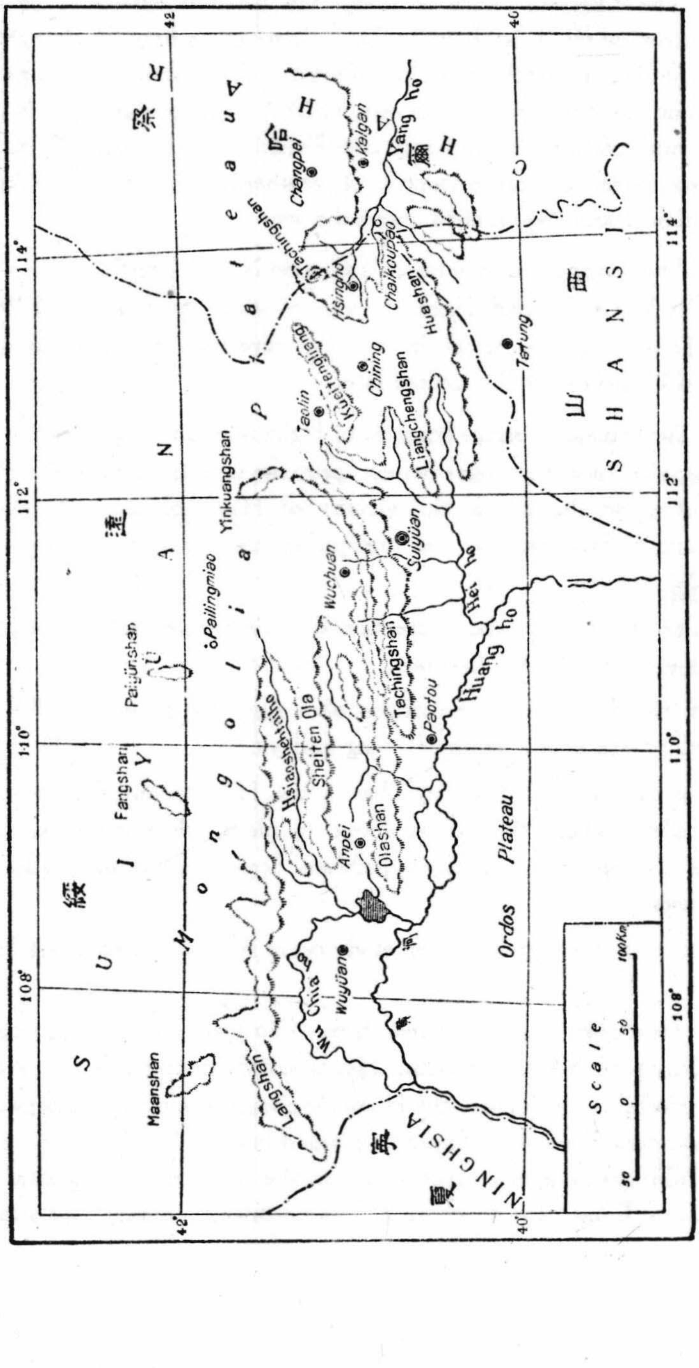


Fig. 1. Topographic outline of Suiyuan and Southwest Chahar

of Palæozoic-Mesozoic sediments. It is characterized by both comparatively low and gently rolling ridges and high precipitous-cliffed hills, the highest hill-top reaches an altitude of 2160 meters above the sea.

(d) The Olashan range is really the western extension of Tachingshan range. Its average width is about 15 km. It stretches from Wulianghai eastwards to Paotou, having a length of at least 100 km. The range forms a partly forested territory, built up by Archæan gneiss, marble and granite, the latter generally pegmatitic, and diabase of probably post-Palæozoic age. The gneiss and marble, owing to their resistence to the agencies of weathering, form many peaks the highest of which attains about 1960 meters above the sea.

(e) The Liangchengshan range is situated N. of Liangchenghsien consisting of comparatively low and broad ridges, the tops of which seldom exceed 1900 m. above the sea. They generally trend in a E-W direction which is followed by the tributaries of Heiho river to be treated later.

(f) The Huashan range lying S. of Hsinghohsien is characterized mostly by the high ruggedly dissected ridges which approximately trend in a NE-SW direction. When standing on the hill in the vicinity of Hsinghohsien and looking towards the south, one is impressed by the precipitous crests rising one behind other for a long distance.

Besides the ranges above mentioned there are several comparatively low or isolated hills mostly in S. W. Chahar.

South of Huaianhsien the ridges of a ruggedly dissected hilly area rise to about 560 m. or less above the intervening valleys.

Rising not far NE of Hsinghohsien, the Hsiaotachingshan is an isolated hill with an altitude of about 600 meters above the plain, which can be seen far away at the head of Talinpa pass of Changpeihsien appearing in multitude of ruggedly dissected crests.

Rivers:—In the region under study occur two main rivers, viz Huangho and Yangho.

The Huangho river originates from Chinghai. It flows through Kansu, Ninghsia, Suiyuan, Shensi, Honan, Hopei and Shantung and discharges its water into Gulf of Pechili. In Suiyuan the Huangho course assumes the shape of an oxbow and has undergone frequent changes in a broad basin. The River (Figure 1), after coming out from the Ninghsia region following the N-S course of Alashan, runs on the southern side of Langshan, which limited its northward course, then after its moving southward went through the southern margin of Olashan. Since the occurring of this change, it has still moved its bed towards the south, resulting in the location of the present course.

On the northern side of the Huangho river there are several tributaries which, when mentioned in order from the east to west, are the Heiho, the Kuntulunho and the Hsiaoshehtaiho. They all have their head water on the margin of Mongolian Plateau and flow southward across the Tachingshan, the Olashan and the Langshan respectively meeting their trunk, the Huangho river, in acute angles. In the mountain ranges the valleys of these streams are mostly narrow, bounded by steep walls of hundreds of meters in height and meander laboreously until they emerge into the alluvial basin.

The Yangho river has its course in the Huashan range flowing with tributaries southeastward beyond into Hsuanhua region and the Sangkanho river to form the Hunho river below the Hsiahuayuan station on the Peiping-Suiyuan railway.

Basins:—In the region surveyed there is one main broad basin drained by the river. The Huangho basin occurs in the depressed downthrows of Tachingshan, Olashan and Wuyuan faults, bordered by the abrupt scarps of the named mountains on the north and continued with the gradually rising Ordos Plateau on the south. Its longest diameter from east to west is about 400 km., while the width from north to south varies from 30 to 80 kilometers. The surface of the basin is a little undulated at an average altitude of about 1200 m. above the sea and is chiefly formed by sediments carried down by Huangho river and its tributaries. Kuisui, Salachi, Paotou, Wuyuan and Linho are the principal cities in the alluvial basin. Owing to the development of the agriculture since the latter part of the last century mostly by emigrants from Shansi the basin has become quickly populous.

On the northwest the basin projects eastward to form two small plains between Olashan and Sheitenola, and between the latter and Langshan; both are covered mostly by the coarse gravels.

Physiographic stages:—As a result of his study of the topographical features in the Tachingshan region three physiographic stages have been recognized by C. C. Wang, namely, the Tanghsien stage representing the Tertiary erosion to maturity, the Fenho stage following early Quaternary faulting, and the Huangho stage of the late Quaternary vertical erosion. From my observation in Suiyuan and Southwest

1. For having an idea of these sediments, see Soil Survey of Salachi area, Suiyuan Province by R. L. Pendleton, C. C. Chang, W. Chen & K. C. Hou, Soil Bull. Geol. Surv. China No. 4, 1932.

Chahar, I have attempted to establish the following stages somewhat different from C. C. Wang.

Peitai stage:—B. Willis first recognized the Peitai peneplane in N. Shansi[1]. In eastern Suiyuan and Southwest Chahar this ancient peneplane is preserved as the floor upon which the Oligocene basalt lavas were poured out. The peneplane now rises about 2000 m. or more above the sea level and is about 700 m. higher than the water level of the rivers in its neighbourhood. Judging from the frequent presence of the sharp ridges projecting into the overlying flows, this surface was an irregular one; in other words, the peneplane was not perfect, the monotony was broken by remnants of erosion, monadnocks.

The peneplane also exists as the limit of altitude of the mountain ranges mentioned above. Although it has been deeply dissected, yet its original surface can still be recognized by the flat-topped mountain crests which rise nearly to the same elevation as the just mentioned old land surface below the basalt flows. When one travels in the Huangho Basin, he will be impressed by the high complexity of a multitude of wide and narrow valleys dissecting the ranges. But as he climbs from the basin to the tops of the ranges and looks upon them, he would feel that he is just on a peneplane, if not for the deep dissection of younger valleys.

As pointed out by Barbour, the peneplane was probably the continuation of the Mongolian Plateau which on one interpretation[2] had reached an advanced stage in late Oligocene times.

Tanghsien stage:—As has been stated above, on the Mongolian Plateau there are many shallow basins (such as Wuyuan plain, Taolin plain, Chining plain, Hsingho plain, etc.) which are filled up mainly by the Pliocene (Pontian) red clay. Below the clay covering is the eroded surface of solid rocks which in some places consist of Tertiary basalt flows, while in other places Archæan gneisses or younger sediments ranging from Palæozoic to Mesozoic. The depth of the rock surface from the surface of the mantle sediments varies from place to place and naturally depends on the altitude of the surface. When the absolute altitude of the rock surfaces of the basins is considered, it is found that the surfaces are generally represented by the relief features (see Figs. 2 & 3) which are marked by low ridges and flat valleys. This is the erosion surface of Tanghsien stage in the advanced maturity.

On the northern slope of Olashan there are isolated patches of red clay (with overlying gravels) at the edge of a terrace facing the Tailiangho valley of

1. Research in China: Carnegie Inst. Public. 54, Vol. 1, Pt. 1, Washington D.C., 1907.
2. Geological reconnaissance in Central Mongolia: Nat. His., Vol. 24, No. 2, p. 160, 1926.

which the bottom lies about 50 to 70 meters below the clay deposition. The terrace is evidently the erosion remnant of the old landsurface on which the red clay extensively occurred. It can then be inferred that during the deposition of the red clay the old landsurface assumed a plain which was connected by a gently rising slope with Olashan range on the south and extended across the present valley (at that time the main valley did not exist) to meet the slope of Sheitenola range on the north, it is the Tanghsien landsurface.

The Tanghsien landsurface may also be established in the Yangyuan region where it, as that mentioned above, assumes rolling hills and smooth valleys filled up by the Pliocene red clay.

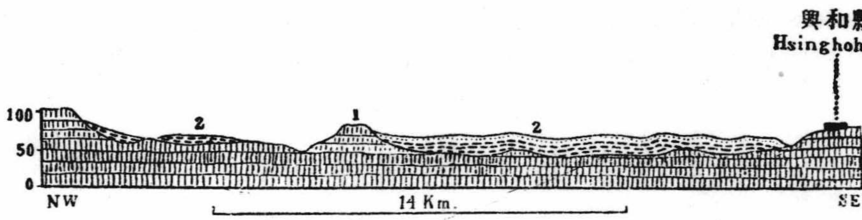


Fig. 2. Section of Hsingho basin showing the Tanghsien erosion surface below the red clay. 1, Tertiary basalt. 2, Pliocene red clay.

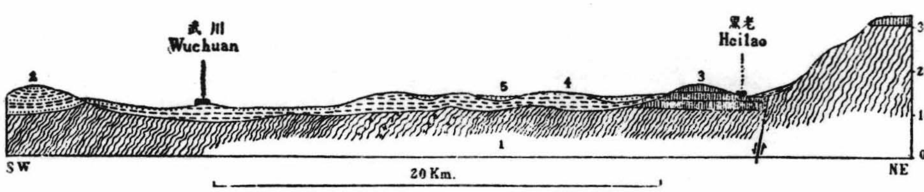


Fig. 3. Generalized section of Wuchuan basin showing the Tanghsien landsurface below the red clay deposits. 1, Archaean gneiss. 2, Jurassic coal series. 3, Tertiary basalt. 4, Pliocene red clay. 5, Alluvium.

Fenho stage: On the southern sides of Tachingshan, Olashan, Sheitenola, Langshan etc. the old bottom of the Tanghsien stage has been cut up by Huangho valley and its tributaries in a number of terraces (see Fig. 4) with more or less steep margins towards the valleys and the flat surfaces, but when the absolute altitude of the surfaces is considered they in fact are slightly sloping towards the main valley. Both the terraces and the valleys are the result of the erosion during the Fenho epoch.

Outside the Huangho basin the Fenho stage is also recognized in Tailiang, Hsiaoshiehtai, Wuchuan and Hsingho basins where by the river erosion the red clay covering of Tanghsien landsurface had been removed so as to form wide valleys of which the bottoms are frequently buried with Pleistocene gravels. The latter are again cut by the present river beds. It is clear that the period of removal of the red clay corresponds to the Fenho stage.

The bottoms of the old wide valleys mentioned above frequently lie 60 to 20 m. and in some cases less, below the Tanghsien landsurface. These figures plainly represent the insignificant amount to which the erosion of the Fenho stage has cut down below the flat surface of the more ancient basin (i. e. Tanghsien landsurface). Probably, when the mature topography of Tanghsien stage was reached the rivers were all slow and weak whose force of erosion was rejuvenated only by a very slight amount of upwarping in the Fenho epoch. Consequently, the Tanghsien landsurface was dissected in a relatively insignificant depth resulting only in the partial removal of the red clay covering and the formation of wide and shallow valleys.

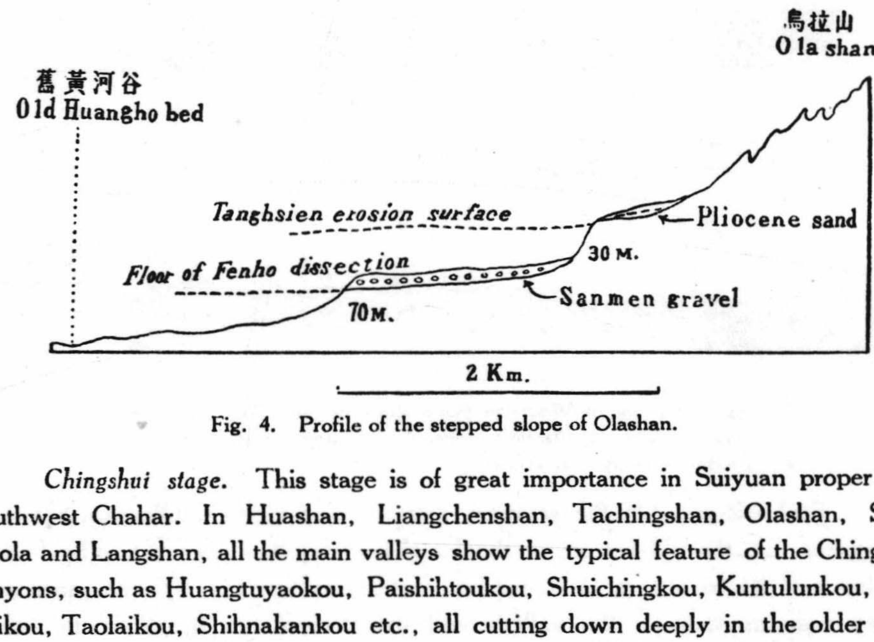


Fig. 4. Profile of the stepped slope of Olashan.

Chingshui stage. This stage is of great importance in Suiyuan proper and Southwest Chahar. In Huashan, Liangchenshan, Tachingshan, Olashan, Sheitenola and Langshan, all the main valleys show the typical feature of the Chingshui canyons, such as Huangtuyaokou, Paishihtoukou, Shuichingkou, Kuntulunkou, Paitsaikou, Taolaikou, Shihnakankou etc., all cutting down deeply in the older wide valleys. In the Hsiaoshiehtai and Kuyang basins the Chingshui trenching can also be easily distinguished by the removal of the Pleistocene gravels and the comparatively wide and shallow canyons. Loess deposit is in some cases found in these canyons, although very often largely washed away by the recent streams.

Panch'iao stage. This stage is also well developed in the area studied, consisting principally of a vertical cutting that acted along the valleys in the basins or on the slopes of rolling hills. It is, however, most marked along the valleys in Huashan and Tachingshan. By its activity, the bottoms of the Chingshui valleys were further deepened down to form small gullies (see Fig. 5) about 10 m. to 15 m. in depth, this feature has been referred by C. C. Wang to his Huangho stage which most probably corresponds to the Panchiao, a name of wider use now.

Physiographic history: From the above facts, the complete physiographic history may be inferred. As will be stated in the chapters on stratigraphic geology and geological structure, in Suiyuan and Chahar the folding movement which seems to have ceased in early Cretaceous was followed by a cycle of erosion which covered the interval of time from late Mesozoic to early Tertiary period. During this time the elevations of anticlinal folds were plained down and the synclinal depressions were filled up by the fan-deposits, viz. Nantienmen series and Tumulu series to be treated later; this is a period of both construction and destruction. The resulting topography was the peneplane of Peitai stage, which was buried by the voluminous outpouring of basaltic lavas in Oligocene time.

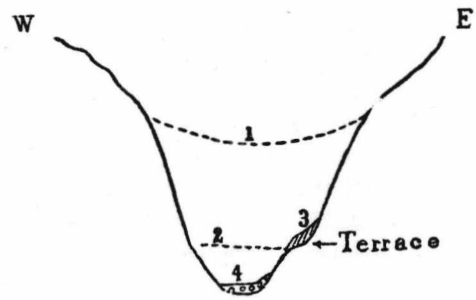


Fig. 5. Features of the valley near Huangtuyaotzŭ. 1, Floor of Fenho. 2, Chingshui trenching. 3, Loess. 4, Panchiao cutting.

Probably in the early Miocene the peneplane with overlying lavas were disturbed by crustal movement involving obvious faulting. This started the second cycle of erosion which has resulted in an advanced mature landsurface of Tanghsien stage consisting of the isolated high mountains and the wide and flat basins that have been filled up by the Miocene-Pliocene sediments.

As stated above the rivers, when the mature topography of Tanghsien stage was reached, became very slow and were rejuvenated by a slight amount of warping in the late Pliocene or early Pleistocene. Consequently, the open valleys of Fenho stage were cut down. This was followed by the deposition of Sanmen gravels. Following the deposition of Sanmen gravels a certain amount of warping took place.

It renewed the force of vertical erosion of the slow streams so that the canyons of Chingshui stage were cut down along the lines of older valleys. The stage was followed by the deposition of the loess.

After the deposition of the loess a very slight amount of warping again renewed the vertical erosion of streams. It resulted in the gullies of Panch'iao stage which continued from late Pleistocene to to-day.

From what has been stated above the following table may be established :

PEITAI STAGE	PENEPLANE	FROM LATE MESOZOIC TO EARLY TERTIARY
	outpouring of basaltic lava	
	FAULTING	
TANGHSIEN STAGE	ADVANCED MATURE LANDSURFACE	MIOCENE
	Deposition of Red Clay	
	WARPING	
FENHO STAGE	OPEN VALLEYS	EARLY PLEISTOCENE
	Deposition of Gravels	
	WARPING	
CHINGSHUI STAGE	CANYONS	PLEISTOCENE
	Deposition of Loess	
	WARPING	
PANCHIAO STAGE	GULLIES	RECENT
	Deposition of Alluvium	

III. STRATIGRAPHIC GEOLOGY

In Suiyuan proper almost all the important formations of North China can be observed except the Cambrian and the Ordovician while in Southwest Chahar the entire Palæozoic is missing. At the close of the Archæan era, the condition was also different between these two provinces In Southwest Chahar it is found that the rocks of Archæan age are overlain directly by the Sinian limestone with basal quartzite and slate. The Wutai formation which occurs in Suiyuan proper is here entirely absent.

The different formations of the two provinces are represented and explained systematically in geological columns shown in Plates I & II. For each formation details as to distribution, character, and stratigraphic relationships will be given as follows:

ARCHÆAN

Sangkan System

Distribution : The large part of Suiyuan and the southwestern part of Chahar are districts of great development of this old formation. In Southwest Chahar the formation consists of a succession of crystalline gneiss and schist which appear to underlie all the younger formations, but are penetrated by the later intrusive igneous bodies. The gneiss comes to the surface largely over the territory between Huaianhsien, Hsinghohsien and Wanchuanhsien and extends to the southeast for a distance, so that much of the upper course of the Yangho is cut in this rock. Near the headwaters of the same river von Richthofen[1] first saw the formation. He named it the Sangkan gneiss in view of its typical development in the valley of Sangkanho about 150 li farther south, regarding it as younger Archæan in age (younger than Taishan and older than Wutai). The term is retained in this paper and to the Sangkan System will be also referred the metamorphosed group (e. g. the series of gneiss, schist and marble) in Suiyuan proper. The gneiss of the Sangkan System also crops out to the southwest in a place north of Yangyuanhsien, forming hillocks covered on all sides by the late Tertiary red clay and northward in the gullies in the Tumulu red beds in western Changpeihsien. Their exact position and their relationship to younger formation are shown in the geological map (Sheet I).

With regard to Suiyuan proper a large part of the area is occupied by extensive exposures of the rocks of Sangkan System. They form the famous mountains such as Olashan, Sheitenola and Kueitingliang and extend from the last mountain southward into Shansi province and to the northwest for an unknown distance beyond. A large portion of Tachingshan is also composed chiefly of Sangkan rocks. In this province the Sangkan System is clearly exposed as a result of uplift and erosion.

Character: The Sangkan System of which the main exposures have been mentioned above has been studied by the writer in Olashan, Sheitenola, Tachingshan, Kueitingliang etc. in Suiyuan and in Tungyangho, Hsiyangho, Nanyangho, Nankouling etc. in Chahar.

In *Olashan*, the rocks of the basal formation are well exposed in several valleys, Kuntulunho, Hatemenkou etc. For a distance of about 15 km. there are valley cuttings in the rocks, the exposures being so clear that structure behaviour and relations between the members of the formation to each other are well exhibited.

1. China Vol. 2, Part 3,

In the formation treated here the gneiss is a dominating member, marble is more subordinate. Petrographically the gneiss is represented by two types: 1) an acid type that varies considerably in character but is mainly a group of injected and steeply inclined metamorphosed sediments and 2) a basic facies which appears, from petrographic study to be mainly igneous and must be intrusive.

In general the acid type has its bedding well preserved with often uniform strike; but it, in some cases, is strongly disturbed by the intruding pegmatite and diabase to be treated later in Chapter IV, resulting in a clear puckered structure (see Pl. XIV A). Its general composition varies from a biotite schist to a migmatite (mixed rock of gneiss and granite). The typical rock is a medium-grained gneiss of grey color, sometimes garnetiferous, usually composed, like that described by G. B. Barbour in Kalgan area, of quartz, microcline, oligoclase, perthite, biotite, apatite, magnetite with sericite and a little chlorite as alteration products. The quartz is present as an angular interstitial filling between feldspar crystals. It also occurs as rounded somewhat uniform grains with margins strongly suggesting corrosion, englobed in larger feldspar crystals of clearly subsequent date (sea Pl. XVI, A).

The above mentioned character seems to comfirm the hypothesis according to whieh the acid gneiss is derived from an ancient group of psammites (arkosic sediments) changed by acid magmatic juices and further affected by dynamic metamorphism. The gneiss was intruded by the granite probably of Wutai age. And in some cases the granitic magma probably in vapour solution and under the high pressure entered the minute foliation planes of the gneiss, and so strongly soaked it as to form migmatites.

The basic type occurs as irregular intrusive sheets intercalated in the acid para-gneiss being traceable along the foliation planes, as if they were also the members of the sedimentary series. For example, at Shapatzu the basic gneisses stand up firmly in bands varying from one foot to a few inches in thickness in many cases the bands alternate with the biotite gneiss. The biotite layers often are readily attacked and weather out, resulting in shallow depressions on exposed surface.

The basic gneisses are usually medium-grained amphibolites of dark color, mainly containing the following mineral components as seen under microscope. The hornblende abundantly present is usually fresh though some alters to chlorite. The feldspar is subordinate and partly altered. The epidote is not infreauently present. The rocks in some cases show a distinctly gneissic appearance.

From what has already been stated, the basic gneisses are evidently igneous intrusives which penetrated the sedimentary formation after the reorganization of the latter. The gneiss is also contaminated by the Wutai granite.

The marble occurs as bands up to about 150 m. in thickness, interstratified in the acid gneiss (see Fig. 6). Its composition varies from a pure white marble to a serpentine marble. The former varies in texture from coarsely crystalline through medium-grained to compact, and its color from pure white to greyish white. The latter may be seen grading insensibly from the pure white type and is a fine-textured rock of yellowish green color, usually traversed by a multitude of asbestos veins. This is well seen on the hill-slopes, N. of Shapatzu.

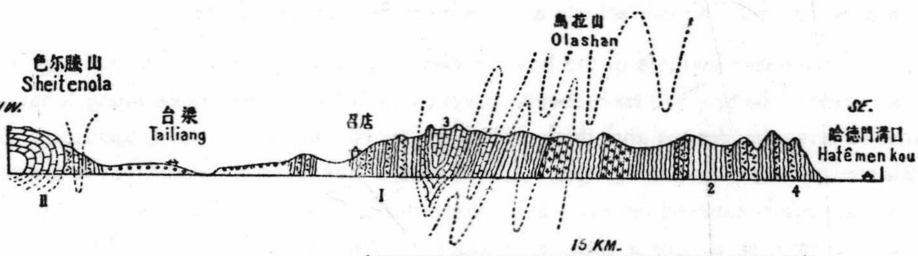


Fig. 6. Ideal section of Olashan and Sheitenola. I. Archaean: 1, Garnetiferous beds. 2. Gneiss. 3, Marble. 4, Granite. II. Sinian limestone.

In *Sheitenola* range, as far as observed SE. of Shihnakan, N. of Maohutung and W. of Chiachuanwan, (W. part of Sheitenola) and NW. of Kungyiming and N. of Paits'aikou (E. part of Sheitenola) the oldest formation, forming either gently rolling hillocks or precipitous-cliffed hills, is composed essentially of the gneiss of basic facies. The basic gneiss is comparable with that of Olashan mentioned above probably corresponding to the same period of eruption to which the latter belongs. This rock has also probably been intruded in the older gneiss though it has not been possible to observe this in the field as here the older gneiss is almost entirely wanting except on the southern slope of Sheitenola where the gneiss composed mainly of quartz, feldspar, biotite and sericite is in well bedded habit and intercalated with layers of marble, suggesting an ancient rock of sedimentary origin.

The basic gneiss includes: a) a dark type, b) a dark green type, and c) a green type.

Type a) is a dark medium-grained hornblende-gneise, of which the typical development is found near Kungyiming village. It mainly contains hornblende, quartz, feldspar and magnetite. The last named is very abundant, thus its streaks often black, and alternating with layers of quartz it gives the rock a banded appearance, though on a small scale. In this rock the gneissic structure is also distinct.

Type b) typically developed in Machutungkou is a hornblende-pyroxenite. The texture is usually fine-grained, but varies somewhat from place to place. The mineral components are hornblende, pyroxene, magnetite with sericite and chlorite as alteration products.

Type c) is a medium-grained rock which like type b) is composed mainly of hornblende and pyroxene with chlorite formed by the alteration of the original non-quartzose material. The characteristic heavy green color is due to the presence of abundant chlorite. The rock frequently shows a gneissic appearance and in some cases it passes into chlorite schists as seen near Shihnakan village.

The notable features of the basic gneiss are that the granites of Wutai age (see further under Chapter IV) have been observed penetrating the gneiss along foliation planes in irregular lenses and thick bands up to 100 m. and should, therefore, be considered younger than the gneiss. Sometimes it has been noticed that the granite magma gradually entered between the minute foliation planes of gneiss and strongly soaked it, so that a mixed rock is produced. This is well seen in Paits'aikou valley.

In *Tachingshan* it is also possible to observe a good development of the Sangkan system. The upper course and the lower course of Shuichingkou valley N. of Sarach'i are cut in the system of metamorphosed rocks recognised by C. C. Wang[1] as the gneisses of Wutai age, which present a well marked stratified habit, i. e. they are all in parallel stratigraphical sequence. The sequence is represented mainly by the grey medium-grained biotite-gneisses of sedimentary origin with intercalations of white marble containing biotite, quartz and feldspar as seen in hand specimens.

The stratified biotite gneiss is also seen in the neighborhood of Paotou where it is associated with dark green hornblendite in an indistinct relationship.

At Shihhueiyaotzu, Pankoa, Yushutein etc. (N. of Chasuch'i) the Sangkan system is found to be composed essentially of well bedded gneiss and white marble. The gneiss is a medium-grained, grey or dark rock usually containing biotite, quartz, plagioclase, and orthoclase, the rock sometimes is invaded by granite along the foliation planes in layers and strings traceable between the planes giving it a banded appearance. The marble often contains serpentine and in many places yields asbestos. At Kulupanpulang (about 110 li NE. of Wuchuan) the well bedded gneiss is

1. Geology of Tachingshan, Bull. Geol. Surv. China No. 10, 1928.

found to be, in many places, associated with medium-amphibolites of black color. They are often cut across by the granite-intrusions.

The formation observed at the *Kueitingliang range* possesses the same composition as that in mountains just mentioned. The gneiss and the marble are all well exposed along Huanghuakotungkou SW. of Taolin, Taolaikou N. of Chining and valleys near Ch'ihsiayingtzu station E. of Kueisui. In the Huanghuakotung valley the gneiss is a relatively fine-grained, dark grey acid rock. The mineral constituents observable under microscope are chiefly biotite quartz, plagioclase and microcline. The gneiss is invaded by the granite of probably Mesozoic age (see under Chapter IV). The granite magma sometimes entering between more or less minute foliation planes of gneiss formed small lenses, so that a real "lit-par-lit" injection is the result. The marble occurs in several bands interbedded in the gneiss, having a fine coarse-crystalline texture. In Taolaikou valley the dark grey acid gneiss of uniform strike as in Huanghuakotungkou, is intercalated with some white marbles (see Fig. 7). Near Ch'ihsiayin station, however, the white marble partly highly silicified predominates sometimes over the acid gneiss. The gneiss being well bedded is often seen to grade into mica schists.

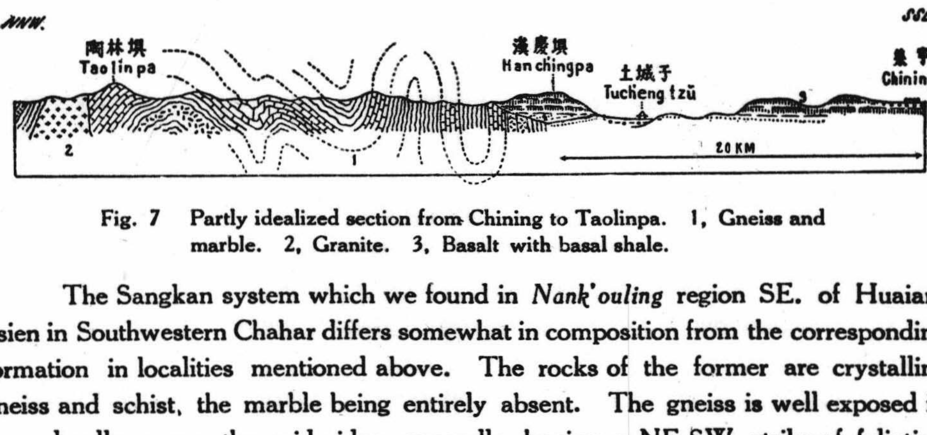


Fig. 7 Partly idealized section from Chining to Taolinpa. 1, Gneiss and marble. 2, Granite. 3, Basalt with basal shale.

The Sangkan system which we found in *Nank'ouling* region SE. of Huaianhsien in Southwestern Chahar differs somewhat in composition from the corresponding formation in localities mentioned above. The rocks of the former are crystalline gneiss and schist, the marble being entirely absent. The gneiss is well exposed in several valleys near the said ridge, generally having a NE-SW strike of foliation with a steady dip to the northwest of 35°-45°. Broadly speaking it bears a certain resemblance to that already described from Olashan being represented by two types, viz. an acid type and a basic type.

As in Olashan the acid gneiss appears to represent a member of steeply inclined metamorposed sedimentary series, with well preserved bedding and locally uniform strike (see Fig 8). It is a fine to coarse textured, grey rock which is probably a reorganization product from arkosic quartzite. The mineral constituents are usually quartz plagioclase, microcline, biotite, magnetite with chlorite etc. The quartz is present n ather round grains with oultine suggesting corrosion. The gneiss is sometimes intercalated with mica schists which probably have been originally layers of argillaceous shales.

The basic gneiss is a medium-grained, black amphibolite occurring as well-defined layers intercalated in the acid gneiss; it consists chiefly of hornblende, feldspar and eqidote, the first being abundantly present and partly very fresh. Though megascopically it appears to be massive, it has in fact a striking gneissic feature microscopically.

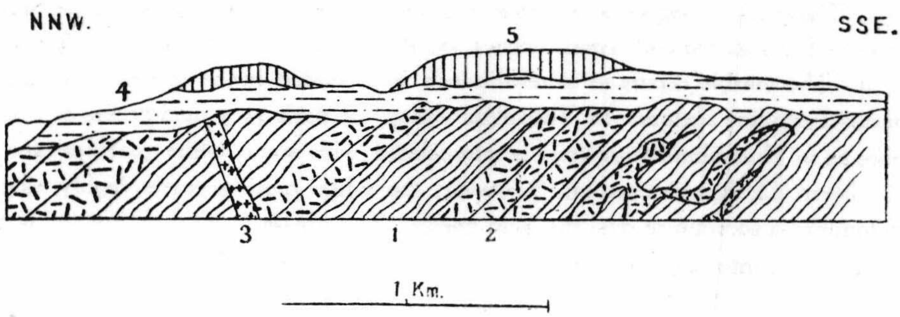


Fig. 8. Section S. of Nank'ouling, Huaianhsien. 1, Sangkan gneiss. 2, Granite. 3, Pegmatite. 4, Red clay. 5, Loess.

The basal formation which is widespread at both sides of *Tungyangho* W. of Wanchuanhsien was followed up this river and found to form the large portion of the mountains along which stretches the Great Wall. The rock is for the most part a fine to coarse grained gneiss, frequently grey or dark grey, though sometimes reddish, and it grades insensibly into mica schists. From the intimate association of the two, it appears apparent that they are portions of a single mass of variable composition, in which the effects of metamorphism have been certainly dissimilar.

The gneiss is composed chiefly of white feldspar, grey quartz, black biotite as seen in specimens.

Along *Nanyangho* which was studied at a place NW. of Huaianhsien the Sangkan formation, here forming Pailungshan, is composed almost entirely of the gneiss which has a N-S strike of locally uniform character with a dip towards the west of 45° and is capped by Sinian limestone which is also developed here. The gneiss is a medium-grained, yellowish grey rock consisting of grey quartz, white feldspar and dark-biotite. It often weathers into soft rock in which the biotite becomes yellow in color.

Along the valley of *Hsiyangho*, especially in its upper course, the Sangkan gneiss is well bedded (see Fig. 9) having a E-W strike with a dip, towards the south, or towards the north, of 30°-40° and being, in some cases, intruded by the diabase dyke. The gneiss is medium-grained and of reddish color, frequently garnetiferous, usually composed of quartz, feldspar, biotite, sometimes graphite. In some places (Huangtuyaotzu etc.) the graphite is very abundant and is of special economic significance.

From what was already stated above, the following summary may be given: The Sangkan system exposed in both Suiyuan proper and Southwest Chahar is composed essentially of the acid para-gneiss of regular, stratified feature and relatively simple structure, which is intruded by the basic ortho-gneiss along the foliation planes and the two penetrated and locally contaminated by the comparatively recent granites of different generations of igneous activity. In these gneisses the marble seams commonly observed in Suiyuan proper are entirely absent in Southwest Chahar.

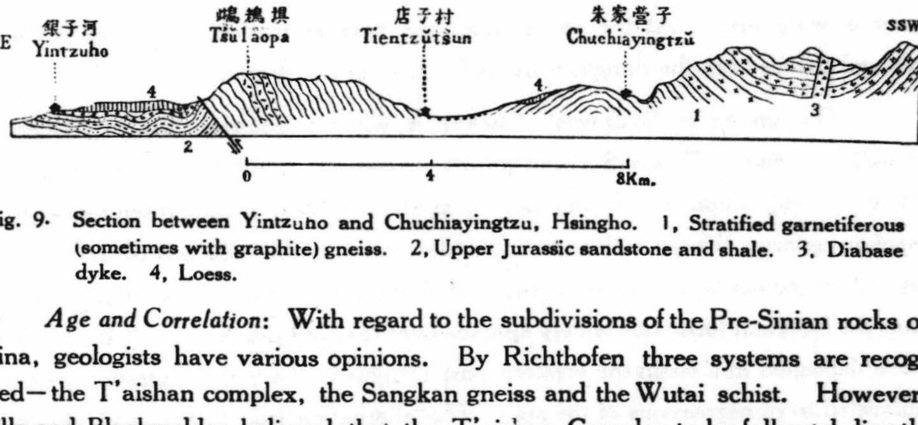


Fig. 9. Section between Yintzuho and Chuchiayingtzu, Hsingho. 1, Stratified garnetiferous (sometimes with graphite) gneiss. 2, Upper Jurassic sandstone and shale. 3, Diabase dyke. 4, Loess.

Age and Correlation: With regard to the subdivisions of the Pre-Sinian rocks of China, geologists have various opinions. By Richthofen three systems are recognized—the T'aishan complex, the Sangkan gneiss and the Wutai schist. However, Wills and Blackwelder believed that the T'aishan Complex to be followed directly by the Wutai System, and the first was classed as Archæan, the latter as Eo-Proterozoic. Recently Prof. G. B. Barbour follows Richthofen's determination and attributes the group of rocks, lithologically standing in the position between T'aishan and Wutai types to the Sangkan gneiss. His opinion may be summarised as follows.[1]

"The petrographic contrast between T'aishan complex and Wutai system as typically developed is distinct. The gneisses of the former are a group of ancient crystalline rocks whose original character has been obliterated by intense metamorphism due to the vast quantity of granitic magma which penetrated, soaked,

1. Geology of the Kalgan Area. Mem. Geol. Surv. China, Ser. A, No. 6, p. 21, 1929.

attacked, reorganized, and in part absorbed, the constituents of the pre-existing formations. These crystalline rocks are characterized by the extreme complexity of structure, the banding showing sharp flexures and shearing, with abrupt thickening and pinching out.

The rocks of the latter, according to Willis' observation in Shansi are essentially a group of dynamically metamorphosed sediments. In the system there are three lithologically separable series. The Shihtsui series probably the oldest group, is of mica schist, gneiss with basal arkosic quartzite. Separate from it by an unconformity is a middle group of marble, jasper, quartzite and schist. The Sitai series has a basal conglomerate followed by chlorite schist and quartzite.

The Sangkan gneiss appears in several respects to stand in a position intermediate between the T'aishan and Wutai types. It is without question an injection-gneiss, produced by the magmatic soaking of a large body of sediments, over a wide area. At the same time, the notable feature is that marble seems always absent from the Sangkan and is frequent in the Wutai."

The gneiss of Southwest Chahar is without question the equivalent of Sangkan gneiss. That of Suiyuan proper appears too in the field behaviour and the mineral composition as already described above to bear a close resemblance to the Sankan gneiss, though with some intercalations of marble which is often considered by other geologists to be characteristic of Wutai formation. Thus we may suppose that the Sangkan formation widely spreads over the said provinces. It has probably been deposited in a basin the western part (Suiyuan) of which in question was often subjected to transgressions of the sea. The alternating transfusions and emergence would have resulted in the bands of limestone intercalated in continental sediments. The eastern part (Southwest Chahar), on the other hand, was constantly preserved in a continental condition, therefore the marine sediments are entirely wanting here.

Rocks of Sangkan system extend to the north and to northeast for a great distance. Gneisses with intercalations of the marble have been observed by geologists of the Central Asiatic Expedition[1] in Outer Mongolia. G. B. Barbour has described acid and basic gneisses from Kalgan region immediately to the east.

1. Geology of Mongolia. Natural History of Central Asia, Vol. 2, Am. Mus. Nat Hist. New York, 1921.

PROTEROZOIC

Wutai System

Kuyang Formation

Distribution and character: In Suiyuan and Chahar the Wutai formation as will be described has mostly been removed by erosion of past periods. The remnant formation named from Kuyanghsien where it is well developed is found only at the following five localities:

1) A little north of Kuyanghsien outcrops of Kuyang strata form Hatashan ridge which is deeply dissected by transverse valleys. Only one part of the formation is observed as denudation has removed the higher strata and the lowest ones are not exposed. It consists of fine-textured grey mica schist containing crystals of pyrite. Above the schist come 20 meters of yellowish white marble which is succeeded by dark-grey mica schist. The upper-most member is a medium-grained, grey and reddish quartzite of about 100 meters (see Fig. 10). Not far north of Hatashan lies largely a mica-schist including layers of white marble, which is probably equivalent of Hatashan mica-schist.

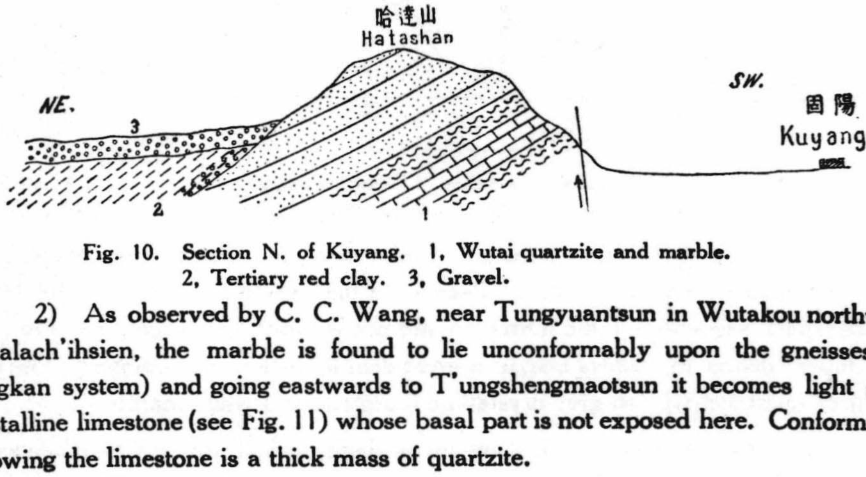


Fig. 10. Section N. of Kuyang. 1, Wutai quartzite and marble. 2, Tertiary red clay. 3, Gravel.

2) As observed by C. C. Wang, near Tungyuantsun in Wutakou northwest of Salach'ihsien, the marble is found to lie unconformably upon the gneisses (of Sangkan system) and going eastwards to T'ungshengmaotsun it becomes light grey crystalline limestone (see Fig. 11) whose basal part is not exposed here. Conformably following the limestone is a thick mass of quartzite.

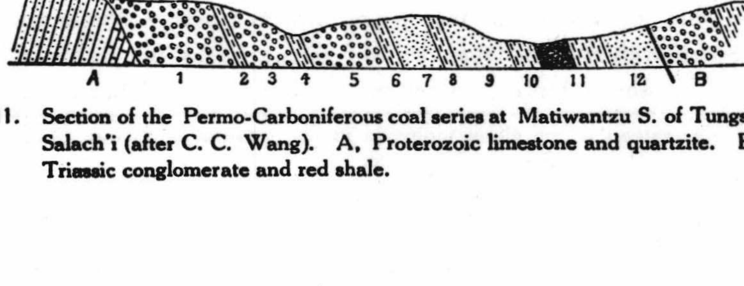


Fig. 11. Section of the Permo-Carboniferous coal series at Matiwantzu S. of Tungshengmiao Salach'i (after C. C. Wang). A, Proterozoic limestone and quartzite. B, Permo-Triassic conglomerate and red shale.

3) In Wanchiakou N. of Chasuch'i village the outcrops of the quartzite form inliers bordered on the southeast by Sangkan rocks and on the north by the granite. The beds stand vertically or dip steeply to the northwest, probably lying in a closed overturned syncline (see Fig. 12). The psammitic sediments, under conditions of metamorphism of varying degree, have been changed into quartzites of various character. The gradation may be traced from slightly altered quartzite, of which the original character of grains may still be recognized, into highly altered and recrystallized micaceous rock of which the original texture has been entirely obliterated.

4) At Wukungpa north of Kueisui the mica-schist sometimes phyllite, including layers of siliceous marble, is associated with the Sangkan gneiss in an indistinct relationship.

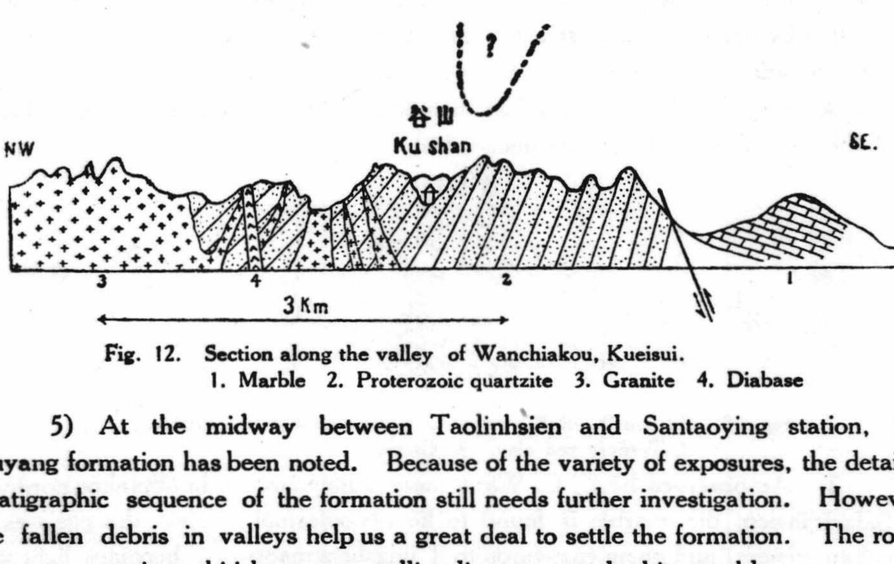


Fig. 12. Section along the valley of Wanchiakou, Kueisui.
1. Marble 2. Proterozoic quartzite 3. Granite 4. Diabase

5) At the midway between Taolinhsien and Santaoying station, the Kuyang formation has been noted. Because of the variety of exposures, the detailed stratigraphic sequence of the formation still needs further investigation. However, the fallen debris in valleys help us a great deal to settle the formation. The rocks are grey quartzite, whitish grey crystalline limestone and white marble.

Age and correlation: This system is distinguished from the Sangkan system by the lack of injection gneiss, and from the Sinian formations by its stronger metamorphism and the absence of siliceous limestone, as already recognised in North China. Both its stratigraphic position and lithological character in fact favor the supposition that it belongs to the Wutai system typically developed in Shansi. It is comparable with the Lioutingssu series,[1] recognised by the author in Wutaishan of Shansi. The series forming only one of the several lithologically separable

1. Some observations of the oldest formation in the province of Shansi. Bull. Geol. Soc. China, Vol. VII, Nos. 3-4, pp. 266, 1928.

groups in the Wutai system which here is composed chiefly of crystalline limestone, marble, quartzite and phyllite, the last often changes into schists.

PALÆOZOIC

A. Sinian System

In both Suiyuan proper and Southwest Chahar the rocks of Sinian System a observed, but the typical Nankou limestone is found only in the latter province; the Sinian system in the former province is an entirely unaltered cherty limestone which seems to belong to the higher part and is named the Shihnakan limestone.

1. Nankou Limestone

Distribution and character: The Nank'ou limestone has been noticed in Chahar. It is thought to be laid down in a basin (see Fig. 14), in the direction of E-W occupying South Chahar, Central Suiyuan and North Hopei. In the Tatung basin in north Shansi, C. C. Wang[1] did not find the Sinian formation. The Sinian limestone in the area surveyed had originally a rather extensive distribution, but is now almost entirely removed by the pre-Tertiary denudation, a few residues being preserved at Ch'imafang, Peishan on the north side of Sangkan valley, Pailungshan and Huhsingshan, N. of Huaianhsien, and Hsiyingtzu 60 li N. W. of Tumulu, beyond the area surveyed, in Southwest Chahar.

At Pailungshan and Huhsingshan, the cliff-forming parts of these hills are composed entirely of Nank'ou formation. It lies almost horizontally upon rotten rock derived from gneiss as described above, acting, owing to its resistance to the agency of weathering, as protectors (See Fig. 13). As the higher strata of the formation have been eroded away, only the beds near the base are preserved here. The basal beds have a basal quartzitic slate of no great thickness which is of grey-purple and greyish color and highly compact texture. This slate is succeeded by the siliceous limestone which varies from whitish-grey to dark grey and is sometimes of a mottled grey and white color, due to the irregular distribution of silica and carbonate minerals in the rock. The total thickness of the beds is estimated at about 130 meters.

North of Ch'imafang, Peishan at the east of Yangyuanhsien the Nank'ou limestone appears to be almost horizontal forming gentle rolling hills bordering the Shangkanho alluvial plain on the north. Its contact with older formation is

1. The coal field of Tatung, Bull. Geol. Surv. China, No. 3, 1921.

not observed here, but going eastwards to a place N. E. of Tungch'engchen the calcareous rock can be followed down to its base on the underlying gneiss. The limestone like that in Pailungshan and Huhsingshan is well bedded, fine-medium-textured and of mottled grey and white color. In some cases it is partly developed as greyish white highly siliceous rock and the dark-grey flinty limestone is not infrequently observed in the eastern extension, the flints forming either nodules or layers. The thickness of the limestone is about 300 m.

Fig. 13. Pailungshan, made of inclined beds of gneiss capped with siliceous limestone, Huaianhsien.

N. of Hsiyintzu NW. of Tumulu as observed by Richthofen[1] the hill is made of gently dipping but not horizontal beds of siliceous limestone closely resembling Nank'ou limestone. Unfortunately the limestone seen by him on the south is exclusively associated with soil plain so that as to its relation to other formations nothing can be said with certainty. However as the northerly dipping Jurassic coal series is exposed at 8 li farther south, it can be reasonally supposed that a fault line occurs between the two exposures.

Age and correlation: In view of its similarity in character and the comparative nearness of occurrence the siliceous limestone of Southwest Chahar is doubtless the same as that of Nank'ou Pass. In 1871 von Richthofen during his journey in the pass saw the siliceous limestone with basal quartzite, naming it Nank'ou limestone[2] and including it in his "Sinian" system (Cambrian). Afterward, the Nank'ou limestone is known to occur in many provinces of China and it has been proved to be of Pre-Cambrian age, since in many cases it underlies the Cambrian beds with a disconformity. At present the formation falls into the Sinian system (Pre-Cambrian) of Grabau[3], which is placed in Palæozoic.

1. China Vol. 2, Part 3, 1882.
2. Richthofen established the term for all the unmetamorphosed sediments from the Cambrian downwards.
3. Sinian system: Bull. Geol. Soc. China, Vol. 1, p. 44, 1922.

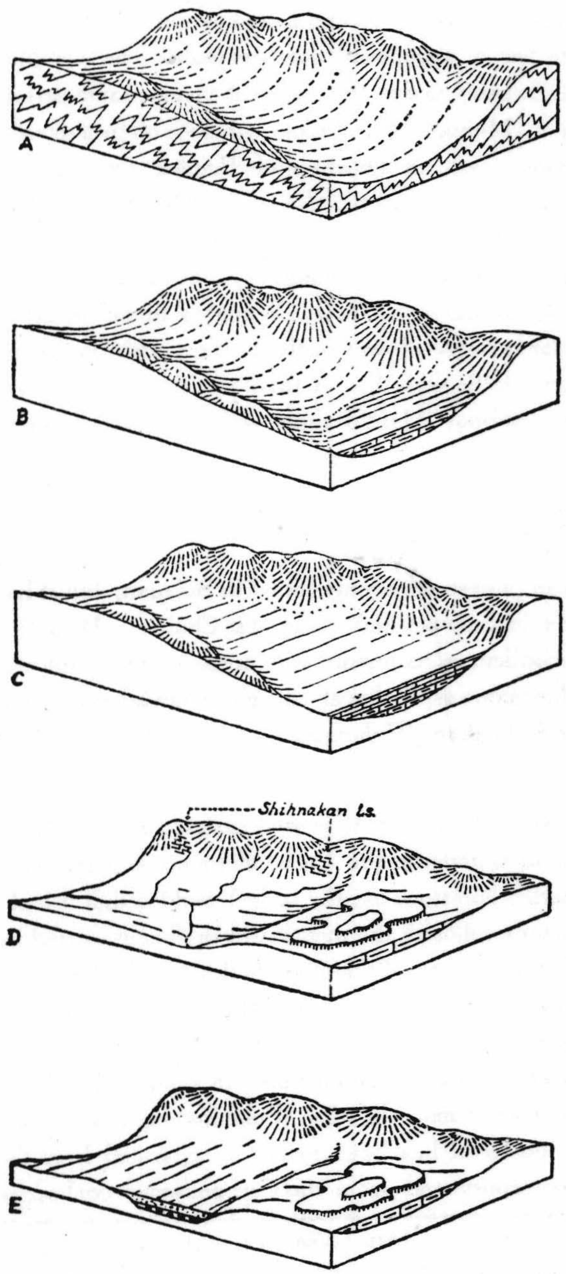
The Nank'ou limestone occurs in Hsuanhua and Lungkuan in S. E. Chahar. Here the basal quartzite member has a significant development. The complete succession was designated by Andersson under the name of Hsuan-Lung series.[1] The writer found the limestone in Miyun of N. Hopei, where it often alternates with quartzites and slates in lower part, in Hsishan of Peiping the siliceous limestone as described by L. F. Yih[2] is succeeded by the Hsiamaling slate. Afterwards Y. T. Chao[3] described the limestone from Kaiping as underlying the basal Mant'o shale of Cambrian formation with a disconformity. In Hueilu of Hopei the limestone is also found, which accordi ıg to Y. L. Wang[4] is to be separated from the Cambrian above by a disconformity. However, the Hut'o system in Shansi, which B. Willis assumed to be correlatable with that of the Nank'ou pass observed by Richthofen is overlain by the Cambrian Mant'o shale with pronounced unconformity and is poor in cherty beds.

2. Shihnakan Limestone

Distribution: The Shihnakan limestone is only found in Suiyuan, but it had originally an extensive distribution in Suiyuan and Southwest Chahar. However, since the deposition of Permo-Carboniferous sediments was preceded by a period of far reaching denudation when the limestone was almost entirely removed, only some eroded remnants being preserved at Shihnakan, Wulanhutung, Chiutsaikou, Shiukueikoupa etc. (see Fig. 14. D).

Character: In Shihnakan district the limestone is well exposed at two places: 1) At Wuhakou the limestone is found to underlie the Carboniferous coal series with a disconformity. It is a dark grey, earthy limestone usually so well bedded that it looks like a slate. The rock is partly metamorphosed, the metamorphism being caused by violent tectonic movements to be discussed later. 2) South of Shihnakan the limestone lies unconformably upon the Sangkan gneiss. Only its lowest portion is preserved, the higher beds have been eroded away; here the basal portion consists of thick bedded, impure lımestone of grey color, being also poor in flints. The limestone is often traversed by fine calcite veins. In the Wulanhutung region the Shihnakan limestone (from which no fossil has been found) is separated from the Sangkan system below by an unconformity and from the Carboniferous coal series

1. Iron ores and Iron Industry of China, Mem. Geol. Surv. China, A 2, pt. 1, 1921.
2. Geology of Hsi-shan, Mem. Geol. Surv. China, Ser. No. A 1, 1920.
3. Geology of Kaiping Basin and its environs, Bull. Geol. Surv. China, No. 12, 1929.
4. A study of general and economic geology along Chengtai Railway, Bull. Geol. Surv. China, No. 15, 1930.



above by a disconformity (see Fig. 15) and is usually thick- or thin-bedded, fine- or coarse-textured, being dark grey in color and impure in composition. It contains flints, either in nodules or in thin lenticular bands characteristic of the Sinian limestone. In some parts, however, the limestone may be quite free from flints. The limestone is not infrequently interbedded with calcareous shales. The total thickness is roughly estimated at about 600 m.

In Chiutsaikou NE of Wuchuan occurs greyish blue, sometimes flints bearing and thick-bedded limestone which unconformably overlies the Sangkan gneiss. Both on a lithologic and stratigraphic basis this limestone is doubtless equivalent to that in the places above mentioned. The same limestone sometimes lies in contact with the granite intrusion, so that it has been passed into white marble frequently silicified. The limestone also occurs at Chiukueikoupa to the east. There it seems to underlie the Permo-Carboniferous with a disconformity.

Fig. 14. Blockdiagrams showing the area of E. Suiyuan, W. Chahar and N. Shansi. A. Dissected basin (pre-Sinian). B. Basin partly covered Nankou limestone (Lower Sinian). C. Basin buried by Shihnakan limestone (Upper Sinian). D. The Shihnakan limestone is almost entirely removed by Carboniferous erosion and the river is formed. E. The river basin is covered by Permo-Carboniferous and Permo-Triassic sediments.

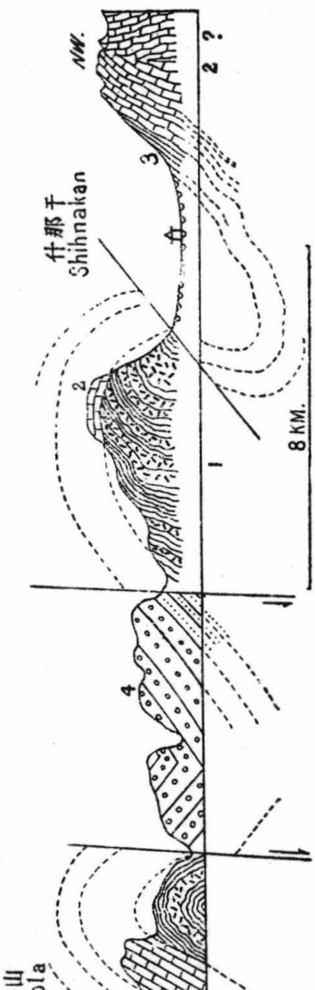


Fig. 15. Partly idealized section from Sheitenola to Shihnakan, Anpei. 1, Sangkan gneiss with granite. 2, Sinian limestone. 3, Permo-Carboniferous coal series. 4, Permo-Triassic conglomerate.

Age and correlation: So far as the data available permit judgement, the limestone is distinctly unlike any of the Cambrian or Ordovician limestones recognized in N. China. Both the presence of flints in some parts and the impurity in composition seem to help the supposition that it belongs to the Sinian system.

In view of the lack of metamorphism at all, this Sinian limestone can not be compared exactly with the Nank'ou limestone in Nank'ou pass. It bears a close resemblance to the unaltered limestone in Miyunhsien observed by the writer, grading insensibly from the typical Nank'ou limestone below. The Shihnakan limestone is thus probably of upper Sinian age. That it lies directly upon the floor of Sangkan gneiss, the Nank'ou limestone being wanting, may be explained by the assumption that the deposition of Nank'ou limestone observed in N. Hopei, S. Chahar is limited within the deeper portion of dissected basin mentioned above, but the higher horizon viz. Shihnakan limestone begins to reach its shallow portion in central Suiyuan. (See Fig. 14, B,C).

B. Permo-Carboniferous

Hsuanmachuang Coal Series

General statement: This coal series is composed of shale, quartz-sandstone, seams of coal and conglomerate. In some places, it has been entirely metamorphosed to phyllite, quartzite and graphite. The number of coal seams varies in different places. According to the tradition of native miners, one or three seams of coal are known to occur in this series.

The coal series rests disconformably on the Sinian limestone. In some cases, the latter completely disappears, so that the coal series and the Wutai formation, or Sangkan gneiss, come into direct contact (see Figs. 16 & 11) with an unconformity between.

The facts can be explained by the hypothesis that the deposition of Permo-Carboniferous sediments was preceded by such a period of far reaching erosion as to expose in some places the oldest formation. The total thickness of the series is estimated at about 100-160 meters.

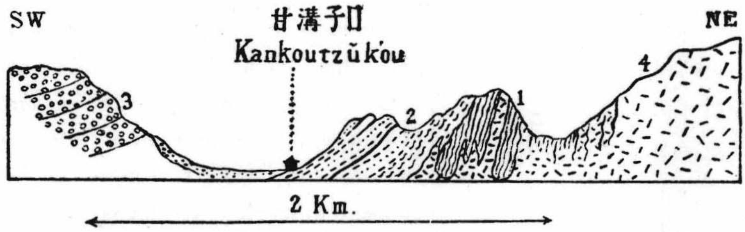


Fig. 16. Section at Kankoutzukou 80 Km. N.E. of Wuchuan. 1, Sangkan gneiss. 2, Permo-Carboniferous coal series. 3, Permo-Triassic conglomerate. 4, Granite intrusion.

Distribution and character: This Hsuanmachuang coal series is observed only at Hsuamachuan, Salach'i, Kankoutzu and Sulitu in Suiyuan, as shown in the geological map. (Sheets 3,4, 5 & 6).

In the vicinity of Hsuanmachuang the coal series is somewhat extensively exposed (eastward to Shamakou according to the report of native miners), occupying an area of about 15 sq. km. The coal series overlies disconformably the Sinian Shihnakan limestone and is succeeded by Permian quartz-sandstone. The strata occur in a close overturned syncline. Petrographically the coal series consists mainly of sandy shale and quartz sandstone with thin seams of coal. A good section of the series has been studied in the northwest side of the syncline. The succession of the different members, in descending order to the base, is as follows (see Fig. 17).

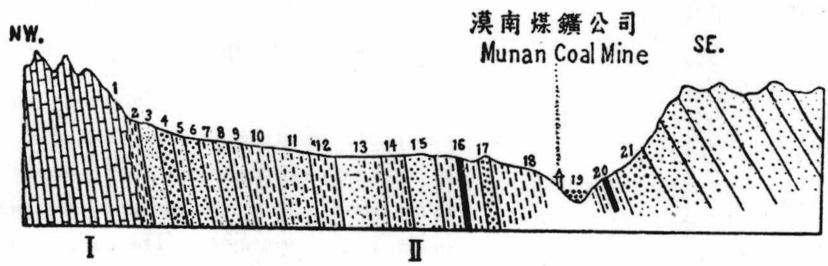


Fig. 17 Section near Munan Coal Mine, Anpei. I Sinian Limestone. II Permo-Carboniferous coal series.

21.	Whitish grey, coarse-grained quartz-sandstone (Permian)	
20.	Grey argillaceous shale with coal seam	10 m.
19.	Gravels covering the bottom of valley	20 m.
18.	Dark grey argillaceous shale	25 m.
17.	Grey coarse-grained quartz-sandstone	3 m.
16.	Dark argillaceous shale containing coal seam	15 m.
15.	Grey micaceous sandstone	10 m.
14.	Greenish grey argillaceous shale	6 m.
13.	Grey micaceous sandstone with shale	20 m.
12.	Dark argillaceous shale	7 m.
11.	Greenish grey, micaceous, sandy shale	11 m.
10.	Grey or black, argillaceous shale	10 m.
9.	Greenish grey, micaceous, sandy shale	3 m.
8.	Coarse-grained quartz-sandstone	2 m.
7.	Greenish grey, micaceous, sandy shale	1 m.
6.	Coarse-grained quartz-sandstone	2 m.
5.	Greenish grey, micaceous, sandy shale	15 m.
4.	Coarse-grained quartz-sandstone	3 m.
3.	Greenish grey, micaceous, sandy shale	5 m.
2.	Black argillaceous shale	4 m.
1.	Limestone (Upper Sinian)	158.5 m.

In this section the two seams of coal are now being worked by the native mines. They are said to vary from 3 to 5 feet thick. The quality of coal varies from anthracite to semi-anthracite.

North of Salach'i, the coal-bearing formation is found in two narrow strips one lying between the Wutai system, the other limited on both sides by the thrust faults. Here this formation comprises mainly shale, bituminous sandstone and conglomerate. The conglomeratic bed contain round pebbles chiefly of quartz. The best section is observed by C. C. Wang[1] near Matiwantzu south of T'ungshengmao village. The rocks arranged in descending order are (Fig. 11):

B. Conglomerate and red shale (Permo-Triassic)
12. White conglomeratic sandstone
11. Black shale with coal seam
10. Black sandy shale richly yielding fossil plants

1. Geology of Tachingshan, Bull. Geol. Surv. China, No. 10, 1928.

9. White conglomeratic sandstone
8. Black shale
7. Grey conglomeratic sandstone
6. Black shale
5. Conglomerate of quartz pebbles
4. Black shale
3. Conglomerate of quartz pebbles
2. Black shale
1. Conglomerate of quartz pebbles.

Unconformity

A. Ouartzite and crystalline limestone (Wutai)

The total thickness of the coal series is estimated at 108 meters, the whole succession of strata strikes NW. and SE. and dips NE. at an angle of 70°.

A little north of Shihnakan, disconformably overlying the Sinian Shihnakan limestone, the coal-bearing formation, having an extensive exposure along the southern side of Langshan range, has been entirely metamorphosed. It is composed mainly of dark grey phyllite, grey schist and coarse-grained quartzite with layers of graphite (in some case with fissure filling of melanterite), which are evidently derived from the sandy or argillaceous shale and quartz-sandstone that are equivalent rocks of the coal series recognized in Hsuanmachuang region. The structure of this metamorphic series is much complicated by local foldings and faultings.

At Kankoutzu ENE. of Wuchuan the Hsuanmachuang coal series, extending from Kankoutzu to the east for about 20 li, unconformably overlies the Sangkan gneiss (see Fig. 16). The coal series has also been metamorphosed, including dark grey phyllite, grey slate, yellowish grey sandstone and coal seam (mostly converted into graphite). Near the Sulitu village the coal series occurring in the belt from Sulitu to Liushuikoutzu is also unconformably underlain by the Sangkan gneiss (see Fig. 18) and is followed by Permo-Triassic red sandstone. The thickness measures at about 150 m. Here the series consists of yellowish grey sandstone, grey shale (yielding fossil plants) and coal seam.

Age and correlation: Plant fossils[1] have been found from the Hsuanmachuang coal series, at Hsuanmachuang, Kumanyintzu, Tungshengmao and Sulitu, which indicate a Permo-Carboniferous age. They are:

1. These fossils together with those previously collected by C. C. Wang will be described by H. C. Sze in a separate paper to be published in the Bulletin of the Geological Society.

Walchia sp.
Lepidodendron sp.
Calamites sp.
Pecopteris arborescens Schloth.
Sphenophyllum oblongifolium (Germ. & Kaulf.) Ung.
Sphenophyllum thoni Zeil
Annularia brevifolia Brongniart
Neuropteris flexuosa Brongniart
Sphenopteris sp.
Cordaites sp.

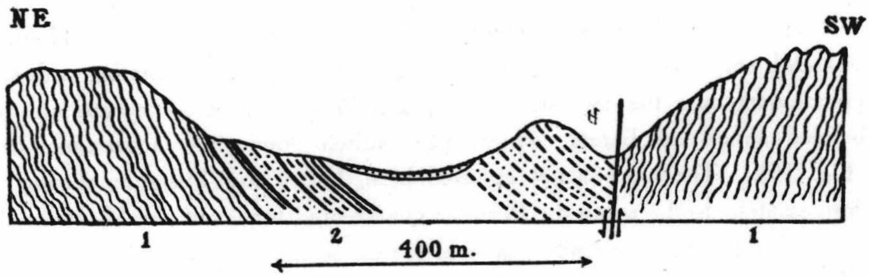


Fig. 18. Section of Permo-Carboniferous coal series near Sulitu, Wuchuan. 1, Archæan gneiss. 2, Permo-Carboniferous sandstone, shale and coal seams. 3, Permo-Triassic red sandstone and shale.

The Permo-Carboniferous formation can be roughly correlated with the so-called Shansi series in Shansi province, which is underlain by Taiyuan series, the latter containing several marine beds. In Suiyuan, on the other hand, the Permo-Carboniferous formation lies directly on either Sinian limestone or Wuta system or Sangkan gneiss as already mentioned above, the Taiyuan series being entirely absent. C. C. Wang thus believed that at that time, an old land existed in Inner Mongolia, which was never covered by the Middle Carboniferous sea.

Transition from Palæozoic to Mesozoic

Permo-Triassic and Triassic

Salach'i Series

Distribution: A formation younger than the Hsuanmachuang coal series occurs in five districts in Tachingshan and Sheitenola 1) the region of Tungshengmao and Tsiennaopao N. of Salach'i, 2) the region of Wenchiayao and Heiniukou N.

of Kueisui. 3) Hsuanmachuang N. of Anpei. 4) Sulitu E. of Wuchuan. 5) Pingantsun NE. of Wuchuan. In (1) (2) (3) and (4) the formation rests conformably on the Hsuanmachuang coal series, but in (5) it is sometimes found to overlie the Sangkan system with an unconformity. These conditions oblige us to think that the formation with Hsuanmachuang coal series below was deposited in a basin approximately located in the present Tachingshan (see Fig. 14 D).

The deposition of the sediments of the Permo-Carboniferous coal series is limited within the interior of this basin, but the higher series in question begins to reach its flank near Pingantsun village. The thickness of this formation measures at 500-600 m.

Character: At Tungshengmao, Tsiennaopao, Wenchiayao and Heiniukou the Salach'i series consists of conglomerate and sandstone alternating with shale. At Hsuanmachuang the formation is composed mainly of conglomerate with some interbedded sandstone bands, which was faulted down into a tectonic trough (see Fig. 15). The base is not exposed here, but at the Hsuanmachuang coal field immediately to the south the Permian quartz-sandstone conformably succeeding, as stated above, the Carboniferous coal series seems to be its basal part. The pebbles of the conglomerate, more or less round in shape and from 4 to 30 cm. in size, consist mainly of quartzites, gneiss and limestone, the cement being usually fine sand and grey clayish materials. In the region of Sulitu and Pingantsun the formation may be distinguished into two parts; the lower part mainly consists of red sandstone and shale and the upper part conglomerate which is also found at Olouhutung 40 li NW. of Pingantsun of which the base is not exposed here. The conglomeratic beds contain round pebbles or boulders mostly of gneiss, granite and marble.

These rocks appear to have been formed as a series of alluvial-fan deposits largely covering the basin by streams coming down from the slopes of mountains which bordered the basin on the north (see Fig. 14 E). Since these sediments are today mostly red in color, it would seem that the climate of this region was comparatively dry in the time when they were deposited.

Age and Correlation: The formation is poor in fossils. The age of it was thought by C. C. Wang to be Permo-Triassic and Triassic by comparing its lithologic character with the red series in Shansi and Shensi.[1]

1. Explanation to the 1:1,000,000 Geol. Map of China, Taiyuan-Yulin sheet, 1926.

MESOZOIC

A. Lower Jurassic

Shihkuai Coal Series

General statement: This series consists of grey, greenish grey and greyish white colored, sometimes slightly conglomeratic sandstones, more subordinate are argillaceous shales. In some places, it also contains a few thin beds of limestone. 3-10 seams of coal are known to occur in it. The whole formation is either conformable in strike and dip with the underlying strata (Permo-Triassic and Triassic series) or lies unconformably on the Sangkan system. The total thickness of the formation is about 500 m. in Suivuan proper and 300 m. (exposed thickness) in Southwest Chahar.

Distribution and Character: This series occurs in Suiyuan proper and also in Southwest Chahar.

Suiyuan proper

The series as described by C. C. Wang, has a typical development at Shihkuaitzu in the western part of Tachingshan in a broad gently dipping syncline although limited on both sides N. and S. by thrust faults. From the said village eastward the strata of this series become more and more steeply inclined until reversed so that its outcrop forms a narrower belt between upper Jurassic on the north and Permo-Triassic on the south (see Fig. 19) and continues so to the east until

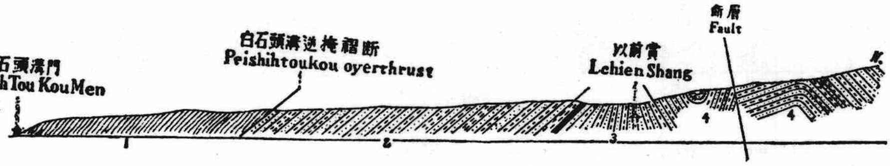


Fig. 19. Section along the valley of Peishihtoukou, Kueisui (after C. C. Wang). 1, Sangkan system. 2, Permo-Triassic red shale and sandstone. 3, Lower Jurassic coal series. 4, Middle and Upper Jurassic red shale and sandstone.

interrupted by faulting and granitic intrusion. East of the granite body, it constitutes small fields. Finally, it occurs in two isolated basins at Pak'outzu and Halachi. The main rocks are medium-grained, mostly grey and relatively easily disintegrating sandstones, sandy and argillaceous shales and quartz conglomerates, sometimes with thin beds of limestone yielding fossil fishes. The number and thickness of coal seams according to the inquiries and personal observations made by C. C. Wang are: In Liushuwan district there are 2 seams of coal, varying from 1-4 feet in thickness.

In Shihkuai region there are / seams of coal, 3, 1, 6, 4, 4, 7, 2 feet thick respectively. The quality of coal varies from anthracite to bituminous.

In many places this series was found to succeed conformably and continuously the Permo-Triassic Salach'i series. No division line can be drawn between them.

At Yangkoling and Kuantientzu immediately to the south and also at Tuchengtzu to the north the same formation occurs as narrow strips which are all limited on both sides by faults. The petrographical character is more or less the same as that described above. In Kuantientzu field 3 seams of bituminous coal 2, 1, 3 feet thick respectively, are known to occur in this formation.

Near Tanyaotsun W. of Wuchuanhsien, the coal series has a rather extensive distribution. Because of the variety of exposures, it is not easy to find typical section of the present formation. However, several pits help us a great deal to ascertain its probable succession. The coal series seems to lie horizontally upon the Sangkan gneiss, consisting of grey, dark-grey shale and yellowish grey sandstone. The coal seams here have been worked by the native mines.

In Sheitenola N. of Tachingshan mountain west from Shachikou southeastward to Yingpanwan there is a continuous belt of coal series which is limited on the north by a normal fault. Here the Permo-Triassic formation does not occur so that the coal series overlies directly the Sangkan gneiss (see Fig. 20) of which the

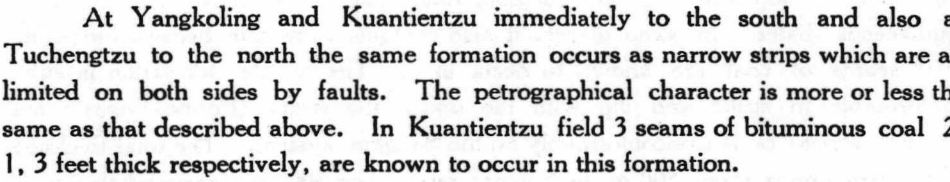


Fig. 20. Section from Chiachuanwan to Erhfentzu (E. Sheitenola). 1. Archaean gneiss with granite. 2. Lower Jurassic coal series

surface is in some cases strongly weathered and transformed into a soft rotten rock. Probably the configuration of the gneiss surface was exposed to weathering action for a long time till the Lower Jurassic sediments were deposited. Petrographically, the coal series may be subdivided into three parts:

Upper part built up by greenish grey sandstone and shale with the bands of conglomerate.

Middle part consisting of medium-grained, greenish grey or grey sandstones. The sandy or argillaceous shales are subordinate. The shales near the coal seams are often dark grey in color. In Kuants'ingkou this part contains 9 seams of bituminous, 8, 6, 5, 2, 5, 3, 5, 2, 5, feet thick respectively.

Basal part built up by coarse grained, easily disintegrating conglomeratic sandstones. The total thickness is estimated at about 500 m.

The Mesozoic coal series also occurs in a limited area at Erhfentzu 15 li to the north. The rocks are greyish white and greenish grey sandstones and sandy and argillaceous shales. Since small mines have been stopped for a long time, no exact information is available about the number and thickness of the coal seams except the tradition of native miners who affirm the existance of 3 seams varying from 2 to 9 feet thick.

West of Kuyanghsien this coal series occurs in a broad extension. Because of the rarity of exposures, it is very difficult to know its detailed succession. However, the fragments of rock from pits heaped up on the surface help us to assert its probable succession. At Wets'inhao, the sandstones seem to be predominating and some of them yield badly preserved impressions of *Podozamites*. Four seams of lignitic-bitumite are known to occur; 3 seams varying from 1 to 3 feet thick, one being 8 feet thick. They are said to be gently inclined if not horizontal. Near Shiehtaiho N. of Kuyanghsien the existence of an exposure of coal series was reported by the native people

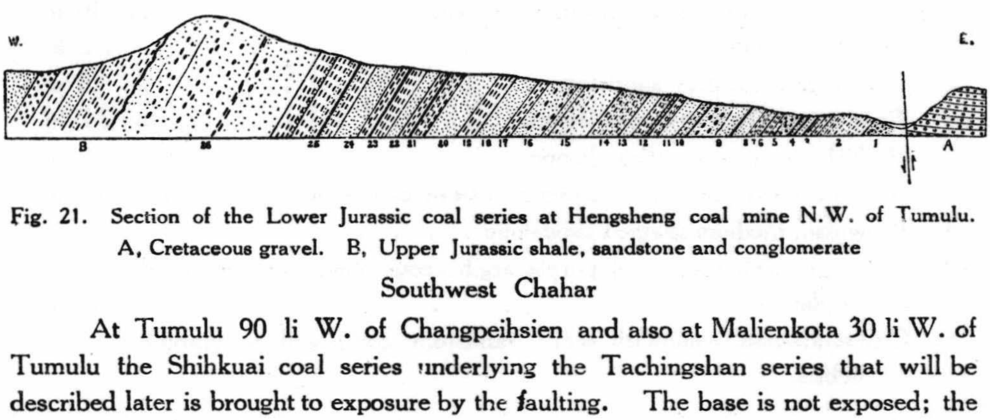


Fig. 21. Section of the Lower Jurassic coal series at Hengsheng coal mine N.W. of Tumulu. A, Cretaceous gravel. B, Upper Jurassic shale, sandstone and conglomerate

Southwest Chahar

At Tumulu 90 li W. of Changpeihsien and also at Malienkota 30 li W. of Tumulu the Shihkuai coal series underlying the Tachingshan series that will be described later is brought to exposure by the faulting. The base is not exposed; the exposed thickness alone varies from 180 to 200 meters. The petrographic character of the series does not greatly differ from that of the other places. According to the tradition of native miners and the survey of surface exposure, 2-8 seams of coal are known to occur in this series. The quality of coal varies from anthracite to bitumite. In Hengsheng coal mine region, the observations on this formation may be summarized in descending order as follows: (See Fig. 21),

26.	Whitish brown conglomeratic sandstone with argillaceous shale	55 m.
25.	Grey argillaceous shale with sandstone bands and coal seam	31 m.
24.	Whitish grey, medium-grained sandstone	11 m.
23.	Grey sandy shale with coal seam	12 m.
22.	Grey medium-grained sandstone	8.2 m.
21.	Grey argillaceous shale with some interbedded sandstone layers and in the upper part with coal seam	7 m.
20.	Whitish brown, medium grained sandstone	15 m.
19.	Grey sandy shale with layers of sandstone	5 m.
18.	Whitish grey, medium-grained sandstone	6.6 m.
17.	Greenish grey shale	1 m.
16.	Coarse-grained, brownish white conglomeratic sandstone	7.5 m.
15.	Yellowish brown medium-grained sandstone, merging upwards into grey sandy shales	17 m.
14.	Grey sandy shale	7.5 m.
13.	Whitish brown, medium-grained sandstone	3 m.
12.	Greyish yellow, argillaceous shale with bands of sandstone	7.1 m.
11.	Whitish brown medium grained sandstone	7 m.
10.	Grey sandy shale	1.3 m.
9.	Coarse-grained, whitish conglomeratic sandstone merging downwards into fine-grained sandstone with coal seam.	40 m.
8.	Dark grey shale	1.2 m.
7.	Coarse-grained, grey sandstone	.3 m.
6.	Grey sandy shale with coal seam.	2-7 m.
5.	Whitish coarse-grained sandstone	12 m.
4.	Whitish brown, medium-grained sandstone containing coal seams	3.9 m.
3.	Brownish, medium-grained sandstone	2 m.
2.	Grey, greenish grey, and purple argillaceous shale with layers of sandstone	45 m.
1.	Coarse-grained, yellowish white sandstone composed of granitic debris.	

The coal series also crops out near Hsiyintzu about 30 li N. W. of Malienkota. Von Richthofen visited this locality in 1871 and noted that the series consists of carbonaceous shale composed in part of granite debris, the beds striking N. 30° W. and dipping 10° to the northeast. From this field, fossil plants of Jurassic age have been obtained, which will be referred to later.

Age and Correlation: The Shihkuai coal series in Tumulu region, Tachingshan and Sheitenola has been settled as of a Lower Jurassic age by von Richthofen. C. C. Wang and the writer from plant fossils, they are:

At Tumulu[1]

Asplenium whitbyense Brongn.
A. argutulum Heer
Anomozamites sp.
Pterophyllum richthofeni Schenk
P. æquale Brongn.
Podozamites gramineus Heer
P. lanceolatus Heer
Elatides chinensis Schenk

At Shihkuaitzu[2]

Cladophlebis cf. *acutangula*
Baiera sp.
Czekanowskia rigida Heer

At Yangkoleng[2]

Podozamites lanceolatus Heer
Asplenium whitbyense Heer
Cladophlebis sp.
Coniopteris sp.

At Kuantsingkou, by a preliminary examination by the writer.

Podozamites lanceolatus Heer
Todites williamsoni Brongn.
Cladophlebis denticulatus Brongn.
Coniopteris sp.
Anomozamites schmidti Heer
Thyrsopteris sp.

The most favourable district for correlation of the Jurassic coal series in Suiyuan proper and Southwest Chahar is the Tatung coal field of Shansi[3]. According to the investigation of C. C. Wang, there are two coal-bearing formations in that field; one Carboniferous, the other Lower Jurassic. They are separated from one

1. China, Vol. II, 1882.
2. Geology of Tachingshan. Bull. Geol. Surv. China, No. 10, p. 3, 1928.
3. Coal field of Tatung, Shansi, Bull. Geol. Surv. China, No. 3, 1921.

another by a succession of sandstones and shales, prevailingly red in color, from 130 m. to 300 m. in thickness. The Lower Jurassic coal series is overlain by a series of green and red shales and sandstones. The Jurassic plants found include the genera *Dicksonia*, *Asplenium*, *Pterophyllum*, *Podozamites* etc.

B. *Middle Jurassic*

Hsiaopeiling Conglomerate

Distribution: This conglomerate is observed only at one place in Suiyuan proper. It is located in the eastern part of the Anpei district. Here it forms the ridge, Hsiaopeiling, bordering the coal field of Kuantsingkou in the north.

Character and Age: In the Hsiaopeiling ridge the Shihkuai coal series towards its top contains layers of conglomerate, and by gradual transition the rock become largely a conglomerate about 250 meters in thickness. The conglomeratic beds contain more or less round pebbles, from 5 to 20 cm. in diameter, partly of sandstone but mostly of reddish and grey gneisses in a sandy or clayish matrix sometimes with a porphyritic appearance.

As no fossils have been found in the formation, the exact age can not be asserted. It may be either the upper part of the Shihkuai coal series, also of Lower Jurassic age, or the deposits of Middle Jurassic time.

C. *Middle and Upper Jurassic*

Tachingshan Series

Distribution and Character: In the central part of Tachingshan this series is exposed in long and more or less continuous belts. In other words, where the Shihkuai coal series occurs, it is constantly found to lie upon the coal series or in fault-contact with the coal series, except at Pak'outzu where it has been eroded away. Its characteristic feature can be recognised from Ts'ienhsiaopatzu N. of Wanchiakou when looking to the northwest.

Generally speaking, this series comprises green, red and sometimes dark grey, shale, sandstone and conglomerate, the last being made up of round pebbles of gneiss, marble, and sometimes white quartz usually in a sandy cement. In some places the sandstone predominates. The shale and conglomerate are more subordinate. The total thickness is estimated at about 500 m.

In Tumulu region, the Tachingshan series, disconformably overlying the Lower Jurassic coal series (see Fig. 21), is exposed in a broad zone i. e. at Malienkota, Yenchiayao, Szutzukou etc. Its petrographic character is more or less the same as that described above. At Yenchiayao it is composed of purple or greenish grey sandy shale alternating with sandstone and conglomerate; at Hengsheng coal mine chacolate, green, and sometimes greenish grey colored sandy shales with interbedded bands of sandstone and conglomerate; at Malienkota grey and red shales and grey fine-coarse-grained sandstones. Owing to the incomplete exposure of this series the total thickness can not be estimated, but so far as can be judged from the surveyed area, it seems to be not less than 600 m. The same formation is also found in the south side of Kaomiaoho about 40 li SW. of Yenchiayao, limited on the south by an overthrust. There the formation consists of yellow, purple and greenish grey shale with intercalated sandstone and conglomerate, the beds being strongly folded (see Fig. 9).

Age: Up to present no fossils have been found from this formation. However, it can be correlated by its lithologic character and stratigraphic position with the red and green series overlying the Lower Jurassic series in Shensi and Shansi of which the age has been asssigned by C. C. Wang to Middle and Upper Jurassic.

D. Late Cretaceous and early Tertiary

Tumulu Series

Distribution: The Tumulu series is found only in Southwest Chahar. The largest exposure of it lies in the vicinity of Tumulu village and it also appears at Shangwulahata. In reality the beds of these two areas are continuous beneath a tongue of Hanoorpa basalt which will be described later. One small but important exposure of this series occurs as an irregular belt in the neighbourhood of Tayingpan 30 li W. of Changpeihsien. This window is due to the removing of plateau basalt by the stream erosion.

The irregular land surface beneath and conditions of deposition of the Tumulu sediments: The investigation of the contact surface between the Tumulu sediments and the hard rock floor has shown that this landsurface must be an irregular one.

A little northwest of Tumulu village the old land surface is strongly weathered and the fine clay-material with small fragments of shales formed by the weathering downwards shows transition into the upper-Jurassic sediments, i. e. Tachingshan formation. The Tumulu series is built up mainly by coarse gravel beds in the lower part and fine sands occur at all horizons of the upper part which owes its preservation to the overlying protective cap of the plateau basalt (see Fig. 22). In Taolipa pass immediately to the east the higher fine sands underlying the basalt lie directly upon highly acid gneiss, the gravel beds being wanting. Here the surface is deeply penetrated by the effects of weathering resulting in the disintegration of gneiss into sands. The same holds true at Paomankou 20 km. SW. of Tumulu, but the fine sands of Tumulu series become very thin and even absent in many cases.

From the facts mentioned above we may form an opinion of the character of the irregular land surface beneath the Tumulu sediments which all accumulated along the lower lands.

The mountain ranges thrown up by the post-Jurassic orogenic movement were not entirely eroded away to form a peneplane at that time. There was a topographical contrast between areas occupied by the highly acid gneiss and the sandy shale. Through the insolation and action of water or wind the easily disintegrating shale seems to have been rapidly broken down and came to form an open valley, whereas the more resistant highly acid gneiss projected over the surroundings as hills or mountain ranges. The basal gravel-beds of Tumulu series were formed as alluvial fan deposits along the bottom of the valley by the streams coming out from the mountains. The clays and sands of higher beds as weathering products coming down from the apexes of mountains eventually filled up the valley thus forming probably a flat surface beneath the basalt flow.

Fig. 22. Section near Kuochiayaotzu E. of Tumulu. 1, Conglomerate. 2, Red clay and shale. 3, Basalt with basal shale.

Thickness and Character: Calculated on the basis of the extension and the dip of the sediments, the thickness of the Tumulu series is about 500 meters.

This series may, as has already being stated above, be distinguished into two parts from its petrographic characters. The lower part is probably a floor deposit and composed of coarse and fine conglomerates interbedded with fine current-bedded sandy layers which are more or less sharply defined. The boulders and pebbles of subangular to rounded shape and of four inches to one foot in diameter consist almost entirely of Sangkan rocks, mainly acid gneiss, granite and diabase cemented by sandy and clayish matrix. The upper part is built up by red, reddish white and sometimes greenish grey colored clays which seem to lie conformably on the conglomeratic beds just mentioned (see Fig. 22) near Kuochiayaotzu, so that they are considered as of the same series. These clays locally passing into shales have often the content of fine grained sands derived from Archæan rocks, and sometimes the bedding-planes are covered with fine mica scales, deposited contemporaneously with the clay substance.

Age: No fossils have been found in the Tumulu series, Its exact age is uncertain. However from the discussion given above, the stratigraphic gap above it is insignificant, while the unconformity anterior to its formation covers, at least, the history of lower Cretaceous. Thus it seems reasonable to assume it to be late Cretaceous and early Tertiary in age.

The lower Cretaceous deposits are known to develop typically in the Kalgan area where they have been referred to as the Nantienmen Formation[1] by G. B. Barbour and are composed mainly of variegated crossbedded sands and gravels with local shale, coal and volcanic ash, the last indicating the effort of the igneous outbreak at that time. To this formation, our Tumulu series is probably not to be compared.

CENOZOIC

A. *Oligocene*

Hanoörpa Basalt

Distribution: This Hanooropa basalt once without doubt covered most of Chahar and Suiyuan but is now largely eroded away, only the remnants being found at present.

The largest area of the lava flow occurs in a more or less continuous belt from Changpeihsien westward through Hsinghohsien, Chininghsien, Taolinhsien almost to Wuchuanhsien (see geological map, sheet 4), clinging to the rim of Mongolian Plateau and generally making up the platform which defines the border-line between two physiographic provinces, especially in Changpeihsien where it forms a rugged bastion overlooking the deeply dissected mountain-land to the south. The famous ridges composed of the plateau basalt are when stated in the order from eas to west, Hanoorpa N. of Kalgan, Taolipa, Naopaopa E. of Chining, Hanchingpa N. of Chining etc. An important extension of this belt projects northward as far as Tantai village NE. of Taolinhsien.

1. Geology of Kalgan Area; Mem. Geol. Surv. China, A6, pp. 44-52, 1929.

The lava flow appears as a small area forming terraced hills north of Yangyuan, and farther north at Shihyangchuang the summit of the hill is made of basalt capping the Sangkan gneiss. The same lava flow is also found at Hungshapa N. of Fungcheng, outside the area mapped, where it seems to lie in a gently sloping basin (the floor rock is Sangkan gneiss) and forms flat-topped hills.

Because one part of the formation was eroded the original thickness is unascertainable, the remaining part amounts to 170 m. (Barbour's estimation) at Wanchuan pass, 200 m. at Naopaopa, 190 m. at Nanchingpa on the basis of the vertical height of the top of the cliffs.

Character: Following Andersson[1] and Barbour's[2] critical examinations in Kalgan region, the Hanoorpa formation consists of two basalt flows which are separated by the irregular layer of coal-bearing shale. But my own observations at Tayingpan W. of Changpeihsien, Tungyaokou E. of Tumulu, Wutekou N. of Chining etc. show different conditions. At Tayinpan and Tungyaokou, the basalt flow overlies

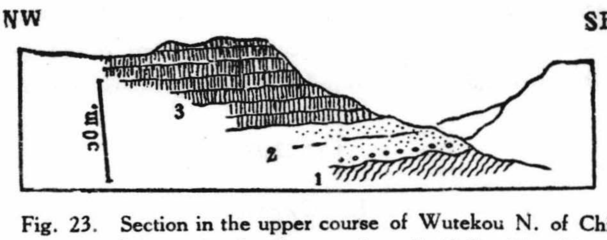


Fig. 23. Section in the upper course of Wutekou N. of Chining-hsien. 1, Sangkan gneiss. 2, Yellowish white sands containing lignite. 3, Hanoorpa basalt.

the Tumulu red clay as could be seen from the tunnels driven beneath the flow in the effort to find the lignites. Near these tunnels there were heaps of wast rock brought out from the tunnelling, which consist of red clay and grey soft shale (coal-bearing), the latter being reported to lie on the former. In other words, the carbonaceous shale occurs as an interbedded layer between Tumulu series and basalt flow. At Wutekou the basalt flow is found to lie conformably on the yellow sands with coal seams, the latter formation is directly underlain by the Sangkan gneiss (see Fig. 23). R. Verbrugge[3] visited Nanhaotsien N. W. of Tumulu in 1922, he also noticed the lignite mines below basalt.

All these facts may be explained by the assumption that the outpouring of the first basalt flow is limited within the Kalgan area, but the later formations,

1. Essays on the Cenozoic of North China, Geol. Surv. China Mem. A3, 1923.
2. Geology of Kalgan Area: Geol. Surv. China Mem. A6, pp. 59, 1929.
3. Les pays de laves en Mongolie du Suo, Antweip, 1922.

viz. carbonaceous shale and overlying basalt flow begin to have an extensive distribution in Inner Mongolia.

The basalts show great change in structure and composition from place to place. Near Hanchingpa there are vitrophyric olivine basalts with the only phenocrysts of olivine in glassy groundmass, while at Huanghuakotung S. of Taolinhsien the sheet of basaltic lava flow lying upon the mass of granite is represented by a particularly coarse variety of dark and greenish grey color; the lath-shaped plagioclase and irregular black magnetite are embedded in augite and olivine crystals, showing a diabase structure (Pl. XVII, C). The layers of greenish grey tuffaceous rock which has been decomposed by weathering are intercalated in about its lower part.

West of Chininghsien there are also olivine basalt which are mostly of fine crystalline variety. When decomposed by weathering they are converted into a loose crumbling material known as wacke.

North of Yangyuanhsien the olivine basalt, usually dark colored, is rather vesicular in the upper part but usually fairly dense toward the lower part. The vesicules often reach the size of fist. Beautiful agate and drusy quartz fill them as amygdules. Under microscope the rock is porphyritic with phenocrysts of augite, olivine and felespars, the latter being largely labradorite. The groundmass is partly glassy and partly crystalline. The olivine has often altered to serpentine.

The varieties noted by Alfred Lacroix[1] in Kalgan area are rather coarse to fine texture. He described them as coarse doleritic basalt, porphyritic basalt and basanitoid the last carrying large numbers of olivine nodules.

G. B. Barbour[2] in his work on Kalgan area distinguished four types of volcanic rock, i. e. porphyritic olivine basalt, vitrophyric olivine basalt, coarser diabase and fine dolerite, the first one being more predominate (Pl. XVII, B).

Near Luanshihshan and Taolipa about 60 km. NW. of Kalgan the same lava flow is highly vesicular on the upper surface. The structure often reaches its maximum development, converting the basalt into a very light porous substance, i. e. pumice.

The carbonaceous shale is insignificantly developed. Although it seems to be widely distributed below the plateau basalt, the exposures are confined to the following localities:

1. Premieres observations sur la composition, minéralogique et chimique des laves mésozoiques et tertiaires de la Chine orientale: Acad. Sc. C. R. t, 185, No. 16, p. 733, Paris, 1927.
2. Geology of Kalgan Area; Mem. Geol. Surv. China, A6, p. 56, 1929.

a. Tatsingkou N. W. of Hanoorpa: The deposit first noticed by Andersson in 1919 occurs as an intercalated layer between two basalt flows. It consists of dark-brown, very soft shales from which he found some plant fossils. These plant remains have been examined by R. Florin who identified the following types: *Pinus* sp,, *Comptonia anderssonii* n. sp., *Carpinus* sp., *Phyllites* sp. The material is insufficient to settle the age of the deposit, but Florin expresses the tentative opinion that the flora is probably Middle-Tertiary.

b. Fengchiayao 13 km. N. of Wanchuanhsien: A lense of baked carbonaceous shale between two basalt flows has been noted by Barbour.

c. Panpa 8 km. NE. of Hanoorpa: Following Barbour's observation the deposit holds the same character as that at Fengchiayao.

d. Tayingpan W. of Changpeihsien: The deposit underlying the basalt flow comprises grey clay, dark-brown shale and lignite. The miners reported that there is only one seam of lignite varying from 2 to 5 feet thick.

e. Tunyaokou near Tumulu: The deposit occurs beneath the basalt flow. The petrographic character of the formation does not greatly differ from that of Tayingpan. Two lignite seams are reported to occur baving variable thickness of 1-6 feet.

f. Liuchiakou N. of Yangyuanhsien: I did not personally visit this place; according to the report of the local people the lignite has been opened beneath the basalt existing here.

g. Malient'an N. of Chininghsien: The lignite-bearing formation horizontally underlies the basalt flow, but in Hanchingpa immediately to the north it has been pulled up nearly vertically into a sharp ridge projecting into the basal part of overlying basalt flow. The following section at T'angnaopao from the base of the basalt downwards has been measured:

Basalt flow	
Yellow sand	8 ft.
Grey clay	12 ft.
Lignite	.5 ft.
Grey clay	10 ft.
White sand	3 ft.
Brown soft shale	7 ft.
Lignite	2 ft.
Dark-brown shale	10 ft.
Lignite	3 ft.

The base is not exposed.

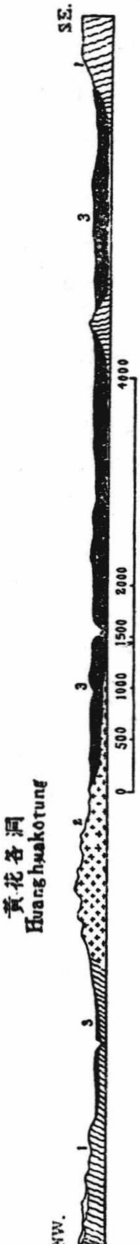


Fig. 24. Section through Huanghuakotung S. W. of Taolinhsien showing the surface relief of the floor on which Hanoorpa basalt rests. 1, Gneiss. 2, Granite. 3, Basalt.

Character of the peneplane anterior to the Hanoorpa formation: As has been stated the Early Tertiary witnessed the gradual reduction of surface relief to an advanced mature topography. It did not reach a true peneplaned condition. Evidence of the irregularity of the ancient surface lies in the presence of detectable relief in the floor upon which the basalt lavas were extruded (see Fig. 24).

The early Tertiary unconformity brings the Hanoorpa Formation into direct contact with the Tumulu, Tachingshan, Nankou and Sangkan formations (see Figs. 22, 25, 26).

Age of the Hanoorpa Basalt: In discussing the age of the Hanoorpa Basalt of Kalgan area G. B. Barbour suggests a late Oligocene age on the basis of two reasons[1]: "(1) The basalt seems to be slightly older than disturbances of Early Miocene date; for, though no faults have been observed actually to cut the lava flows (E. of Wuchuan it is found by the writer that the Permo-Triassic sediments are brought in contact with basalt flow by a normal fault), at least one minor intrusion is affected by the faulting. (2) Though the plant fossils found by Andersson from the intercalated shale beds are rather equivocal, similar shales associated with basalt flows in the Fushun coal field in Liaoning have yielded a decisive plant association. Though Inouye originally referred to the beds as Miocene, careful studies by Palibin[2] and Florin[3] suggested a late Oligocene age". No additional material has so far been obtained to lead me to modify Barbour's suggestions.

B. Mio-Pliocene

Red Clay

The red clay is found in the land-locked basins and wide valleys in the region studied. In some localities

1. Geology of Kalgan Area: Mem. Geol. Surv. China, A 6 p. 61, 1929.
2. Palibin, J. W. Remnants of the Tertiary Flora found near Vladivostok, Mem. Soc. for the Study of the Amur Region, Vol. 16.
3. Florin, R. Zur Alttertiären Flora der Südlichen Mandschurei Pal. Sin., Ser. A, Vol. 1, Fasc. 1. 1922.

cutting in the wide valleys the streams expose it in some detail, but in other places it is frequently thickly covered by the later soil. The following occurrences may be specially recorded: (1) At Nank'ouling (Laoyehling) SE. of Huaianhsien there are several meters of red clay alternating with thin conglomerate or containing pebbles scattered throughout it. This clay is disconformable with the overlying loess and unconformable with the underlying gneiss. (2) The territory between Tienchenhsien and Yangyuanhsien. The red clay is extensively distributed. It contains no pebbles. Its deposition is limited within a dissected basin. (3) On the slopes of hills near Hsinghohsien the red clay unconformably overlies the Sangkan gneiss or Hanoorpa basalt. The best section brought out by the river cutting is found at the midway between Hsinghohsien and Kaomaotsun. Above the gneiss is about 30 meters of red clay sometimes alternating with thin layers of gravel, which is

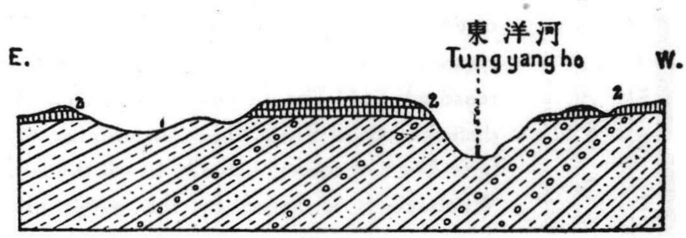


Fig. 25. Section south of Yenchiayaotzu, Changpei. 1, Upper Jurassic red sandstone and shale. 2, Basalt.

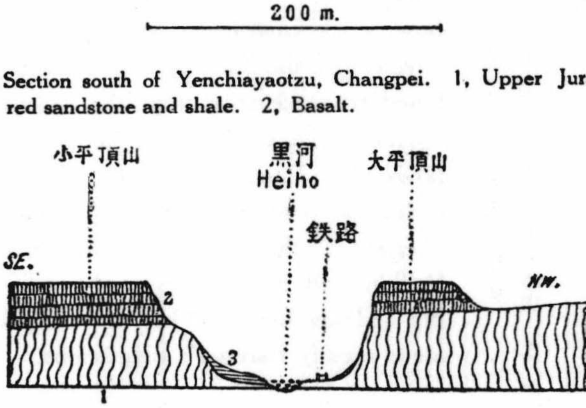


Fig. 26. Section near Santaoyingtzu. 1. Gneiss. 2. Basalt. 3. Red clay.

succeeded by the yellowish white sands. (4) In the region of Chining the red clay is found lying on the slopes of basalt hills at Kungkou and Wutekou. (5) In the Wuchuan plain the red clay occurs in a broad extension forming hummocks on Mongolian Plateau. At Changhantzelao and also at Huangchiayingtzu it is seen to alternate with layers of reddish white sand resting upon the Sangkan gneiss. Sometimes the red beds overlie the Hanoorpa basalt. (6) In the vicinity of Kuyanghsien below the Sanmen gravel is found the red clay which has the same character as that in the places just mentioned above. (7) In Hsiaoshihtaiho valley N. of Anpeihsien it is widely distributed. The clay in some cases is yellow or greenish grey in color alternating with reddish white sand, sometimes with gravel beds. This clay is unconformable with the overlying Quaternary gravel and the underlying Sangkan gneiss (see Fig. 27).

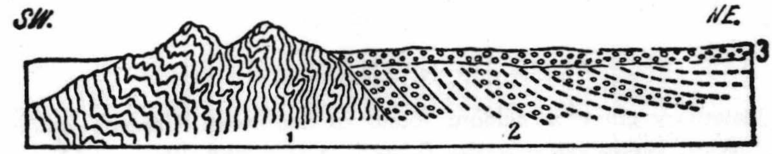


Fig. 27. Section about 15 li SE of Shihnakan. 1. Gneiss.
2. Red or green clay (Miocene-Pliocene). 3. Gravel.

For the red clay the writer found no fossils, but in other places in Inner Mongolia from similar clay Andersson has found fossil mammals of Mio-Pliocene age[1] such as *Aceratherium*, *Hipparion*, *Artiodactyla* etc. Thus there is little doubt that we have to do here with the Pontian clay, so commonly known in North China.

C. *Pliocene*

Yellow sand

In some localities the loess or gravel is separated from the red clay by a fluviatile yellow sand. The sand deposit bears a close resemblance to the Santaoho formation[2] found by Teilhard and Licent in the western part of Ordos. The Santaoho formation consists of sand and conglomerate with clay layers carrying numerous mammalian bones: *Mastodon*, *Rhinoceras*, *Chalicotherium*, *Hyæna*, *Felis*, *Tragulus* etc. Teilhard and Licent referred the beds to Pliocene.

In the northern side of Shihnakan at a village N. of Anpeihsien there occurs below Quaternary gravel about 40 meters of yellowish grey fine sand resting upon Mio-pliocene red clay. The sand beds dip 20° to the southwest, their stratigraphical relation with the gravel above is unconformable. In both Anpei and Paotou basins the yellow sand is often interbedded with thin conglomerates and greyish white clay. It is very gently dipping if not horizontal, being separated from the Quaternary gravel above by a disconformity. The base is not exposed.

1. Essays in the Cenozoic of N. China: Mem. Geol. Surv. China, A 3, p. 47, 1923.
2. On the geology of N. W. and S. Borders of the Ordos: Bull. Geol. Soc. China, Vol. 3. No. 1, 1924.

In Yangyuan basin, i. e. Sangkan river plain this formation is well developed. Here yellowish grey clay and greyish white clay prodominate, yellow sand is more subordinate. Near Pamafang the loess is seen overlying disconformably this deposit (see Fig. 28). Sometimes the red clay of probably Mio-pliocene age crops out in the gullies. but its exact relation with the yellow sand was not observed.

D. Pleistocene

1. Gravel

Quaternary gravel is seldom found in Southwest Chahar, but in Suiyuan proper it occurs extensively: in the Paotou, Anpei, Shihnakan and Kuyang plains. As near the source of supply, the gravel deposit exhibits a wide variety of facies. In most of the localities mentioned above it is a mixed series of coarse and fine gravel alternately interbedded with finer sandy layers. The coarse gravel is commonly from a few inches to one foot in size. The formation varying from 10 to 50 meters in thickness overlies disconformably the Pliocene yellow sand or rests on the Mio-pliocene red clay with unconformity (see Figs. 10, 27).

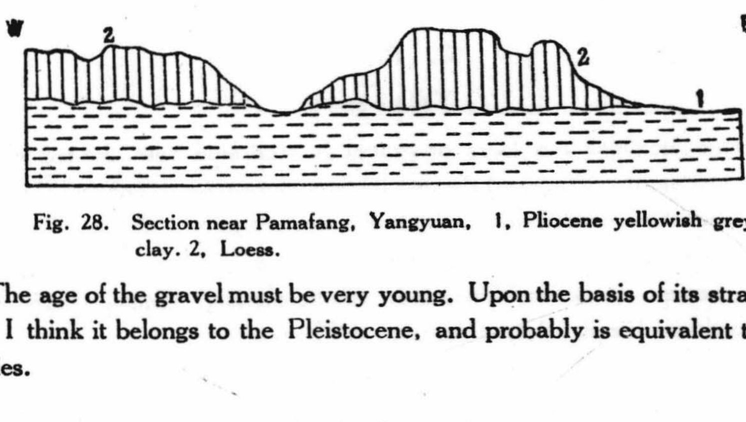


Fig. 28. Section near Pamafang, Yangyuan, 1, Pliocene yellowish grey clay. 2, Loess.

The age of the gravel must be very young. Upon the basis of its stratigraphical position I think it belongs to the Pleistocene, and probably is equivalent to the Sanmen series.

2. Loess

In the provinces of Shensi, Shansi, Honan and Hopei the loess is extensively developed and two distinct types are recognized the wind-blown deposit showing the characteristic vertical cleavage and the reworked deposit interstratified with water-laid gravels. Following Andersson's nomenclature, the first is primary loess, and the latter redeposited loess.

These two types are not infrequently found in Suiyuan proper and Southwest Chahar. Along the northern side of Yangyuan plain, or Sangkan valley, the eolian loess is present with its characteristic columnar joints, forming a veneer on the surface of the Pliocene yellow sand. Its thickness is variable and often less than 15 meters in this region. At Hsiachiatun (N. of Yangyuanhsien), Pailungshan (N. of Huaianhsien) etc. much of the slopes between the alluvium of the valley bottoms and the rocky outcrops of the ridges is covered with yellow grey loess intercalated with horizontal layers of gravel indicating fluviatile facies. Sometimes the gravel beds become predominant, containing intercalations of loess-material.

The redeposited loess also occurs on the hill slope on both sides of Paits'aikou valley in Tachingshan, forming the walls. The fluviatile facies is very clear, whereas in Shaopuhai region immediately to the south the true primary loess was found. It lies on the hill slopes showing a characteristic absence of layered structure. Its vertical thickness is about 10 meters. In the upper courses of Hatemenkou (N. of Paotou) and Santaoyingtzukou (SW. of Taolin), there are also terraces of primary loess with a height of three to six meters on either side of the valleys. This loess shows a tendency to split along the vertical joint planes. But it is locally intercalated with horizontal layers of gravel near the base.

Recent

Alluvium

Generally speaking, the alluvial deposit may be distinguished into three series.

(1) Loamy deposit: On the flood-plains or the wide valley-bottoms there is an extensive occurrence of grayish yellow loamy deposit. This deposit is principally composed of silt in which the percentage of sand is very low, typical examples of it can be found in the Huangho basin. In Kueisui basin the similar deposit is not infrequently met with.

(2) Fine sand deposit: This deposit is mainly built up by whitish grey, fine sand while the gravel pockets are frequently found at various horizons. It is of extensive development in the wide plain on the Mongolian plateau. In the upper valley of Yangho the same deposit was also observed.

(3) Boulders: Boulders of six inches to one foot in diameter are very common while angular blocks of two and even four feet also occur in the detritus in several localities. Their distribution is all along the river beds or in the gullies.

IV. IGNEOUS ROCKS

Igneous rocks play a rather important rôle in the geological constitution in Suiyuan proper and Southwest Chahar both as intrusive bodies and as extrusive flows. The latter essentially consisting of basaltic flows have been already described in the preceding chapter. Only the description of the former is given here. The intrusives include granite, diabase and andesite, the last two being more subordinate.

A. Granite

There are granites ot two different generations. The older granite usually occurs in the form of dykes or sills in the Sangkan gneiss and is chiefly of a medium grained rock of red color. Gneissic structure is not well developed.

The younger one occurs as intrusive stocks or batholiths in the Sangkan gneiss or younger formations. It is a coarsely crystalline biotite granite with the inclusions of gneiss in many cases. It is of economic significance because it carries in some places the deposits of gem minerals. These two types of granites have been distinguished in the geological map (sheets 1-7) and the present description follows the same classification.

1. Older Granite

The older granite intrusions are frequently met with in the Sangkan gneiss areas. The main masses are found in Sheitenola, Tachingshan, Kueitengliang and Nank'ouling. Only the first two areas have been studied in some detail.

(a) *The Granite of Sheitenola*—At many points in Sheitenola the older granite is intruded in the acid or basic gneisses as dykes or sills which vary in width from a few inches to more than one hundred meters. Close to the margin of the granitic intrusives the gneiss is sometimes strongly changed. And sometimes it is not pure being contaminated by granitic material. For example, in Tanuchikou, the granite magma gradually entering between more or less minute foliation-planes of the gneiss forming small lenses and strings traceable between the planes.

The granite usually is a medium-grained rock of red color containing the following mineral components as seen under microscope; felspars, quartz and biotite, the first two being very abundant. Felspars consist of two kinds namely orthoclase microcline and plagioclase, the plagioclase represents a slightly undulatory extinction suggesting that the rock has been subjected to pressure. The rock shows a distinct gneissic appearance in some cases.

(b) *The granite of Tachingshan.*—Around Miaoerhkou and elsewhere along the upper valley of Wanchiakou, in Tachingshan, the older granite occurs abundantly as dykes, sills or minor intrusions in the Sangkan system. Between large granitic masses and the invaded gneisses, all gradations may be traced. The gneiss has usually been so strongly pervaded by the granitic juices that its original characters have been almost entirely effaced. But the minor intrusive bodies often make sharp contact with the intruded rocks.

The granite is medium-grained in texture and red or reddish grey in color. Under the microscope it is seen to be a rock of rather simple constitution. Felspars are the dominating components, of which more than half is orthoclase and microcline and the remainder a slightly zoned plagioclase. Hornblende is also rather abundantly present. More subordinate is quartz which occurs usually as an interstitial mineral (see Pl. XVI, B). The felspar is seen to show a strongly undulatory extinction (see Pl. XVI, C) and sometimes it is distinctly broken. Foliated structure is however, seldom distinct. There are several varieties of this rock; at Shihhueiyaotze the red granite becomes rather coarse with red felspar, grey quartz and black biotite, at Pankou it lacks dark minerals approaching an aplitic granite.

Age of the older granite.—The granite must belong to Pre-Cambrian igneous activity. That it is of Wutai age may be established by the fact that the granite is intruded in the Sangkan system but escapes the intense metamorphism and that Sinian Limestone is found overlying the eroded surface of the granite in several places. This igneous intrusion occurred probably during the Wutai period.

2. Younger granite

The younger granite intrusions frequently occur in the hills forming the border of Mongolian Plateau. There are six main bodies which, when mentioned in the order from east to west, are Hsiaotachingshan, Huanghuakotung, Pichiashan, Wanchiakou, Chunhuailiang and Sailinhutung. They all fall within the scope of the present work.

(a) *The granite of Hsiaotachingshan.*—Hsiaotachingshan is a ridge lying on the Suiyuan-Chahar border. It is composed mainly of biotite gneiss of Archæan age. Granite intrusion is found in the gneiss as an intrusive stock in the western portion of the said hill.

The character of the granite indicates a homogeneous and massive rock, not distinctly gneissoid; such structure is only locally developed at the contact with gneisses. In higher peaks near Erhtaopei village the granitic mass is irregularly divided by extensive joints into huge blocks up to several tens of meters in size. Pegmatitic differentiation-products have been noticed in the rock. They frequently carry minerals which are worked as precious stones of some economic importance (see below).

The granite is in general a coarse-grained one, light red to reddish grey in color. Microscopically quartz is in nearly equal abundance as the felspars and occurs either in small grains or in large crystals. Felspars usually tabular in form comprise orthoclase and oligoclase. Orthoclase is predominant in quantity over the oligoclase. Biotite is present as ferromagnesian mineral. Black and metallic masses are crystals of magnetite.

(b) *The granite of Huanghuakotung.*—About 15 km. SW. of Taolinhsien, the Huanghuakotung hill is composed entirely of granite rock which occupies about 15 sq. km. Isolated small outcrops are also found in the basalt area which is passed by the route from Taolinhsien to Santaoyingtzu. This leads me to think that the granite mass extends still further southeastwards under the cover of lava flow.

The granite, which is remarkably homogeneous and massive throughout the main body, has the same character as the granite of Hsiaotachingshan. The gem-bearing pegmatite dikes are also found in the granite, the gradation, where the graphic structure is sometimes noted, between the two rocks being gradual and complete. Large joints cut the granite into horizontal beds, and in cut where the joint planes are well exposed, the rock often presents a characteristic sheeted stucture (see Pl. VIII, A).

The rock is rich in quartz which usually occurs as an interstitial mineral or in micrographic intergrowth with orthoclase (Pl. XVI, D & Pl. XVII, A). Orthoclase is also predominant in quantity over the oligoclase and often forms large tabular crystals. Biotite coexists with hornblende, but the latter is more subordinate. Magnetite and apatite are very common, the former seemingly to be less abundant here than in the Hsiaotachingshan granite.

The granite is intruded into both the Sangkan gneiss and gneissic granite in the form of batholith. The granitic mass often sends off pegmatitic or micrograntic veins into the gneiss, either obliquely across or along the foliation planes. These veins make sharp contacts with the gneiss on either side.

(c) *The granite of Pichiashan.*—The Pichiashan hill is located 60 km. N.E. of Wuchuanhsien. The granite extends from the northern part of the said hill southwards to Kankoutzu.

The granite mass is intruded on the southwest into the Sangkan gneiss, Sinian limestone and Permo-Carboniferous coal series of which the coal has been metamorphosed into graphite. As no attention was paid to its northeastern extension, the relation of it with country rock on this side is uncertain.

The granite, characterized generally by dark brown quartz, reddish or white feldspar and black biotite, is composed of the same mineral constituents as that at Huanghuakotung. Veins and irregular patches of pegmatite are also found in the granite, the gradation between the two rocks being gradual. The pegmatite consists chiefly of quartz, orthoclase, microcline (mostly Amazon-stone)[1] and biotite with minor amounts of muscovite.

(d) *The granite of Wanchiakou.*—Along the lower valley of Wanchiakou, NW. of Chasuchi, there is encountered a considerable body of granite occupying about 100 sq. km. which forms precipitous-cliffed hills with many high peaks. This territory, therefore, is not only geologically in contrast with, but with its rough contour differs also topographically from the surroundings which appear mostly as

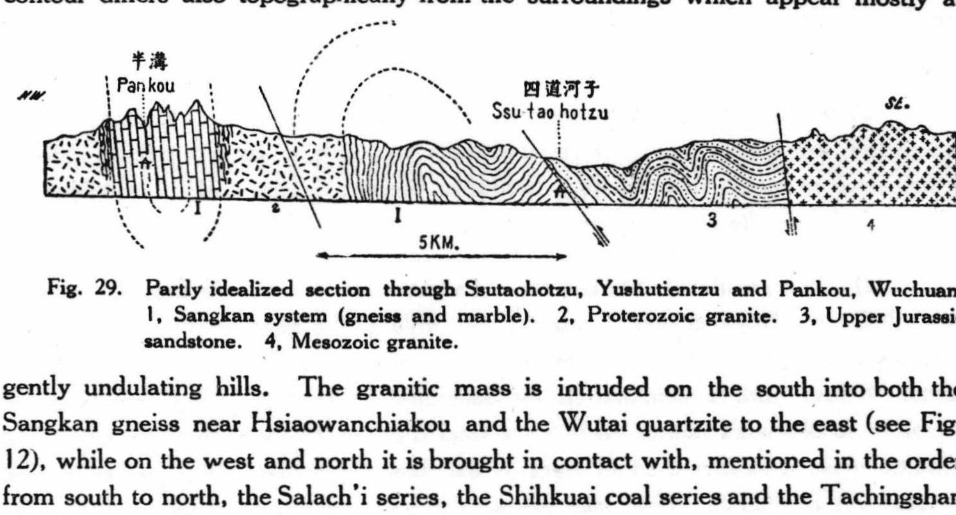


Fig. 29. Partly idealized section through Ssutaohotzu, Yushutientzu and Pankou, Wuchuan. 1, Sangkan system (gneiss and marble). 2, Proterozoic granite. 3, Upper Jurassic sandstone. 4, Mesozoic granite.

gently undulating hills. The granitic mass is intruded on the south into both the Sangkan gneiss near Hsiaowanchiakou and the Wutai quartzite to the east (see Fig. 12), while on the west and north it is brought in contact with, mentioned in the order from south to north, the Salach'i series, the Shihkuai coal series and the Tachingshan series by faulting (see Fig. 29). It is bordered on the east by the Tachingshan series and the Shihkuai coal series. The contact between them is thought by C. C. Wang to be an igneous one. The writer is not in possession of the necessary evidence to confirm this view, as he has not been able to find metamorphic products in the contact zone, though the sedimentary rock here is relatively hard in character.

1. This is the typical "Lingsi granite" of Teilhard (s. Etude géologique sur la region du Dalainoor, 1926).
2. Geology of Tachingshan: Bull. Geol. Surv. China, No. 10, 1928.

The rock shows a change both in texture and in composition at different places. Around Shawantzu the rock is reddish grey, medium-grained with frequent inclusions of gneiss. The predominant constituent is felspar, of which more than half is orthoclase and the remainder plagioclase. Ouartz is more prevalent than plagioclase. Hornblende coexists with biotite but the former is more abundant. Magnetite is often associated with hornblende. In Hailiusu region the conditions are a little different. Here the constituent grains increase in size, and the quartz is nearly equal to felspar. Instead of hornblende, biotite becomes prevalent.

(e) *The granite of Chunhuailiang.*—In Chunhuailiang, the higher peak of Tachingshan, near Shaopuhai, a village about 45 km. SE. of Kuyanghsien the Sangkan gneiss is intruded by a large granite body which sends off numerous pegmatitic veins into the former.

The granite is, like that of Wanchiakou, a reddish, medium- to coarse-grained rock with inclusions of gneiss. Sometimes aplitic or pegmatitic differentiation-products carrying specular iron ore are found as lense-shaped masses in the rock.

Under microscope the rock is rather poor in quartz. Orthoclase and microcline are present nearly in equal quantity and both are usually tabular in form. Plagioclose is more subordinate. Biotite is present as the main ferromagnesian mineral. Magnetite is very common.

(f) *The granite of Sailinhutung.*—Sailinhutung is a village located about 50 km. NE. of Kuyanghsien. Around the village the gently rolling hills are all composed of granite rocks. The area of granite rocks extends with a width of about 10 km. from Tuchingtzu (E. of Sailinhutung) westwards to Kungtulun, and possibly to Shapatzu farther west for a total distance of more than 30 km. The granitic mass is bordered on all sides by the Sangkan gneiss. The former is seen to send off pegmatitic veins into the latter in some places, suggesting an intrusive batholith in the Sangkan formation.

The granite is often associated with gem-bearing pegmatite which forms either veins of varying width or wholly irregular patches. In general the change from one rock to the other is rather sudden, although characterized by complete crystallographic continuity.

The granite is, in general, a rather fine-grained rock of reddish colour containing prevalent felspars and quartz with only subordinate mafic minerals.

Microscopically felspars and quartz are present almost in equal amount. Quartz occurs either in large aggregates or in small grains. Felspars consists of three kinds, namely orthoclase, microcline and plagioclase, the first two, usually tabular in form, being by far more abundant than the last. Among the mafic minerals, biotite is nearly equal to magnetite. When weathered it alters into chlorite.

Toward the southwest, near Shuikou village for instance, a change takes place both in texture and in composition. The constituent grains increase in size. Biotite is abundantly present. Instead of microcline, plagioclase becomes prevalent. Quartz is rather subordinate.

Besides the large granite bodies described above many pegmatite dykes (very similar to granite apophyses) have been found penetrating the Sangkan gneiss without sharing its general foliated nature. They are composed chiefly of orthoclase and quartz with biotite or hornblende, grading into simple aplite and even quartz veins. Near Sailingpao in Olashan for instance, the pegmatite is often associated with very fine-grained aplite in which a small amount of specular iron ore is present.

Age of the younger granite.—The similarity of the petrographic characters and the mode of occurrence of the intrusives described above seems to prove without doubt their contemporaneousness of intrusion. Though they are frequently found in the Sangkan formation, the age of the igneous intrusion is as yet beyond doubt Post-Palæozoic. This has been proved by the granitic mass of Pichiashan which is, as already stated above, intruded into the Permo-Carboniferous coal series that is metamorphosed at its contact. How young it is hard to judge, because the relation of the intrusives to younger formations is not well known. However the coal of the Jurassic Shihkuai series near the intrusives is always passed into anthracite; good examples of this fact are furnished by the anthracites of Takou coal field and Liushuwan coal field around the Wanchiakou granite and Malientan coal field just east of the Hsiaotachingshan granite. There seems no better explanation for the alteration of the coal of the Shihkuai series than that it is caused by the metamorphic effect of the granite intrusion. If the assumption is correct, the age of the intrusives must be Post-Jurassic.

The upper limit of the age of the granitic intrusives is fixed by the Oligocene Hanoorpa Basalt which is found overlying them. Thus the age of the intrusion is Pre-Oligocene.

The comparatively recent granite intrusion of Suiyuan proper and Southwest Chahar occurred probably during the early Cretaceous, accompanying the last phase of the Yenshan tectonic movement which will be explained later.

B. *Diabase*

Diabase is often found forming dykes or veins of varying width in the Sangkan gneiss. These dykes cut obliquely across the foliation of the gneiss and also across the pegmatite veins and make sharp contacts with the country rocks. This relation is most conspicuous and regular at Tsainaopao in Tachingshan, about 45 km. N. of Salach'i (see Fig. 30).

The rock is as a rule, greenish in color and very fine in texture. Microscopically it is a holocrystalline one with well formed crystals. Plagioclase is the prevalent constituent. Judging from the extinction angle measured from the twining planes, the felspar forming the microlitic crystals is largely labradorite. The interstices between the microlites are filled up by a green mass mainly composed of pyroxene with chlorite and other secondary minerals, giving an ophitic texture (Pl. XVII, D). Very fine grains of magnetite are not infrequently observed.

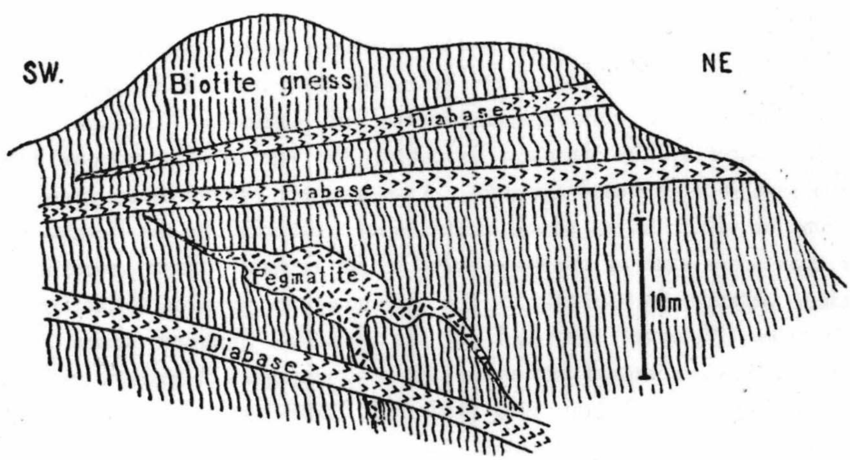


Fig. 30. Section near Tsainaopao 45 km. N. of Salach'i

The petrographical study of the diabase and the Oligocene basalt has compelled us to think that they are mutually connected, though the investigation could not be extended to adjoining localities in order to establish the relationship of these two rocks. Moreover, the diabase dykes are often cut across the pegmatite veins which have been assumed to be of early Cretaceous age so that the age of the basic intrusion is Post-Mesozoic, or possibly middle Tertiary.

C. *Andesite*

In Wuhakou NE. of Shihnakan village numerous igneous dykes are found traversing the Sinian limestone. These dykes are usually pale grey in color. Advanced alteration makes impossible accurate determination of the minerals, the general characters are very like rocks of andesitic type in other places. Andesite dykes also occur near Tungwusutu, N. of Kueisuihsien intruded into the Permo-Triassic formation.

V. STRUCTURAL GEOLOGY

On examining the chronological sequence, it is evident that one unconformity exists between the Sangkan and the Wutai systems, while another great unconformity separates the Wutai system from all the overlying formations ranging from Sinian to upper Jurassic in age, the latter strata are remarkably conformable with no sign of angular discordance though several stratigraphic gaps occur in the sedimentary record as shown in geological columns (Plates I & II). The third unconformity occurs between the Tachingshan series and the Tumulu series. The Hanoorpa basalt also unconformably overlies the Tumulu series with a moderate discordance. The whole sequence (from Sangkan gneiss up to Hanoorpa basalt) has been disturbed by the faults in many places.

From the descriptions given above, it is known that the strata in Suiyuan proper and Southwest Chahar not only have been deformed by folding or warping but also dislocated by faulting.

FOLDING AND THRUSTING

1. *In Sangkan and Wutai Systems*

The strike of foliation of the Sangkan gneiss is roughly constant in any one locality, indicating that the tectonic forces acted in the same direction. It is, in general, east-west with only local changes which can often be explained by the existence of normal faults or by the occurrence of igneous intrusions.

Near Nankouling in Huaian district, the strike of the gneiss and the associated rocks, neglecting local deflections, varies between N 60°-80° E with a dip to the north of 35°-45°.

This direction is generally consistent with the strike observed by G. B Barbour at Tulamiao in the Kalgan area. Along the road from Huanghuakotung to Santaoyingtzu, where the gneiss and the marble are well exposed, the strike is essentially east-west. The southerly dip is rather steep, sometimes it becomes vertical. Along the upper valley of Wanchiakou in Tachingshan the strike is constantly N 45°-80° E. This accords with the trend lines noticed in the Paitsaikou more than 50 km. farther west. In Wutakou, Patukou etc. the strike varies from ENE. to E. with a southerly, sometimes northerly dip characteristic of the southern margin of Tachingshan. Going west to both Olashan and Sheitenola the gneiss maintains the E-W trend. The dip is usually vertical. In a place not far SE. of the body of Sailinhutung granite, the gneiss often assumes the NNE-SSW strike, viz. the strike has been deflected to the north. This change may be due to the derangement connected with the granite intrusion.

The Sangkan system has been so strongly folded that the isoclinal folds are of frequent occurrence, which may be recognised by the repetition of calcareous layers interstratified in the gneisses. Along the Haolaikou valley N. of Chininghsien, which is cut in the Sangkan System, the four layers of marble are found intercalated in the acid gneiss, having a E-W strike and a northerly and vertical dip and another layer overlying the gneissic granite. Thus there seems apparently to be five layers of marble altogether, but in reality only one layer is present, which has been repeated in the isoclinal folds. The interesting structure is represented in the Fig. 7.

Beginning N. of Huanghuakotung the exposure of the acid gneiss extends southward for about 6 km. Throughout this distance there are three layers of marble which are parallel to each other and have, in general, similar thickness. Tectonically they are just the same as those in Haolaikou above mentioned.

In the Olashan the acid biotite-gneiss has been thought by Teilhard to form a central anticline between two synclines of white marble and garnetiferous mica-schists, but in fact they are probably folded in a much more complex manner. In Hatemenkou there are two layers of marble, both of which lie in the synclines, and in the same valley the layer of garnetiferous mica-schists is repeated in a closed fold. Thus these seem to owe their form to the conditions shown in Fig. 6. In both Sheitenola and Tachingshan foldings in the Sangkan rocks have also been frequently observed, such as at Wulanhutung, Maliutsun (in Patukou), Pankou, Laotaokou (in Heiniukou), etc.

The rocks of the Wutai system have been folded in comparatively simpler manner. At Hatashan N. of Kuyanghsien the Wutai strata dip to the north at 20° but farther northwest to a place 4 km. N. of Wotsinhao they become rather steep to the southeast. Thus an open syncline is formed on both limbs of which the mica-schist and the marble are exposed. The quartzite conformably overlying them forms the centre of the syncline. As already stated above, the large sheet of Wutai quartzite has been found in Wanchiakou. The field study on this quartzite shows that it has been so strongly folded as to represent a closed syncline (see Fig. 12).

2. *In formations ranging from Sinian to upper Jurassic*

Tectonically all the formations ranging from Sinian to upper Jurassic form one and the same unit which has been folded and thrusted all together at a same period. These two types of structure may be treated as follows:

Heiniukou Folds.[1] From Shuimokou, NW. of Kueisuihsien, westward through Heiniukou to Hsikou N. of Chasuchi village, the Mesozoic sediments develop in a succession of anticlinal and synclinal folds of E-W trend. The folds are often unsymmetrical with the axis inclined toward the north, so that the northern limb of an anticline generally dips more steeply than its southern one. In the section of Tungkou and Hsikou the southerly dip largely prevails at a gentle angle. The folds have been complicated by faults in some cases.

Yitsienshang Syncline. From Paishihtoukou NW. of Chasuchi westward across Maitakou to Shuichingkou N. of Salachihsien, the Mesozoic beds tend to form a syncline, as can be observed N. of Yitsienshang, which deepens and widens westward. The strata, ranging from Permo-Triassic to Lower Jurassic in age, forming the southern limb of the syncline first become vertical and then overturned to dip southward instead of northward at angles of 30° to 40°. The overturned strata are followed on the south by the important overthrust from the south northward which C. C. Wang calls Paishihtoukou overthrust (see below).

Shihkuai Syncline.[1] In the vicinity of Shihkuai village the synclinal basin is on both the north and the south sides cut by faults, so that only the Triassic red sandstone and shale and the Lower Jurassic coal series are preserved.

Hsuanmachuang Syncline. In the Sheitenola range, Hsuanmachuang is an interesting region for the study of geological structure. The structure is a ENE-WSW syncline overturned towards the northwest (see Fig. 15). The younger formations exposed in the center of the syncline are the Permo-Carboniferous coal series and the Permo-Triassic sandstone which are succeeded toward both the northwest and the southeast by the Sinian limestone forming the two limbs. The inclination of the beds on the two limbs is very steep with the dipping angles varying from 60 to 75 degrees. The syncline can be distinctly observed in the vicinity of Hsuanmachuang hill.

In the vicinity of Wulanhutung immediately to the east the front of the Sinian limestone which is followed toward the north by the Permo-Carboniferous coal series assumes a curved form apparently stretched out toward the south and lying on the Sangkan gneiss which dips steeply. As to the structure of this limestone Teilhard de

1. Mainly after C. C. Wang.

Chardin had the idea that the Sinian limestone is folded into an anticline overturned and thrusted towards the south over the Sangkan gneiss, but it seems highly probable to me that the limestone here corresponds but with the southern limb of a syncline which is the eastern extension of the Hsuanmachuang overturned syncline above described (see Fig. 6).

Kuantsingkou Syncline. From Yingpanwan westward across Kuangtsingkou to Shachikou E. of Wulanhutung, the strata of Jurassic Shihkuai series develop in a syncline of WNW-ESE trend which is broken on the north by the vertical fault of a later age (see Fig. 20).

Erhfentzu Syncline. Going from Kuantsingkou northward for about 16 km. we have a syncline basin of Shihkuai series with the centre nearly at Erhfentzu, it is cut on the northwest by the vertical fault to which is due the abrupt rising of the Sangkan gneiss range (see Fig. 20).

Besides the important synclines described above many others are worth mentioning: (1) From Malienkota (W. Changpeihsien) to Niuchinyingtzu, the Jurassic Tachingshan series lies in the flat syncline of NW-SE trend. The fold is, however, often complicated by faults of later age. (2) The syncline basin of Wotsinhao (W. of Kuyanghsien) (3) The syncline basin of Pakoutzu (N. of Kueisuihsien).

Yinshan overthrust.[1] This overthrust runs from Takou (NE of Pao ouhsien) eastward through Hutungtu, Shanshenmiao, Szutaohotzu and Laotaokou to Shuimokou along a total distance of about 100 km. The general trend is east-west nearly parallel to the prevailing strike of the sedimentary strata. The overthrust is directed from south to north with the Jurassic beds thrown over the Sangkan system; such relation is distinctly observed north of Laotaokou and of Szutaohotzu NE. of Pikochi.

Paishihtoukou overthrust.[1] It extends from Chimaoyaotzu eastwards through Tsientengchang, Chungpaokosu, Lutaokou to Paishihtoukou for about 50 km. This overthrust is easily recognised by its bringing Sangkan gneiss from south to north over the Permo-Triassic and Jurassic strata. As shown in the geological map, (Sheets 4 & 5) the eastern end of the overthrust possibly goes further east through the contact between the granite and the Permo-Triassic strata directly northeastward to Laotaokou close to the Yinshan fault on the north. The eastern extension of the overthrust is followed on the south by another overthrust which brings the Jurassic beds northward in direct contact with the Wutai quartzite and marble. The latter rocks N. of Mamihata are therefore brought by two overthrusts on the north and south so as to be included amidst the Jurassic beds.

1 Mainly according to C. C. Wang.

Further south, at the Heiniukouk'ou the Wutai quartzite and marble appear again on the south of Permo-Triassic red sandstones. That the Wutai formation is brought by the overthrust northward over the Permo-Triassic beds is well shown by the outcrop of the latter as the marble and quartzite have been there eroded away. The Heiniukou overthrust seems to be continuous westward with the Kucheng overthrust N. W. of Chasuchi village, which brings the Wutai marble northward over the Permo-Triassic red beds there, and S. of the marble there appears again the red shale dipping northward which is probably brought by another thrust.

Instead of narrow belts of Wutai quartzite and marble among the Permo-Mesozoic sediments as we have just explained near the eastern extension of Paishihtoukou overthrust, there occurs near the western end of the said overthrust a number of narrow east-west belts of Permo-Carboniferous or Jurassic strata appearing in the midst of Sangkan gneiss. In certain cases, as south of Kuantientzu it is obvious that the gneiss has been thrusted from south northward over the Jurassic sandstone. It is therefore of great probability that these belts in the vicinity of Kuangtientzu are all limited on both north and south sides by parallel northward overthrusts.

Shihnakan overthrust. On the summit of a hill S. of Shihnakan village, as has been stated, occurs an isolated Sinian limestone lying over the Sangkan gneiss, and N. of said village appears the Permo-Carboniferous coal series which has been profoundly metamorphosed (see Fig. 15). The field study in this region showed to the writer that the limestone being originally broadly distributed is so profoundly folded as to constitute an overturned anticline thrust upon the Permo-Carboniferous sediments with a gently inclined thrust plane beneath the anticlinal nappe. It is evident that there must be an overthrust from the south northward bringing the limestone over the coal series.

In a place NW. of Wulannaopao, which has been visited by the writer, there, according to the report of Mr. Y. S. Wang of the Industry Bureau of Suiyuan, occurs an overthrust running in E-W direction for some distance. It often brings the Sangkan gneiss northward in some direct contact with Permo-Carboniferous coal series. It is highly probable that the overthrust is the western extension of the Shihnakan overthrust.

Tzulaotsun overthrust. This is also an important overthrust which extends from Niuchinyingtzu, SW. of Changpeihsien, on the east through Tzulaotsun to Santaokou, NE. of Fungchenhsien, on the west for about 70 km. It is recognised by its thrusting the Sangkan gneiss northward over the upper Jurassic sediments as shown in Fig. 9, the upper Jurassic strata have been so intensely pushed northward as to form isoclinal folds.

From what has been stated above, it is known that all the axes of folds and the lines of overthrusts generally run in the E-W direction not only parallel to one another but also parallel to the general strike of the formations in Southwest Chahar and Suiyuan proper.

The date of folding and thrusting. From the direct field evidence in the area surveyed the date of folding and thrusting can be stated only to be posterior to the Tachingshan series and prior to Tumulu series, more exact data can not be ascertained. But in the Kalgan area G. B. Barbour observed that the orogenic movement only threw Kalgan volcanic series into a series of folds, Nantienmen formation being not affected by such a disturbance. He has thus, assigned it a Lower Cretaceous age, being the last and main phase of Yenshan movement which began at the close ot the Jurassic, continuing spasmodically into the Cretaceous time. This seems to be well applicable to the whole area under survey.

The direction of the Mesozoic orogenic movement. According to the opinion of Teilhard de Chardin[1] the direction of the Mesozoic orogenic movement was from north southward and from west eastward. Ordos is considered as "avant pays" of the orogenic force which came from W. and N. all against it. Such was indeed the classical opinion of many European geologists. However, C. C. Wang[2] first demonstrated that the orogenic force in Tachingshan was clearly from the south northward. He interpreted the whole tectonic structure of Alashan, Ordos and Tachingshan by assuming an horizontal force coming from Alashan through the Ordos as a mass of resistance from which it spreaded and proceeded toward N. E. and S. respectively on a semi-elliptical front. In the way not only Tachingshan, but Olashan, Sheitenola and Langshan which were not visited by C. C. Wang, all lying on the north front of the imagined ellipsis of the propagation of the orogenic force, should suffer also particularly violent compression, and hence large overthrusts and sharp folds from the south northward should be observed.

The writer's field survey in extension of C. C. Wang's enables him to fully confirm the latter's opinion, as he has found in these more western ranges several overthrusts bringing various strata northward, and unsymmetrical folds with their axial planes pushed to the north. Especially typical is the closed

1. Observations géologiques sur la bordure occidentale et meridionale de l'Ordos, Bull. Soc. Geol. de France, 4 Series, Tome XXIV, 1924.
2. Geology of Tachingshan range; Bull. Geol. Surv. China, 10, p. 11, 1928.

Hsuanmachuang syncline which is, as has been stated above, evidently overturned in that direction. And recently Teilhard also found in a range about 40 km. N. of Pailingmiao (see Tectonic map Pl. III, A) large overthrust[1] bringing the Carboniferous strata northward in directly contact with the Permo-Triassic beds. There is nothing to prove any southward pushing in these ranges north and north-east of the great bending of the Yellow River which were only pure hypotheses of theoretic tectonists.

WARPING

At Tumulu and also at Tayingpan the Hanoorpa basalt, as previously mentioned, horizontally lies upon the Tumulu red beds. The latter dip generally towards the east, the dipping angle varying from 10° to 15° at Tumulu, while at Tayingpan the dip is reversed towards the west with the dipping angle of 16°. Thus the Tumulu sediments evidently lie in a broad syncline. Probably the deposition of the former was followed by a tectonic movement which had the nature of a gentle warping or sinking of the crust, in that the force involved was vertical. Under such a tectonic movement a gently sloping depression occurred in the region between Tumulu and Tayingpan. This depression was filled up by the Hanoorpa basalt lava when it poured out over an extensive area.

FAULTING

In Southwest Chahar and Suiyuan proper, besides the folds, thrusts and warps above described, there are a number of normal faults which are mostly of strike or oblique type.

Wuyuan fault. The Wuyuan fault has a E-W course N. of Linhohsien and then gradually turns to the south to take a SE-NW direction northeast of Anpeihsien. Its length amounts to 250 km. with a vertical displacement of more than 1000 m. The existance of the fault is clearly indicated by the topographic evidence as the fault scarp forms mountains, namely Langshan and Sheitenolashan, abruptly rising from the northern margins of the Wuyuan alluvial plain and the Tailiang basin.

Hsuanmachuang and Hsiaoshiehtaiho faults. North of Anpeihsien the Triassic conglomerate sinks in contact with the Sangkan gneiss both on the north and south. Tectonically speaking this conglomerate lies in a trough bounded by two parallel faults (see Fig. 15). The northern fault is called Hsiaoshiehtaiho fault, while the southern is Hsuanmachuang fault.

1. Observations géologiques à travers les deserts d'Asie centrale de Kalgan à Hami, Revue de Géographie physique, vol. v, fasc. 4, pp. 371, 1932.

The Hsiaoshiehtaiho fault has a NW-SE course with a probable length of about 12 km. Its vertical displacement is doubtless very great. The Hsuanmachuang fault runs across the axis of Hsuanmachuang syncline in exactly the same direction as the Hsiaoshiehtaiho fault. Its length is about 15 km. Its upthrow in the western part is on the south, while in the eastern part the reverse is true. Thus the fault is evidently a pivotal one.

Kuantsingkou fault. This fault appears on the northern side of Kuantsingkou basin and runs from NW. to SE. with a probable length of about 10 km. Its existence is recognised by the Sangkan gneiss brought in contact with lower Jurassic coal series. Its upthrow is on the northern side with a vertical displacement of more than 500 m.

Erhfentzu fault. The fault occurs on the northern border of Erhfentzu basin in the E-W direction, Its upthrow on the north consists of Archæan mass which forms the precipitous-cliffed mountains, the downthrow is on the south of the lower Jurassic coal series.

Wotsinhao fault. The Wotsinhao fault occurs along the southern foot of Ch'angliangshan and on the northern margin of Wotsinhao basin. The upthrow is made of Archæan mass of Ch'angliangshan and the downthrow of lower Jurassic coal series of Wotsinhao basin.

Olashan fault. This lies along the S. foot of Olashan and has a E. and W. course with a length of about 140 km. Its vertical displacement is doubtless very great as the height of Olashan mass lying in the upthrow of fault amounts to 700 m. above the Paotou alluvial plain. The topographic evidence of the fault is well marked by a fault scarp that forms a straight and steep cliff abruptly rising from the northern margin of the Paotou plain.

Tachingshan fault. The whole Tachingshan range is separated from the Kueisui plain by the Tachingshan fault which like the Olashan fault, has a E. and W. course with a probable length of about 120 km. between Kueisui and Paotou. Its vertical displacement is at least several hundred meters. The fault scarp is well shown by the abrupt elevation of the said range with an almost straight front. The fault cuts across Heiniukou-Kucheng overthrust and Pak'outzu syncline.

Takou, Hsikou and Heiniukou faults.[1] In the vicinity of Takou on the west of the granite body and Hsikou, Heiniukou on the east of the intrusion there occurs several normal faults (see geological map). These are generally oblique to the strike

1. Mainly after C. C. Wang.

of the strata and extend often over pretty long distance from 10 to 20 li. But the displacements are within the Permo-Mesozoic beds.

Wenchiayaotzu fault. From C. C. Wang's observation in the vicinity of Wenchiayaotzu N. of Pak'outzu, the Permo-Triassic red beds unconformably lie upon the Wutai schists. In the writer's recent survey, no clear evidence of erosion feature between the two formations was observed; it seems to him highly probable that the schists are brought in contact with the red beds by a normal fault which firstly has a S-N course and then runs in a E-W direction with the vertical displacement of no great magnitude.

Pingankoutzu fault. This fault runs from Mamikou eastwards through Pingankoutzu to Yangwantzu having a WNW. and ESE. course. It possibly goes further east through the southern margin of Taolin basin to Kunghutung. Its total length is about 70 km. The upthrow of the fault is on the south, consisting of the Sangkan gneiss which is raised in contact with the Permo-Triassic sediments north of Tihungtai and Sulitu, etc.

At Pingantzu, N. of Pingankoutzu fault, the Permo-Triassic red beds are found brought in contact with the basalt flow by another normal fault which has a E. and W. course with a length of at least 10 km.

Sulitu fault. This occurs southwest of Sulitu village. It runs in a NW and SE direction. Its upthrow is also on the south, being made of the Sangkan mass which is raised in contact with the Permo-Triassic beds. The fault seems to be continuous westward with the Wutaopa fault, SW. of Tat'anchen, by which the Sangkan mass is also brought in contact with the Permo-Triassic beds. In this assumption the total length of the fault is at least 30 km.

Malienkota, Tumulu and Tungcheng faults. In the vicinity of Malienkota, Tumulu and Tungcheng in Southwest Chahar there are also normal faults which as exhibited in geological map, bring either the Sangkan gneiss in contact with the Nank'ou limestone or the basalt flow or the lower Jurassic coal series in contact with the upper Jurassic sediments.

The date of faulting. The faulting has been assigned by C. C. Wang to Pleistocene time, but my recent observation shows that it is older in age. As already stated above, Oligocene basalt is faulted, while the red clay of late Miocene and early Pliocene age is unaffected. It is clear that the faulting took place in early Miocene time in Suiyuan and Chahar. On physiographic grounds the faulting must be prior to the opening of the Tanghsien cycle of erosion, as it produced the deformation which induced that cyle in Miocene time. This accords with the age of normal faults in other parts, such as Liaoning and Shantung, of North China.

VI. USEFUL MINERALS

With regard to mineral resources, more detailed description has been given in the Chinese text, this is only a summary. The principal minerals in the area surveyed in Suiyuan and Southwest Chahar are coal, asbestos and minerals used as precious stones. Iron, graphite, mica, sulphur, melanterite, salt, clay etc. are also known, but they have less economic importance.

COAL

Coal is found in Langshan, Sheitenola, Tachingshan, Kueitengliangshan, Hsiaotachingshan etc. Geologically it is known in three ages, the Permo-Carboniferous, the Lower Jurassic and the Tertiary. The first two can be grouped into several distinct fields due to the folding and erosion. The Tertiary coals crop out in isolated regions only by the removal of basalt flows.

Permo-Carboniferous

(1) *Langshan coal fields.* On the southern slope of the Langshan range, the metamorphosed Permo-Carboniferous coal-bearing series occurs as almost a continuous belt which may be however distinguished into separate coal fields, such as Shihnakan coal field, Wulannaopao coal field etc. At one time there were several small mines, but now no work is being done; it is reported that the two seams, 2 ft. to 4 ft. thick, of coal are known in the lower part of the series. The coal is anthracite but it has been largely converted into graphite.

(2) *Hsuanmachuang coal field.* In the Hsuanmachuang region N. of Anpeihsien, the Permo-Carboniferous coal-bearing series lies in a closed syncline containing thin seams of coal. In the vicinity of the Munan Coal Mine, two seams of coal are now being worked by the small mines. They are reported to vary from 3 to 5 ft. thick. The quality of coal varies from anthracite to semi-anthracite. The analysis of the sample taken from the lower seam is given below:

Locality	Moisture	Volatile M.	Fixed C.	Ash	Remarks	Cal. P.
Munan Coal Mine	2.35	7.25	85.20	5.20	Non-Coking	7975

If we take 2 m. as the average total thickness of the workable seams and assume that the workable extent of the coal beds at the limb of the syncline is 1,250,-000 sq. m. and specific gravity is 1.3, the probable reserve is 3,250,000 tons. The coal beds are said to extend towards the east to Hsiliang village. Thus the total reserve possibly reaches a figure of 5,000,000 tons.

(3) *Tungshengmao coal field*[1]. This field is constituted by Permo-Carboniferous coal series. One coal seam is observed at Matiwantzu S. of Tungshengmao about 6 meters thick. The coal is bituminous and coking.

Locality	Moisture	Volatile M.	Fixed C.	Ash	Sulphur	Remarks	Calorific P.
Tatanhao	1.16	22.68	66.54	9.62	0.0162	Coking	7685

If we take 3 m. as the average thickness of the seam, the probable reserve is estimated at 37,800,000 tons.

(4) *Yangkoleng coal field.*[1] This is situated S. of Tungshengmao coal field. It consists of both Permo-Carboniferous and lower Jurassic coal series and therefore may be subdivided into three parts as below:

	Geological Ages	Average thickness of coal seam	Probable reserve
East part	Permo-Carbon.	2 m.	4,500,000 tons
Middle ,,	Lower-Jurassic	1.5 m.	5,800,000 ,,
West ,,	Permo-Carbon.	1 m.	1,600,000 ,,
		Total	11,900,000 ,,

The coal is all bituminous, but only that of the Lower Jurassic coal series is coking.

(5) *Sulitu coal field.* About 2 li W. of Sulitu village occurs a small area of the Permo-Carboniferous coal series. The place lies on the Wuchuan-Taolien border. One small mine is working in the Taolin district. Two seams of coal are known in the series one is about 3 ft. thick and the other 5 ft. thick. The coal is bituminous but non-coking; tbe analysis of a sample from a small mine SW. of Sulitu is given below:

Moisture	Volatile M.	Fixed C.	Ash	Sulphur	Calorific P.
0.90	16.25	59.70	23.15	0.61	6633

On the basis of the inclination and the extension of the coal beds, the coal reserve has been estimated at about 1,950,000 tons. Thence westward to Liushuikou,

1. Mainly after C. C. Wang

outcrops of the same series are reported to occur in a belt containing the workable seam of coal. Here a few years ago there was a native mine, but now it has been stopped.

Lower Jurassic

(1) *Kuantsingkou coal field.* The field is situated about 100 li E. of Anpeihsien, composed of lower Jurassic coal series extending from Yingpanwan westward through Kuantsingkou to Taolaikou. According to the prospecting of the small native mines, there are 9 seams of coal whose thickness is shown as follows:

Seam 1 (lowest)	5 feet
,, 2	2 ,,
,, 3	5 ,,
,, 4	3 ,,
,, 5	5 ,,
,, 6	2 ,,
,, 7	5 ,,
,, 8	6 ,,
,, 9	8 ,,

The coal is bituminous but not-coking; the analyses of my samples are as below:

Locality	Moisture	Volatile M.	Fixed C.	Ash	Remarks	Calorific P.
Kuantsing-kou	4.53	34.47	54.73	6.27	Non-coking	7520
Yingpanwan	5.80	37.10	41.79	13.31	,,	5837

If the average total thickness of the coal seams is taken as 9 m. the coal field should have a reserve of 58,800,000 tons.

(2) *Erhfentzu coal field.* About 10 li NW. of Kuantsingkou coal field is the Erhfentzu coal field. It also consists of Lower Jurassic coal series which was formerly mined extensively for coal, but have all been abandoned. According to the tradition of native mines and the survey of surface exposure four seams of coal are known in the series. The coal seems to be bituminous. The probable reserve is about 36,000,000 tons.

(3) *Wetsinhao coal field.* This field is located about 7 li W. of Kuyanghsien. Stratigraphically, the coal series seems to be of Lower Jurassic age. Five or six small mines are working here. Four seams, 2 ft. to 8 ft. thick, of coal are said to occur in the series. The coal is bituminous, but sometimes lignitic bitumite or lignite. The reserve of coal has been estimated at about 48,000,000 tons.

(4) *Shihkuai coal field*[1]. This is the largest and most important coal field in Tachingshan extending from Takou westward through Yitsienshang, Liutaopa and Laowepu to Shihkuaichen with a total length of about 120 li. It is composed of lower Jurassic coal series. The coal seam about 4 ft. thick, is known at Takou, Liutaopa and Chunglaowepu, while in the vicinity of Shihkuaichen 7 workable coal seams of which two have been worked, respectively 3 ft. and 6 ft. thick. The quality of the coal changes very much from place to place. Between Liutaopa and Takou the coal is anthracite. Samples taken from Yitsienshang have yielded the following analysis:

Moisture	Volatile M.	Fixed C.	Ash	Remarks	Calorific P.
1.40	4.80	84.26	9.54	non-coking	7350

While at Hulussutai and Shihkuaichen the coal is all bituminous; the analysis of samples from Shihkuaichen is as the following:

Moisture	Volatile M.	Fixed C.	Ash	Sulphur	Remarks	Calorific P.
1.44	33.02	56.62	8.92	0.0127	Coking	7751

If the average total thickness of the coal seams between Takou and Chunglaowepu is taken as 1.5 m. and that in Shihkuaichen and west of Chunglaowepu as 3 m; the coal field should have a reserve of 20,300,000 tons of anthracite and of 85,800,000 tons of bituminous coal.

(5) *Kuantientzu coal field*[1]. This is situated about 25 li NW. of Salach'ihsien, composed of the lower Jurassic coal series. There are three coal seams worked at Kuantientzu; the upper one is about 2 ft. thick, the middle 1 ft. and the lower 3 ft. If 2 meters are taken as the average total thickness of the coal seams, the reserve is about 24,000,000 tons. The coal is all bituminous and coking.

(6) *Liushuwan coal field*[1]. This field is located about 90 li W. of Kueisuihsien and also composed of lower Jurassic coal series. Two coal seams have been worked, one is about 1 ft. thick and the other 2 to 4 ft. The coal is anthracite; the analysis is shown as following:

Moisture	Volatile M.	Fixed C.	Ash	Remarks	Calorific P.
1.46	3.44	79.86	15.24	Non-coking	7046

The reserve is about 11,700,000 tons.

(7) *Heiniukou coal field*[1]. About 70 li W. of Kueisuihsien, there is the Heiniukou coal field composed of lower Jurassic series. The worked coal seam is

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semi-bituminous in quality and 1 or 2 ft. in thickness. The probable coal reserve seems to be not more than 2,900,000 tons, if the average thickness of the coal seam is taken as half meter.

(8) *Pakoutzu coal field*[1]. About 20 li N. of Kueisuihsien, the Pakoutzu coal field is also built up by the lower Jurassic coal series. Here no good coal seams are discovered; those formerly operated by small mines are from a few inches to 1 ft. thick and of semi-bituminous quality.

(9) *Tuchengtzu aud Tanyao coal fields.* In west Wuchuan there are, as far as I know, two districts where coals are known to occur. They are Tuchengtzu (15 li SW. of Wuchuanhsien) and T anyao (10 li W. of Wuchuanhsien), both of them seem to consist of lower Jurassic coal series. Only thin beds of coal are reported to be found in the Tuchengtzu field, probably semi-bituminous. At one time they were operated by small native mines. In Tanyao coal field, three coal seams have been worked; each one is about 1 ft. thick. The coal, like that in Wets'inhao coal field, is lignitic bitumite or lignite, The probable reserve is about 2,160,000 tons.

(10) *Tumulu coal field.* This field is situated about 5 li NW. of Tumulu village extending from Tapakou southwestward to Soutzuping at a length of about 8 li. It consists of lower Jurassic series which contains 8 coal seams two of which have been worked by Hengsheng coal mine, 4 ft. and 8 ft. thick respectively. The coal is bituminous and coking, the analysis of samples from Hengsheng coal mine is as follows:

Moisture	Volatile M.	Fixed C.	Ash	Remarks	Calorific P.
0.82	27.26	62.79	9.15	Coking	7817

If the average total thickness of the coal seams is taken as 2 m. the field should have a coal reserve of 4,800,000 tons.

(11) *Malienkota coal field.* About 20 li W. of Tumulu also occurs a small area of lower Jurassic coal series. The place is known as Malienkota. Chengping coal mine are working here. Two coal seams have been worked; one is said to be 5 ft. thick and the other 7 ft. The coal is anthracite; the analysis is shown as below:

Moisture	Volatile M.	Fixed C.	Ash	Remarks	Calorific P.
0.98	8.78	74.64	15.60	Non-coking	7261

The coal reserve is about 3,900,000 tons.

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Besides the coal fields above mentioned, there are in the region studied, several other areas of lower Jurassic coal series, which have not yet been studied in some detail.

Shiehtaiho coal field about 50 li N. of Kuyanghsien.
Mentoukou coal field about 90 li E. of Wuchuan.
Halach'i coal field about 20 li NE. of Kueisuihsien.
Ssutsunti coal field about 30 li NW. of Tumulu village.

Tertiary lignite

(1) *Malient'an lignite field.* In Malientan region about 15 li N. of Chininghsien, the Tertiary coal series underlying the basalt flows contains mainly 3 coal seams, 3, 2, 0.5 or 5, 3, 1 feet thick respectively. The analysis of sample taken from Tangnaopao is as follows: Moisture, 18.45; Volatile M. 34.07; Fixed C., 33.41; Ash, 14.07; Sulphur, 1.79; Calorific P., 4749. A number of small pits exist during the writer's visit with little output. The probable reserve is about 2,500,000 tons, if the average total thickness of the lignite seams is taken as 2.5 meters.

(2) *Tungyaokou lignite field.* Not far E. of Tumulu, below the lava flows occurs the Tertiary coal series extending from Tungyaokou eastward to Taolipa. At the two places mentioned it was formerly mined for brown lignite, but now have all been abandoned. According to the tradition of native people lignite seam was found in this series, varying from 1 ft. to 5 ft. in thickness. The reserve is about 1,440,000 tons.

(3) *Tayingpan lignite field.* At Tayingpan 28 li W. of Changpeihsien there is an exposure of Tertiary coal series. It contains one seam which was being worked by a small pit at the time of examination varying from a few inches to 5 feet in thicknees. It is a poor lignite which has the following composition:

Moisture	Volatile M.	Fixed C.	Ash	Calorific P.
21.48	36.18	17.94	24.40	4166.

(4) *Chuangmatai, Tantai. Metzushan, Painaopao and Liuchiakou lignite fields.* Some exposures of the same series are said to occur also at Chuangmatai S. of Taolinhsien, Tantai NE. of Taolinhsien, Metzushan NE. of Chininghsien, Painaopao N. of Hsinghohsien and Liuchiakou N. of Yangyuanhsien. They contain some seams of lignite which have been prospected by a few small pits.

Quaternary peat

The peat deposits occur at three places in Suiyuan. (1) S. W. of the Taikomu station the peat deposit extends from NE. to SW. over 24 li. The thickness of peat is 1 to 3 feet. The peat contains 54% vol. mat. and only 16% fixed carbon. The reserve is about 11,000,000 tons. (2) SE. of the Taotzuhao station there is a peat deposit in the limited area. (3) E. of the above named station the peat deposit is said to occur also in a small area.

Summary and Conclusion

From the conclusions reached at in the examination of the different coal fields in Suiyuan proper and Southwest Chahar, we may attempt now to form a general idea of the different coal fields of the region. Geologically in Suiyuan proper the Permo-Carboniferous series includes about 23,250.000 tons of anthracits (Am) and 45,850,000 tons of bituminous coal (Bm); the lower Jurassic series about 32,000,000 tons of anthracite (Ah), 11,000,000 tons of semi-bituminous coal (AB) and 269,560,000 tons of bituminous coal (Bm-BC): the Tertiary series about 12,500,000 tons of lignite (C); the Ouaternary series about 15,000,000 tons of peat. The total coal reserve (including peat) is about 409,160,000 tons.

In the same way, in Southwest Chahar there are 3,900,000 tons of anthracite (AL) and 4,800,000 tons of bituminous coal (Bm) in the Lower Jurassic series; 6,440,000 tons of lignite in the Tertiary series.

PRECIOUS STONES[1]

In Suiyuan province four precious stone fields are found to produce beryl, topaz, and smoky quartz, viz., (1) Huanghuakotung 30 li SW. of Taolinhsien, (2) Sailinhutung 100 li NE. of Kuyanghsien, (3) Hsiaotachingshan 20 li NE. of Hsinghohsien and (4) Kankoutzu 120 li NE. of Wuchuanhsien. The geographic distribution of these fields is shown in the geological map. It can readily be seen that the precious stone fields form almost a continuous belt approximately parallel to the border of Mongolian Plateau.

The Huanghuakotung field

(1) The deposits in Tsungshengkou. On the slope of Tsungshengkou, in the granite occurs a mass of pegmatite (Fig. 31) which has an irregular strike approximately NE. and SW. and with a dip of 80° NW. The pegmatite is composed of smoky quartz, reddish feldspar, and occasionally muscovite. In the pegmatite an old pit was sunk to a depth of about 10 feet, reaching a cavity or geoid and another pit sunk to a few feet also struck a cavity. These cavities are more or less spherical in form

1. This has been partly published in Bull. Geol. Soc. China Vol. XII, No. 2, p. 275. 1933.—A crystallographic study of some Beryl have been made by S. W. Wang in Bull. Geol. Soc. China, Vol, XI, No. I. p. 65, 1932.

and vary from two to three feet in size. They carry crystals of smoky quartz, projecting inward from their walls.

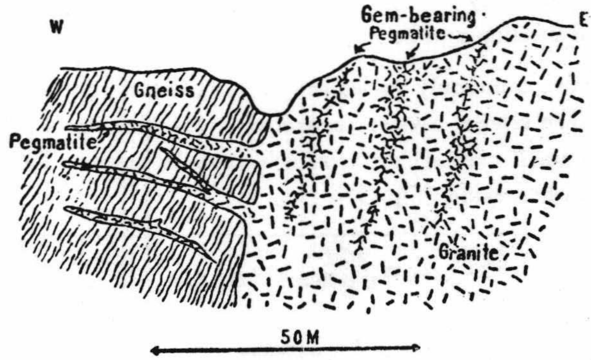


Fig. 31. Diagram showing pagmatite veins in granite and pegmatite off-shoots from it, Huanghuakotung.

(2) *The deposits W. of Tungtaikou:* These deposits are located about 2 li NE. of Tsungshengkou. Pegmatite veins occur in a reddish, medium-grained granite (Fig. 32). The strike of the vein is NW. and the dip is almost vertical. At a depth

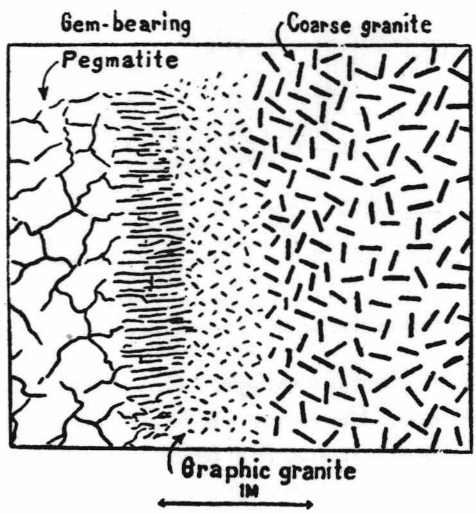


Fig. 32. Relations of pegmatite, graphic granite and coarse granite of Tungtaikou, Huanghuakotung.

of 6 meters in the vein there shows three cavities more or less round in shape and ranging from a few inches to three feet in size. The cavities are filled partly with red or yellowish red clay which is probably the decomposed product of feldspars forming the walls of the cavities. Many of the crystals of smoky quartz and occasionally beryl are embedded in the clay, though some are attached to the walls of the cavities. There is no doubt that they once grew on the walls, but now they have been loosened from their original position and lie in the clay.

Smoky quartz commonly varies from a faint tint of yellowish brown to nearly black in color. The largest crystal measured 1 foot long by 4 inches in diameter. The be··ls (all in small crystal) are greenish blue in color. They are often firmly attached to the quartz crystals (Fig. 33).

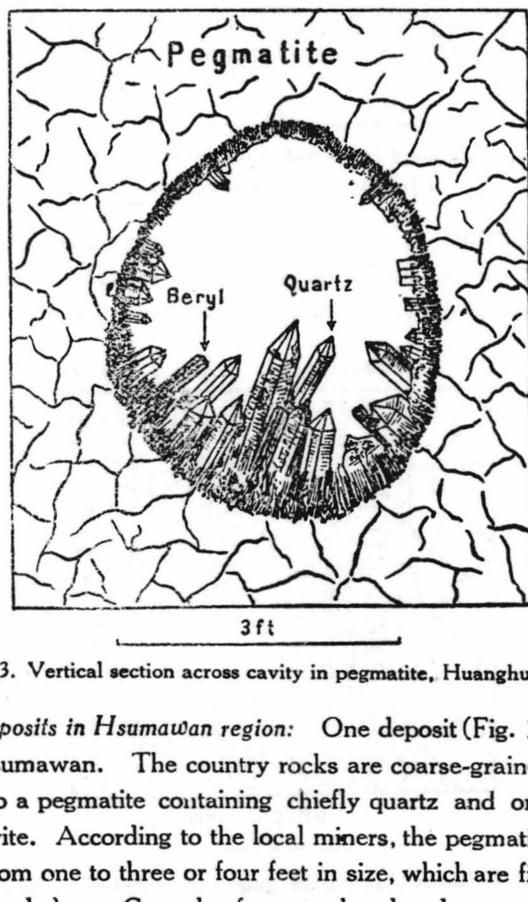
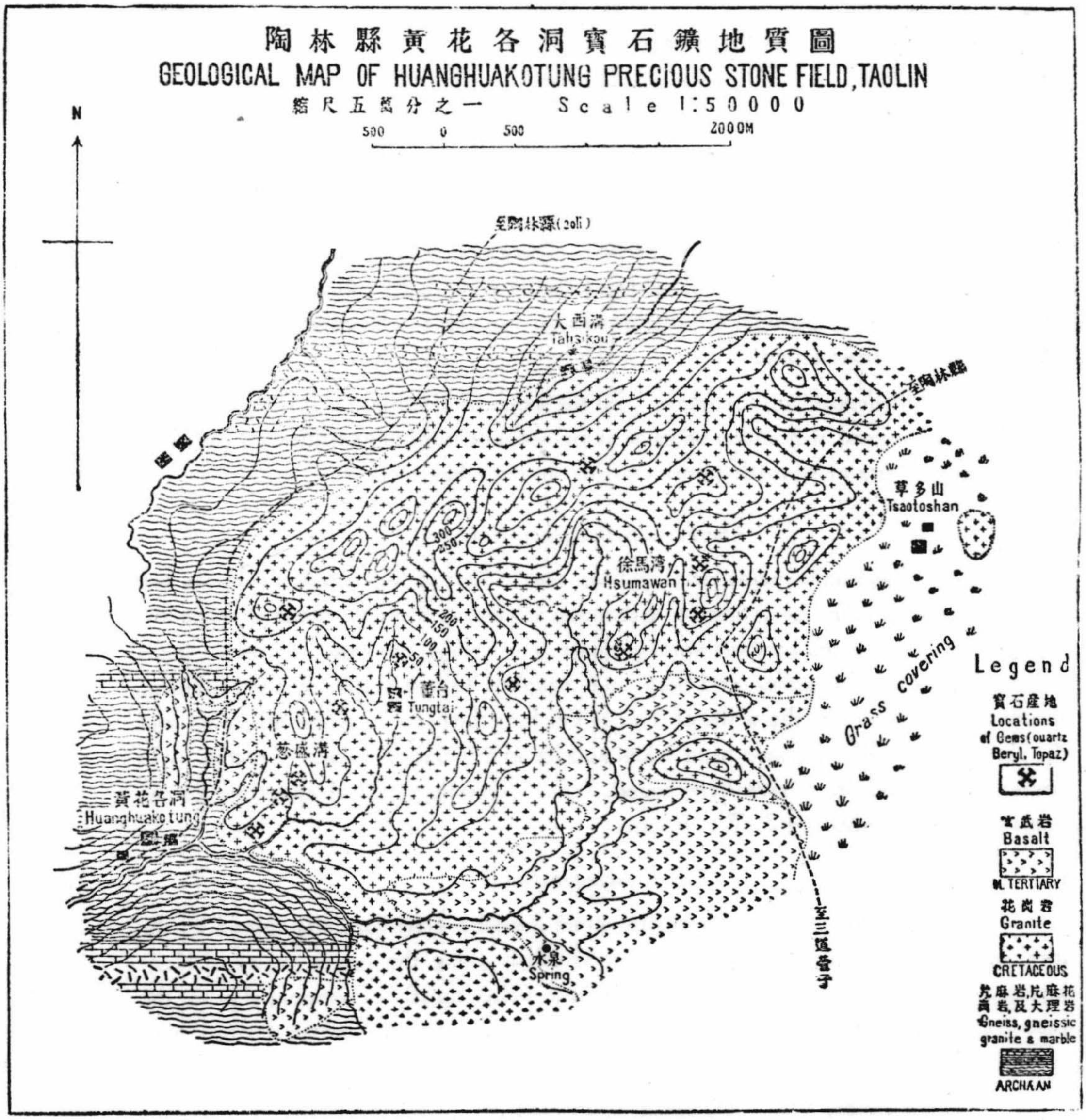


Fig. 33. Vertical section across cavity in pegmatite, Huanghuakotung.

(3) *The deposits in Hsumawan region:* One deposit (Fig. 34) is situated about 500 m. SE. of Hsumawan. The country rocks are coarse-grained granite which insensibly grade into a pegmatite containing chiefly quartz and orthoclase with minor amount of muscovite. According to the local miners, the pegmatite contains irregular cavities varying from one to three or four feet in size, which are filled partly or entirely with yellowish red clay. Crystals of quartz, beryl and topaz grow on the walls of the cavities, but in some cases the crystals are also embedded in the clay.

Another deposit is located about 1 km. NE. of Hsumawan, where an old pit sunk in pegmatite vein may be observable. The granite on the east side of the pit



陶林縣黃花各洞寶石鑛地質圖
GEOLOGICAL MAP OF HUANGHUAKOTUNG PRECIOUS STONE FIELD, TAOLIN
縮尺五萬分之一
Scale 1:50000
500 0 500 2000M
N
大西溝
Tahsikou
草多山
Tsaotoshan
徐馬湾
Hsumawan
蕫台
Tungtai
黃花各洞
Huanghuakotung
水泉
Spring
Grass covering
Legend
寶石產地
Locations of Gems (quartz Beryl, Topaz)
玄武岩
Basalt
TERTIARY
花崗岩
Granite
CRETACEOUS
Gneiss, gneissic granite & marble
ARCHAEAN

Fig. 34

and closely connected with the pegmatite vein is badly decomposed. The pegmatite vein is said to contain several cavities filled up with yellowish red clay. The cavities only carry dark smoky quartz crystals.

The Sailiuhutung field

(1) *The deposits of Ch'achitsun.* W. of Chach'itsun occur a number of pegmatite veins which range from one to six feet in thicknesss striking north or northwest and have vertical dips. Of the veins, only three have been found to contain cavities of smoky quartz and amethyst. The cavities frequently are roofed with quartz and their walls composed of feldspar mixed with some quartz, whilst crystals of smoky quartz and amethyst mostly grown on the walls. Very good crystals are reported to have been found.

(2) *The deposits of Tsaoshan.* On the slope of Tsaoshan 2 li SW. of Sailinhutung occur several pegmatite veins striking west or northwest with vertical dips. Both smoky quartz and amethyst are reported to have been found.

The Hsiaotachingshan field

Several pegmatite veins ranging from one to four or five feet in thickness are found in the granite in the vicinity of Erhtaopei village, on the W. slope of Hsiaotachingshan. The veins contain smoky quartz and beryl cavities. In some cases the crystals of smoky quartz and beryl are attached to the walls of the cavities. In other cases, however the walls of the cavities have been so much disintegrated that the crystals have been loosed from walls and lie in the clayey mass. Crystals with smoky quartz and beryl have been found. The crystallographical character of the beryl has been studied by S. W. Wang.

The Kankoutzu field[1]

In Kankoutzu region the precious stone deposits were formerly mined by the local people at only two localities, one of which is along the upper valley of Kankoutzu. In this place occur several pegmatite veins mostly of vertical dip in the mass of granite. Of these veins, only one has been found to contain cavities with crystals of smoky quartz.

Another place, viz. Pichiashan, is located about 30 li NW. of Kankoutzu, where several old pits sunk in the pegmatite veins in the hope of finding the quartz, beryl or topaz crystals. The pegmatite veins vary from a few inches to 3 ft. in thickness and have north-south or west-east strikes in the granite.

1. This was recently discovered by the writer in 1933.

Origin of the precious stone deposits

The field investigation of the writer shows that the granite is wholly devoid of cavities of any kind, the cavities or geoides are found only in the pegmatite. Such geoides have been attributed by various writers to the shrinkage of the pegmatite mass in the process of solidification. This may in fact play a little part in their formation, but that they were filled with some material which has since disappeared, is shown by the presence of crystals of quartz, beryl and topaz growing on the walls of the geoides and projecting inward from the walls. It is probable that immediately after the solidification of the pegmatite veins the geoides were entirely filled up with a gazeous solution which may then have liquified and has had since disappeared. The gas or liquid probably carried numerous mineral substances in solution, such as silica, alumina, fluorine oxide and beryllium oxide which in combining form crystals of quartz, beryl, and topaz on the walls of the cavities. The abundance of quartz crystals indicates that silica was the most abundant of these substances.

At Erhtai W. of Changpeihsien and Shihpaochuang N. of Yangyuanhsien, agat is found filling the amygdaloidal cavities of basalt flow. It is commonly red in colour and sometimes consists of alternating layers of jasper and other varieties of silica.

ASBESTOS

The asbestos has been found at a number of localities in Suiyuan, viz. Pankou, Luchowwan, Shihueiyaotzu, Shapatzu, Shaopuhai, etc. The asbestos mineral is a fibrous variety of serpentine known as chrysotile. In some places it has been worked by the local people, and at one time there were many small mines but now no work was being done at the time of visit.

(1) *The Pankou asbestos deposits.* About 60 m. SW. of Wuchuanhsien there is a ridge close to Pankou village, on the summit of which the asbestos is found. From here through Menchingpa to Pikoich'i station there is a somewhat smooth road. The distance is about 90 li or 45 km. The asbestos is scattered along the ridge for about 5 li in a E. and W. direction. It occurs in seams (steeply inclined if not vertical and parallel to each other) of varying width in serpentine marble which dips at an angle of 80°. The fiber of the best quality is usually 1.5 cm. in length, its color being white and its luster silky. It is easily separated from the barren rock. On the basis of accurate survey of the surface exposure, the amount of asbestos contained in the deposits has been estimated at about 20,000 tons.

(2) *The Luchowwan asbestos deposits.* The deposits are situated about 4 li N. of Luchowwan village and about 6 li SW. of Pankou deposits. A large sheet of

serpentine marble (200 m. long and 30 m. broad) was noticed on the summit of a low ridge, completely wrapped by the gneissic granite. The serpentine marble is traversed by multitude of asbestos veins of varying width. In these veins, the chrysotile of good quality occurs as white, or brown, fibers which vary from 5 mm. to 2 cm. in length. Probable reserve is about 6,000 tons.

(3) *The Shihueiyaotzu asbestos deposits.* The asbestos is also found at Shihueiyaotzu 5 li NW. of Chasuch i village. The chrysotile occurs in two valleys, viz. a northern and an eastern valley NE. of Shihueiyaotzu, partly forming veins in serpentine and partly filling the fissures in the highly silicified marble. The fibers of chrysotile are shorter than those mentioned above, rarely exceeding 1 cm. in length, but they have greater strength.

The probable reserve of asbestos existing here is giver. as follows:

Northern valley	7,000 tons
Eastern valley	5,000 tons
Total	12,000 tons

(4) *The Shapatzu asbestos deposits.* These are located in the southeastern part of Anpei district. From here to Paotou city there is a convenient way of transport along Kuntulunho. The distance is about 100 li. The chrysotile which is exposed in both sides of Kuntulunho a little N. of Shapatzu ridge occurs in lenticular veins in serpentine marble. Two types of chrysotile are found, one similar in character and quality to the Pankou fiber, the other, of inferior quality, is greenish in color.

The reserve of asbestos contained in the Shapatzu deposits is about 8,000 tons.

(5) *The Shaopuhai asbestos deposits.* These are situated W. of Shaopuhai village in S. E. part of Kuyang district, the chrysotile like that in other places forms seams of varying width in serpentine marble. The fibers of chrysotile vary from 5 mm. to 1.5 cm. in length. The reserve is not more than 3,000 tons. Similar chrysotile is reported to occur also at Pansh'ench'i (Kuyanghsien), Santaoyingtzu (Liangchenghsien), Wutakou (Salach'ihsien), Chimaoyaotzu (Paotouhsien), etc.

OTHER MINERALS

Iron

(1) *Magnetite of Kungyiming village.* Kungyiming is situated 20 li SW. of Kuyanghsien. On the north of the village, occur the hornblende-gneiss which

mainly contains hornblende, quartz, feldspar and magnetite. The magnetite segregation reaches a reserve of about 700,000 tons.

(2) *Specular hematite of Shaopuhai village.* Shaopuhai is a small Mongol village lying about 90 li SE. of Kuyanghsien. About 2 li E. of that village, the pegmatite veins in the granite contain some specular hematite. Specular hematite is also found in the Kulientukou NW. of Paotouhsien, where it forms the veinlets in the aplite mass.

(3) *Hematite of Laowopu.* Near the Laowopu village N. of Salach'ihsien occurrences of hematite beds are known to be present. The hematite beds have been locally mined, and what now left is the low grade ore only.

Graphite

The graphite occurs in Suiyuan in two forms, crystalline and amorphous. The first type is widely distributed in the vicinity of Huangtuyaotzu about 90 li S. of Hsinghohsien, occurring as an essential constituent of the gneiss, but the known deposits of economic value are found at Shihyaokou only, where the layers of graphite-gneiss have an irregular strike approximately S. and N. and a vertical dip intercalated in garnetiferous and micaceous gneisses. The graphite, as a rule, forms more than 10 per cent of the gneiss. Crystalline graphite is also known in the region of Lamayingtzu 60 li S. of Hsinghohsien, where it occurs in several pegmatite veins in the gneiss, being found in large flakes and also found in the region of Hungshankou N. of Kueisuihsien, forming layers from 1 to 2 inches thick in the Sangkan gneiss.

Amorphous graphite has been ound in the metamorphosed Carboniferous coal series in the Langshan range.

Mica

Though mica is known at a number of localities in Fungchen and Chining districts, viz. Tich'inchuang, Chaoshoukou etc. but it is usually found in small flakes. They are chiefly muscovite and phlogopite, the former being more common than the latter. Muscovite and phlogopite are all found in pegmatite veins cutting gneisses and gneissic granites. In these veins the mica is in rough crystals associated with quartz and feldspar.

Sulphur ore

Sulphur ore is only found at Liushuwan and Shihkuaitzu in Tachingshan. The ore consists of pyrite which usually occurs in nodules from a few inches to 1 foot in diameters embedded in the lower Jurassic coal series.

Melanterite

The melanterite ($FeSO_4 \cdot 7H_2O$) has been seen in the fissures of the graphite of metamorphosed Permo-Carboniferous series in the Koshaokou valley about 5 li NW. of Shihnakantsun. It is greenish white colored and of fibrous structure, resembling gypsum in appearance.

Salt

About 60 li SE. of Chininghsien lies a small lake, called Erhsumuhaitzu. In the lake, salt is said to occur.

Clay

Clay occurs in the Shihkuai coal field in the Lower Jurassic series, used for making crude potteries. The principal clay-works in Suiyuan province are in the Chingshuiho district outside the area surveyed.

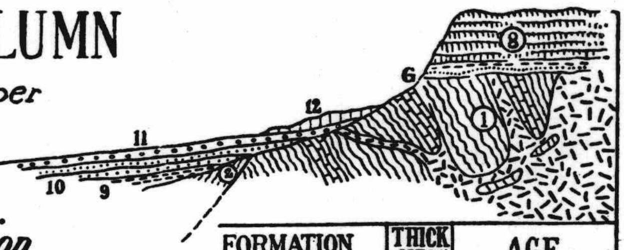
Useful Stone

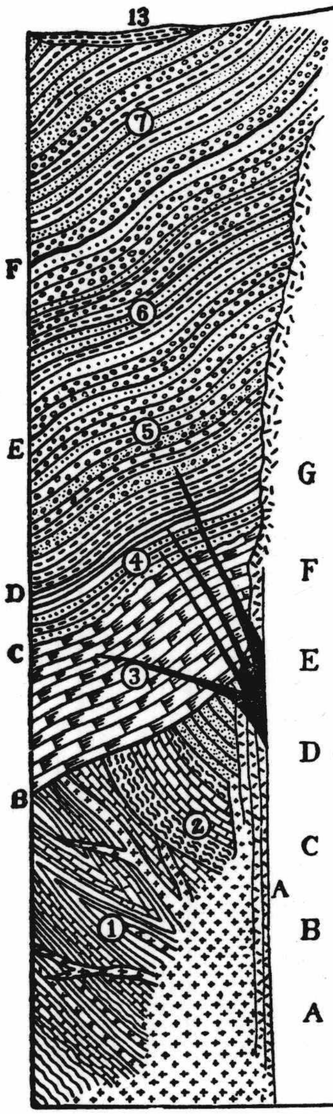
In East Suiyuan the Hanoorpa basalt is often used for different purposes. Besides a great deal used in buildings, the stone is also cut for tomb stones, rollers, culverts, water-troughs, well-curbs, windlass etc.

PL. I

GEOLOGICAL COLUMN

of Suiyuan Proper





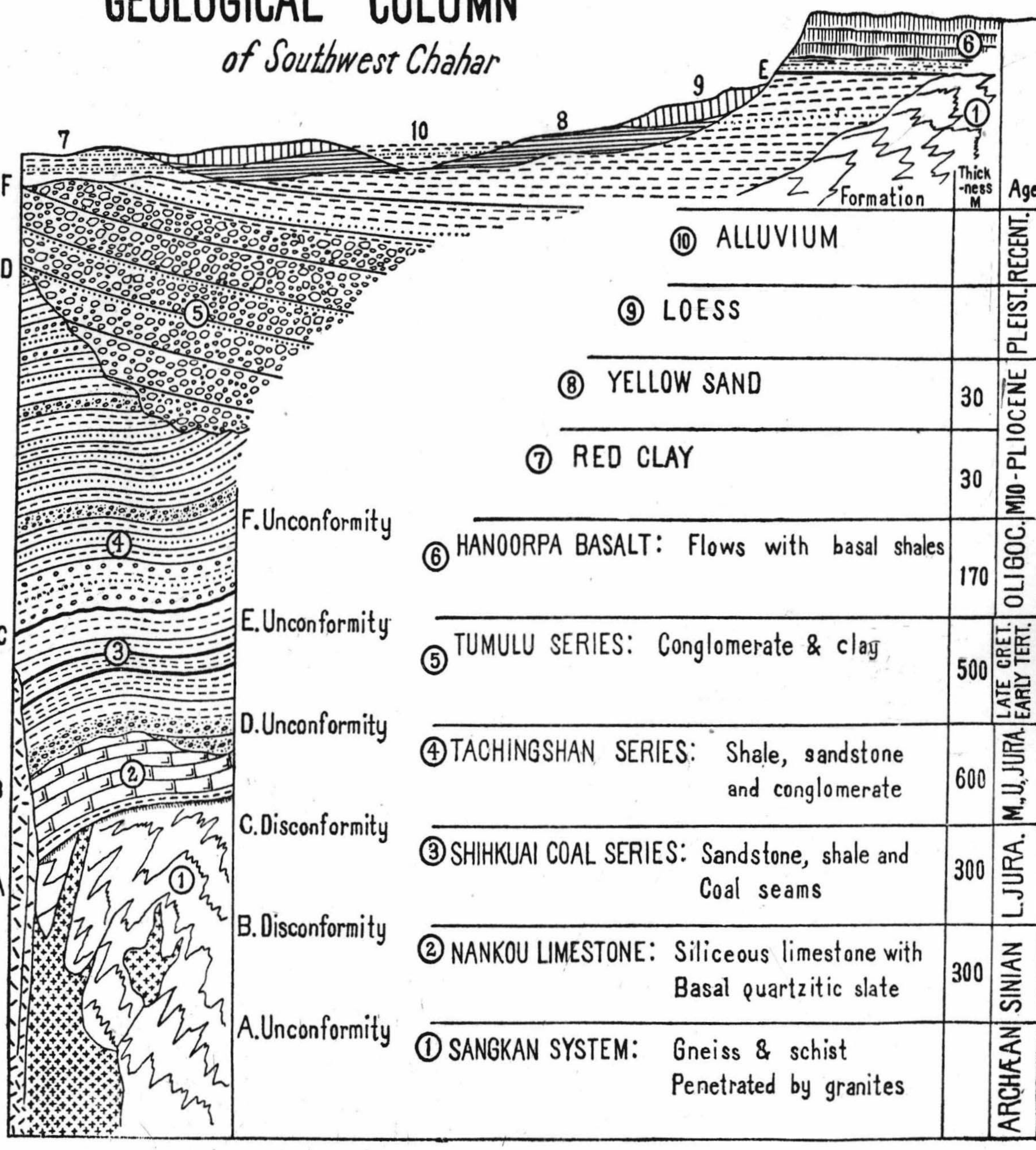
Explanation

	FORMATION	THICK-NESS M	AGE
	⑬ ALLUVIUM		RECENT
	⑫ LOESS	10	PLEISTOCENE
	⑪ GRAVEL	50	
	⑩ YELLOW SAND	40	MIO-PLIOCENE
	⑨ RED CLAY	60	
	⑧ HANOORPA BASALT: Flows with basal sand & shale containing lignite	200 30	OLIGOCENE
G Unconformity	⑦ TACHINGSHAN SERIES: Red, green sandstone and shale with conglomerate	500	M&U. JURASSIC
F Disconformity	⑥ SHIHKUAI COAL SERIES: Sandstone, shale and coal seams with upper conglomerate	500 250	M&L. JURASSIC
E Conformity?	⑤ SARACHI SERIES: Mostly red sandstone, and conglomerate	600	PERMO-TRIASSIC & TRIASSIC
D Conformity?	④ HSUANMACHUANG COAL SERIES: Shale & sandstone with coal seams	160	PERMO-CARB.
C Disconformity	③ SHIHNAKAN LIMESTONE: Black limestone, in some cases, with layers of flint	600	U. SINIAN
B Unconformity	② WUTAI SYSTEM: Quartzite, marble and schist.	250	PROTEROZOIC
A Unconformity	① SANGKAN SYSTEM: Gneiss & schist with marble intruded by older and younger granites and the latter two cut across by diabase dyke		ARCHÆAN

PL. II

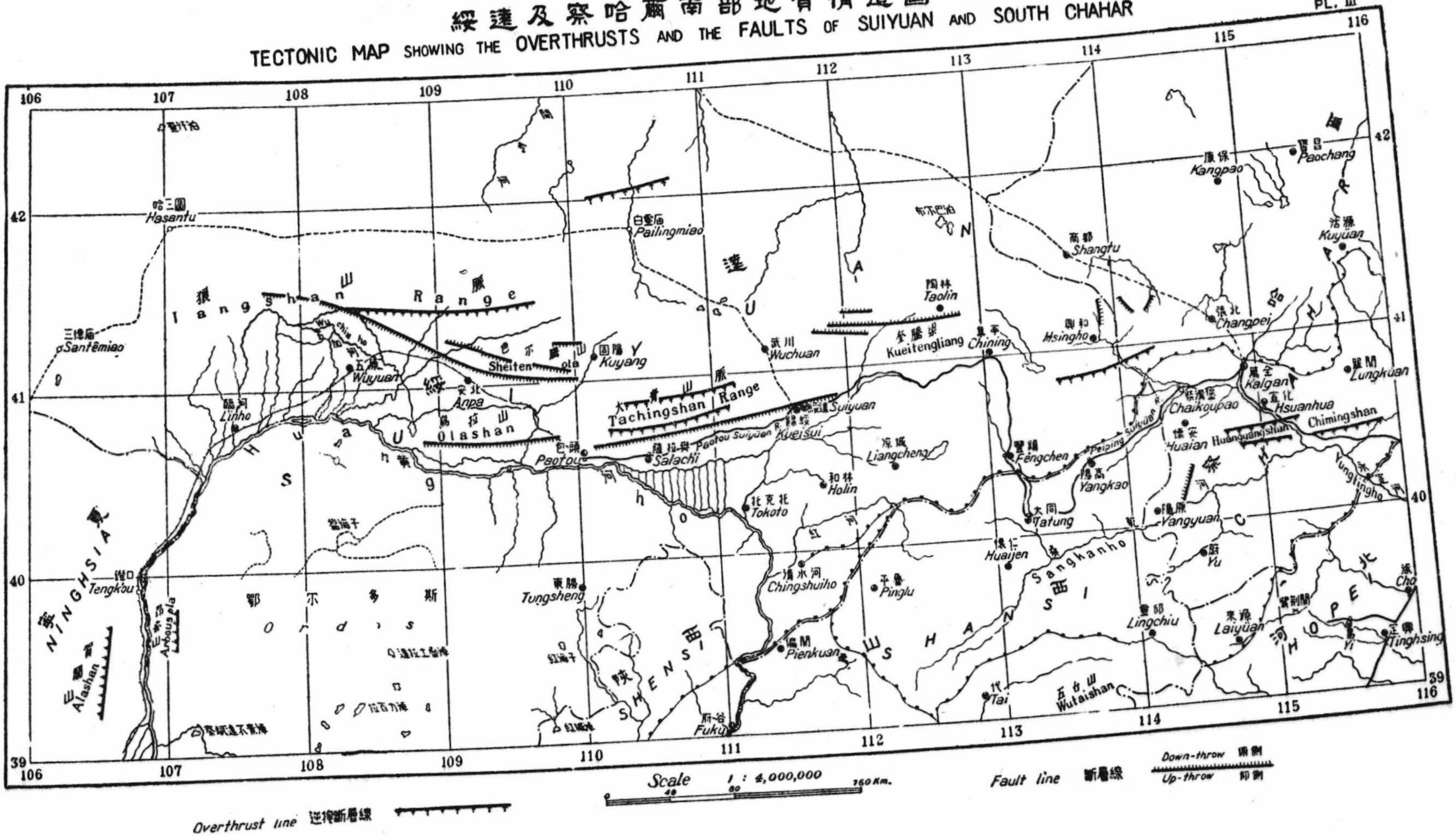
GEOLOGICAL COLUMN

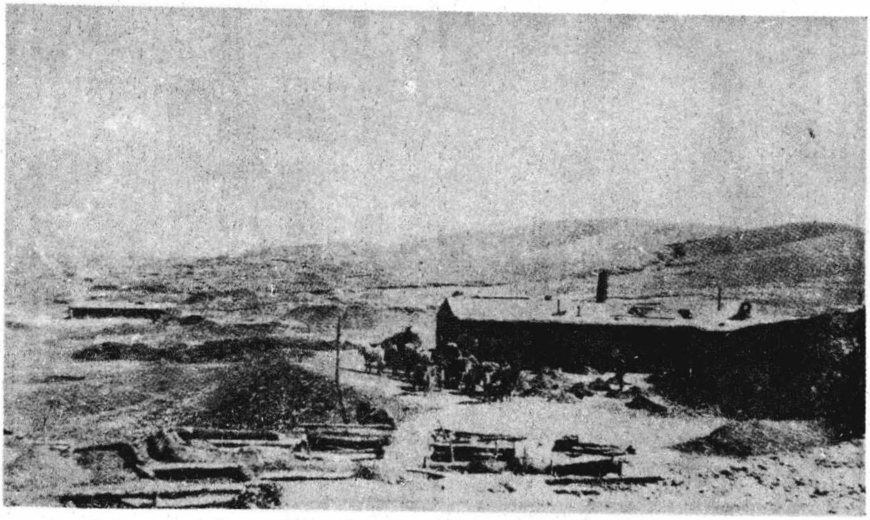
of Southwest Chahar



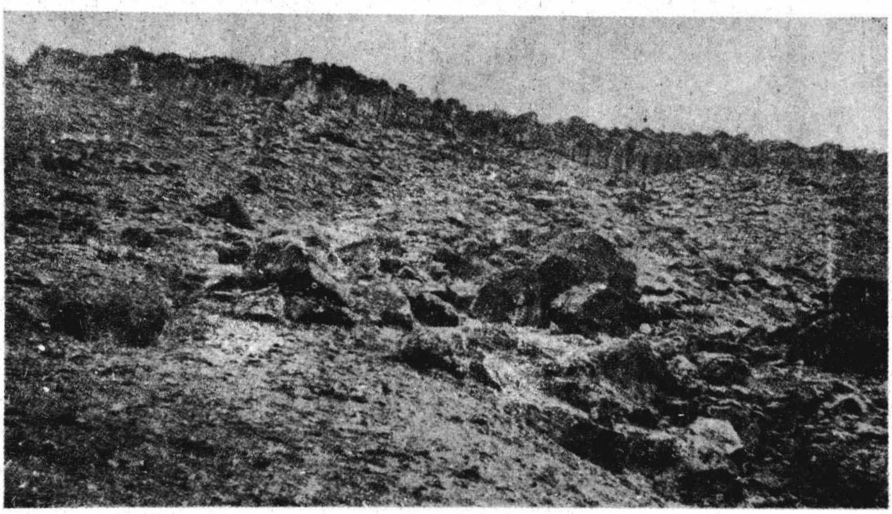
綏遠及察哈爾南部地質構造圖

TECTONIC MAP SHOWING THE OVERTHRUSTS AND THE FAULTS OF SUIYUAN AND SOUTH CHAHAR

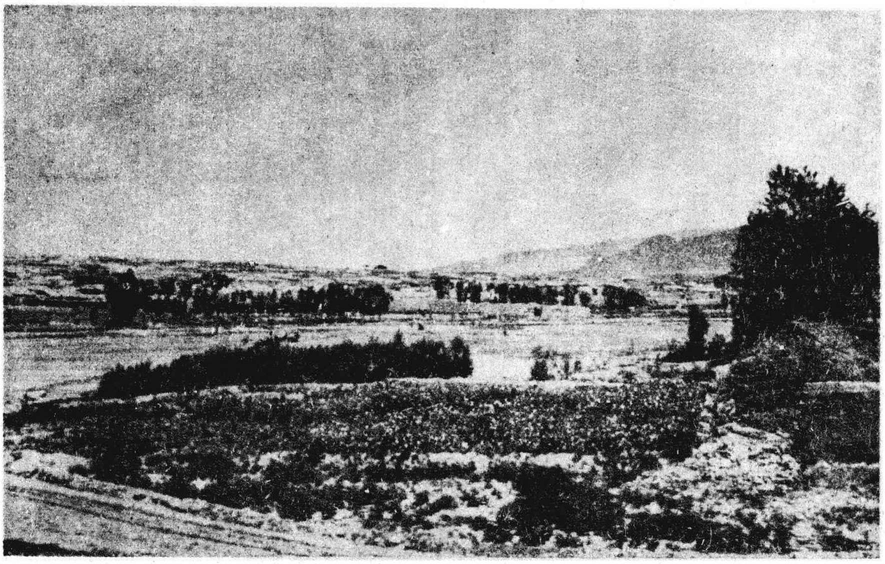




A. Panoramic view of Hengsheng Coal Mine, Tumulu, Changpei.
張北縣土木路恒升煤礦全景

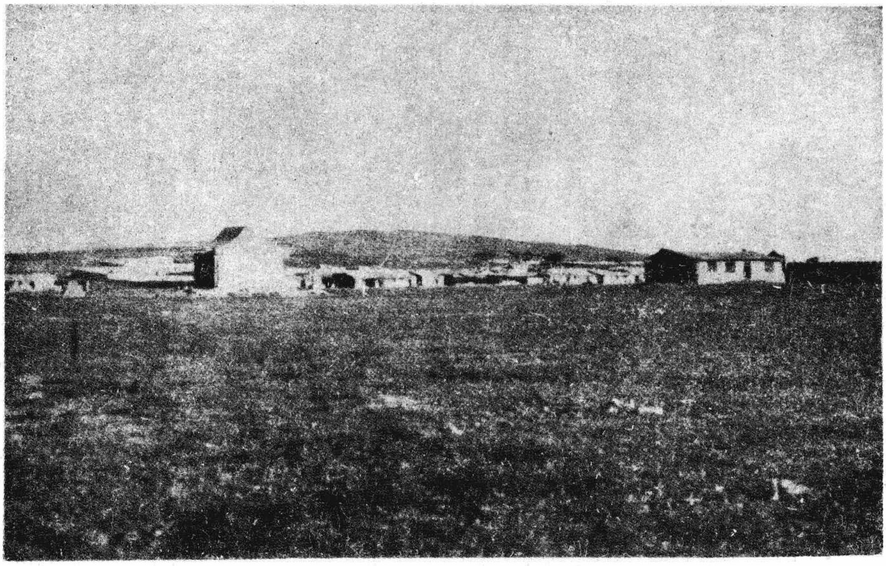


B. The columnar basalt capping U. Jurassic sandstone, Hsianaling, Changpei.
張北縣下納嶺玄武岩流覆于上侏羅紀砂岩之上



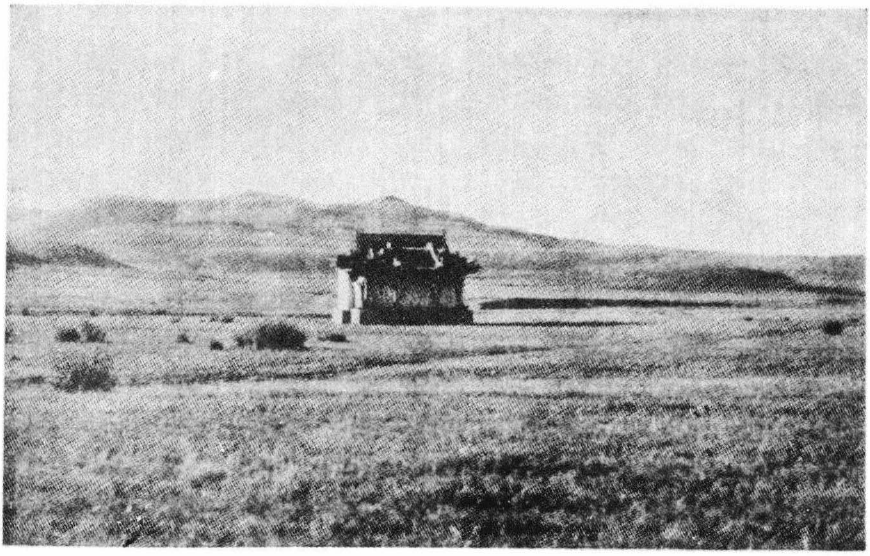
A. City of Hsinghohsien, standing on the basalt hill. The high mountain in right back ground is Hsiaotachingshan.

興和縣城全景其右後方之高嶺即所謂小大青山者是也



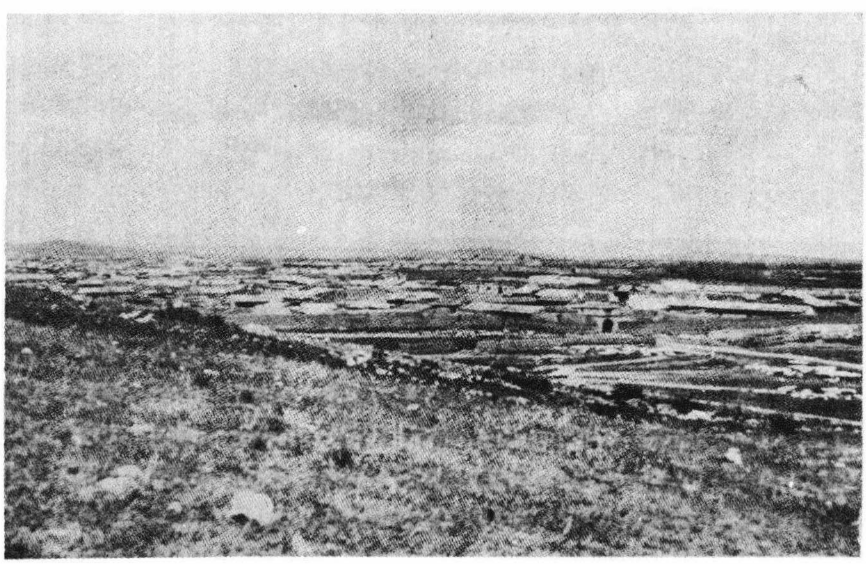
B. The shallow basin on the plateau of basalt, in the basin lying a famous town, Penhungchen 40 Km. N. of Chininghsien.

集寧縣北八十里之賁紅鎮



A. The low hills of the basalt margin of Huangchiyingtzŭ basin and the theatrical room, Hsingho.

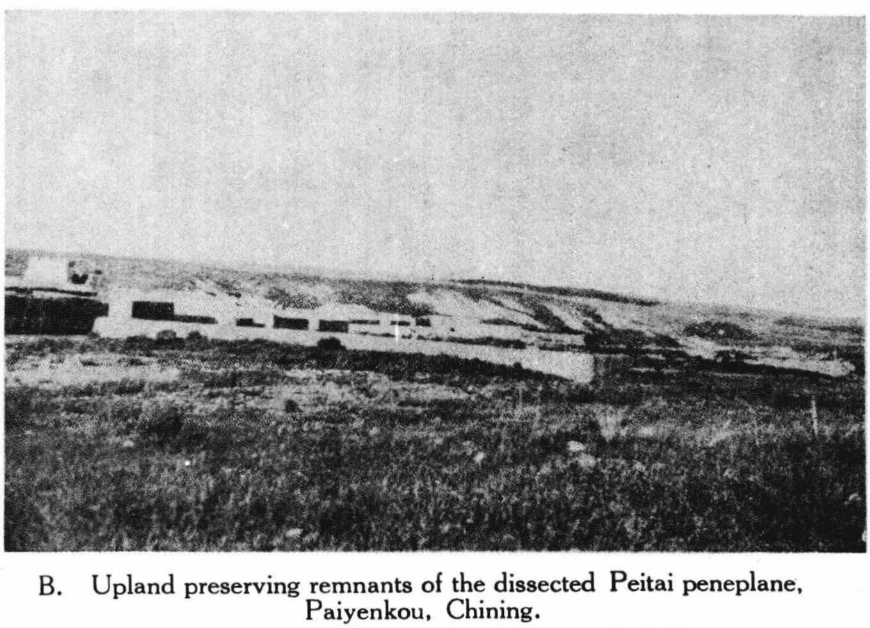
興和縣西黃旗營子平地一邊之玄武岩山嶺山前有極美觀之戲樓一座



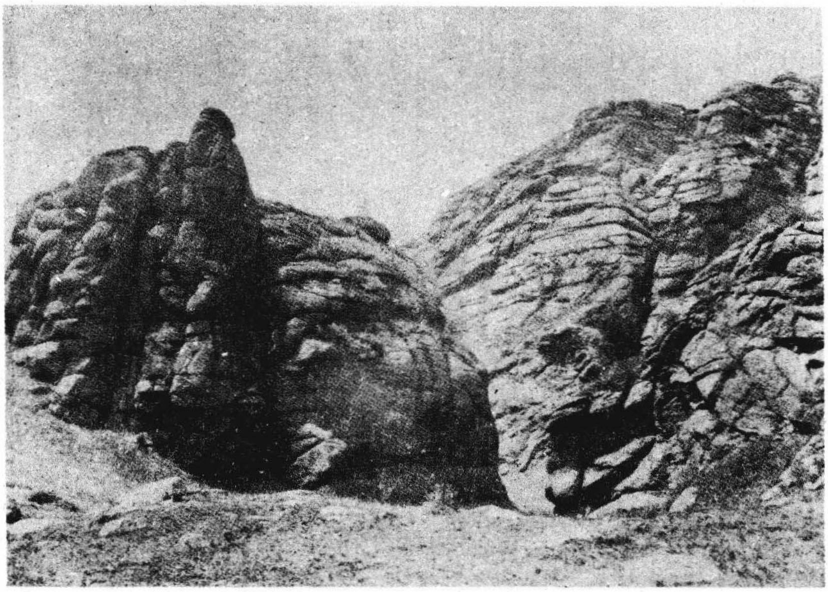
B. City of Chininghsien looking northwest, the high plateau in the back ground being composed of the basalt.

集寧縣全景其後方之山嶺爲玄武岩所組成

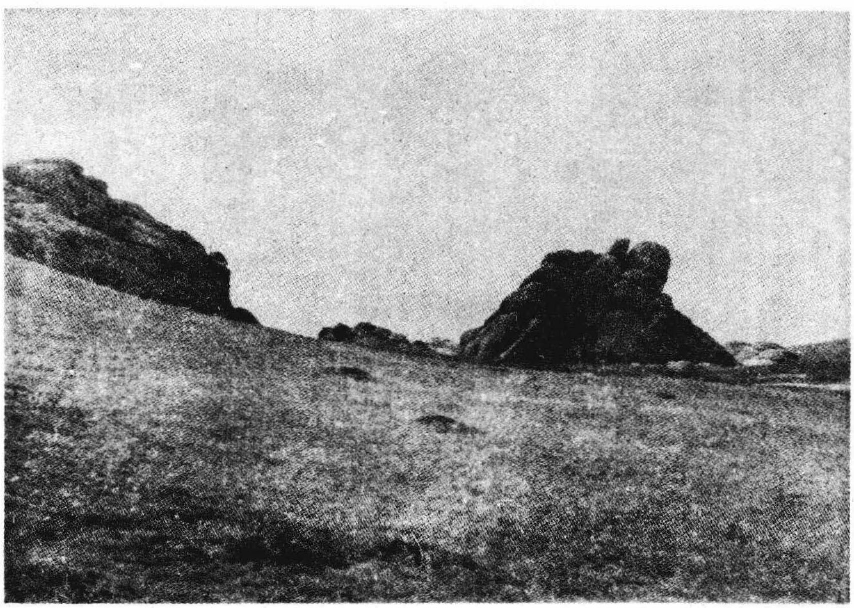
A. View looking north from edge of Hanchingpa towards its head, Chining.
集寧縣北漢慶壩山景



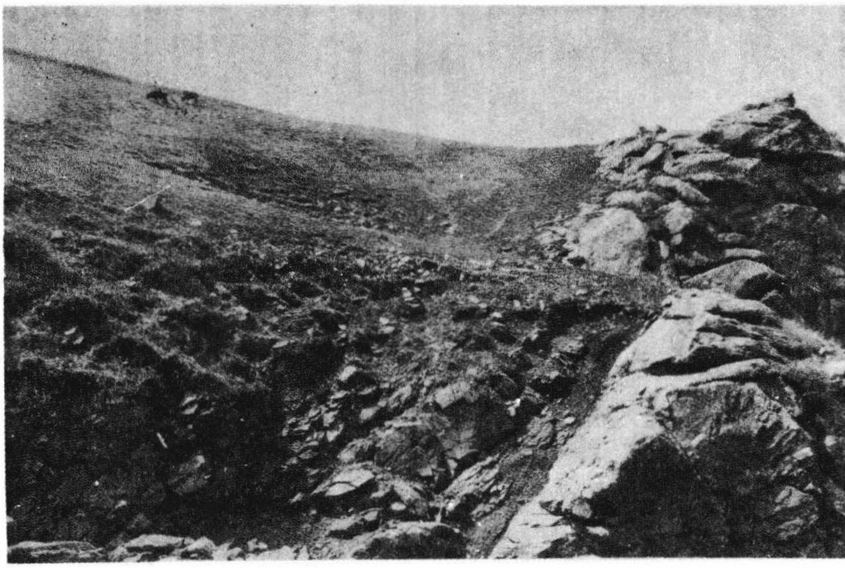
B. Upland preserving remnants of the dissected Peitai peneplane, Paiyenkou, Chining.
集寧縣白岩溝附近北台侵蝕平原一部之保留



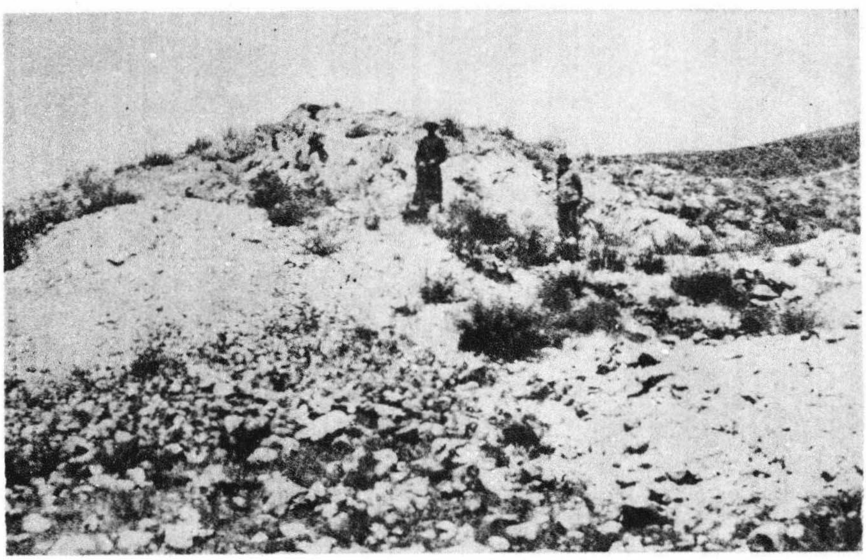
A. Cliff of granite in Tsungshengkou, Huanghuakotung, Taolin.
陶林黄花各洞葱盛溝內花崗岩所成之絕壁



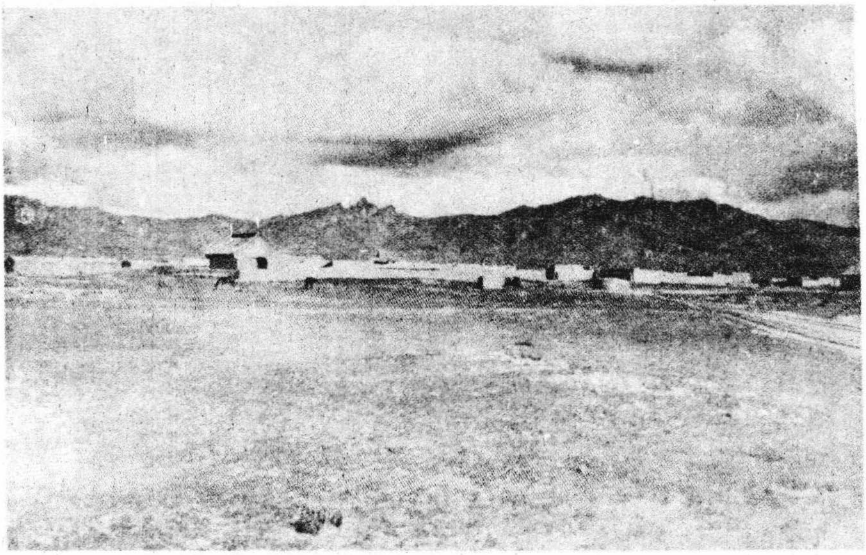
B. Vertical and horizontal joints in massive granite, Huanghuakotung.
黄花各洞花崗岩內之縱橫節理



A. Contact of Huanghuakotung Granite with Archæan gneiss, Taolin.
黃花各洞花崗岩與片麻岩接觸之情形

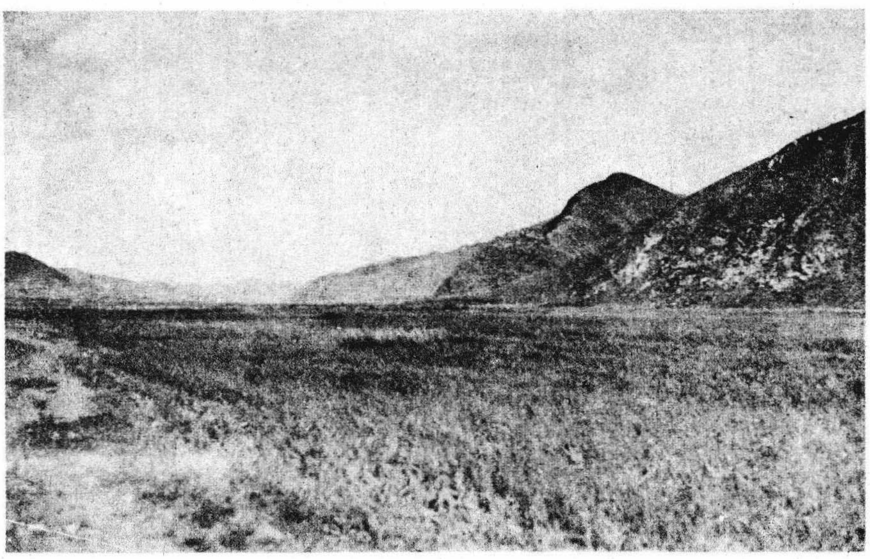


B. Pegmatite vein in gneiss, having been worked for the mica, Chaohsiukou, Chining.
集寧趙修溝附近偉晶花崗岩脉含大片雲母已經開採



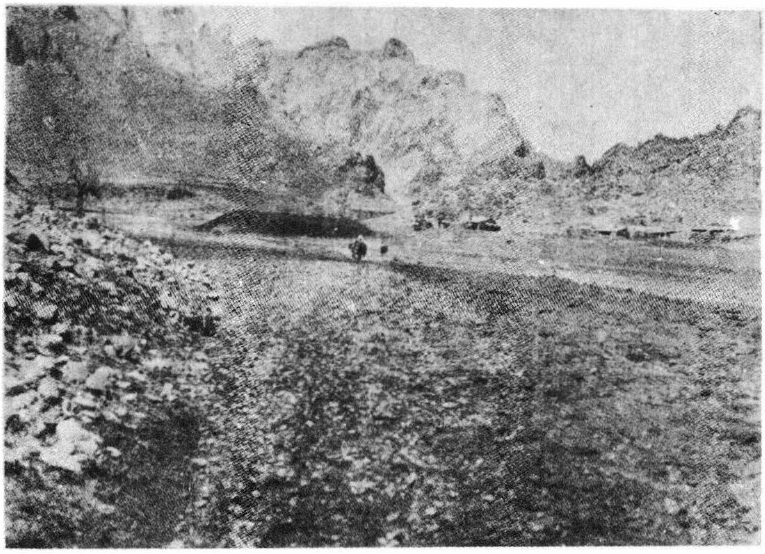
A. Pichiashan, a granite hill, as seen from Hofut'an valley, S. of Wulanhua, Wuchuan.

武川烏藍花南之筆架山

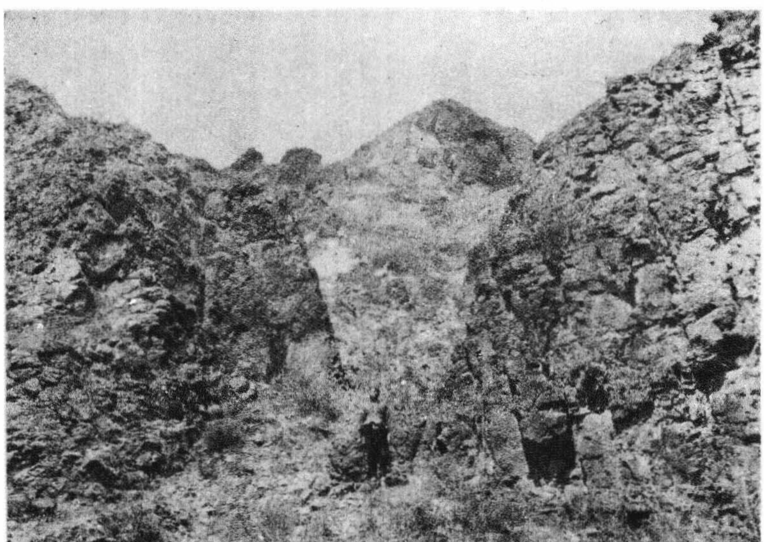


B. The ridge at the side of Sulituho valley is formed of Permo-Triassic sandstone and Archæan gneiss, in which the valley marks the position of a normal fault.

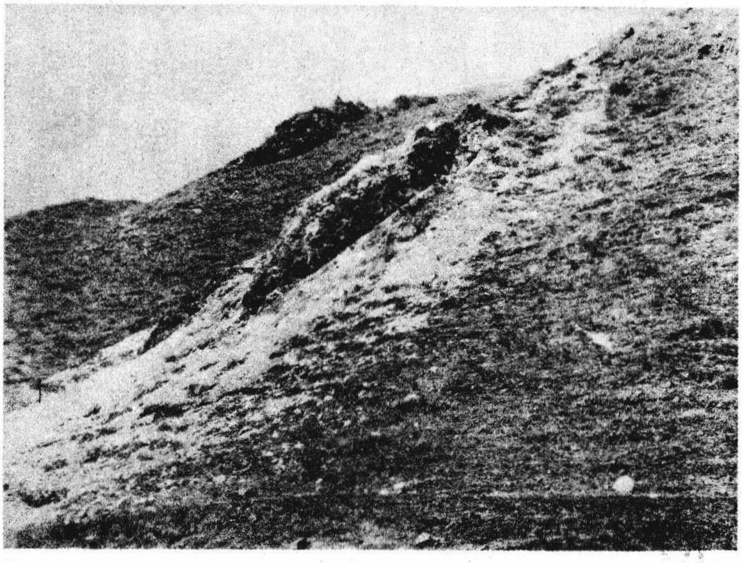
速力圖河一邊之高山爲二疊三疊紀砂岩及片麻岩組成
其中之小溝示斷層之位置



A. Marble hills near Pankou SW of Wuchuan.
武川西南半溝附近大理岩山景



B. Cliff of marble W. of Pankou, Wuchuan. In this picture the white point is an old pit for asbestos.
武川半溝西大理岩絕壁其上白色處爲石棉礦舊洞

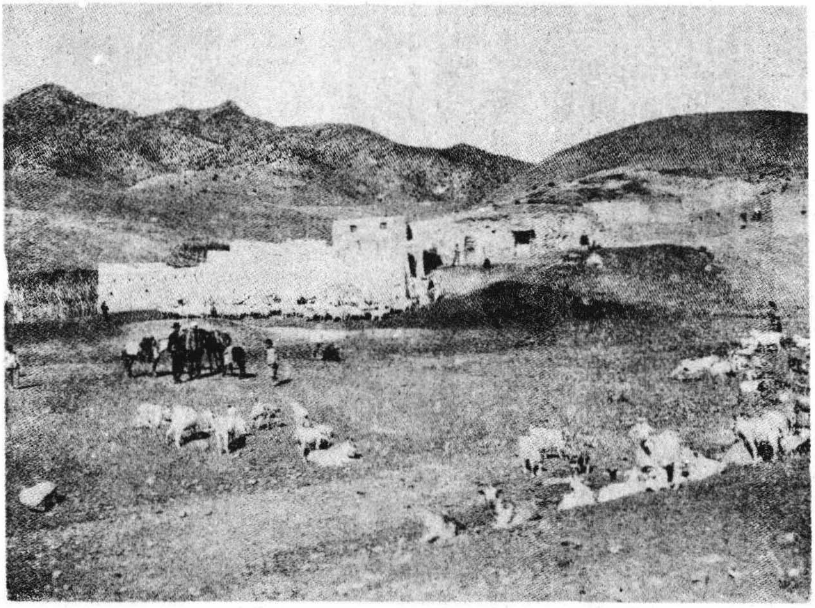


A. A large sheet of white marble yielding asbestos, completely wrapped by the granite, Luchouwan, Wuchuan.

武川六洲灣北花崗岩中之大理岩內產石棉

B. The old elm near Yushutientzŭ, Wuchuan.

武川楡樹店子附近之古楡(內蒙樹木稀少僅于武川境內見此大楡樹)

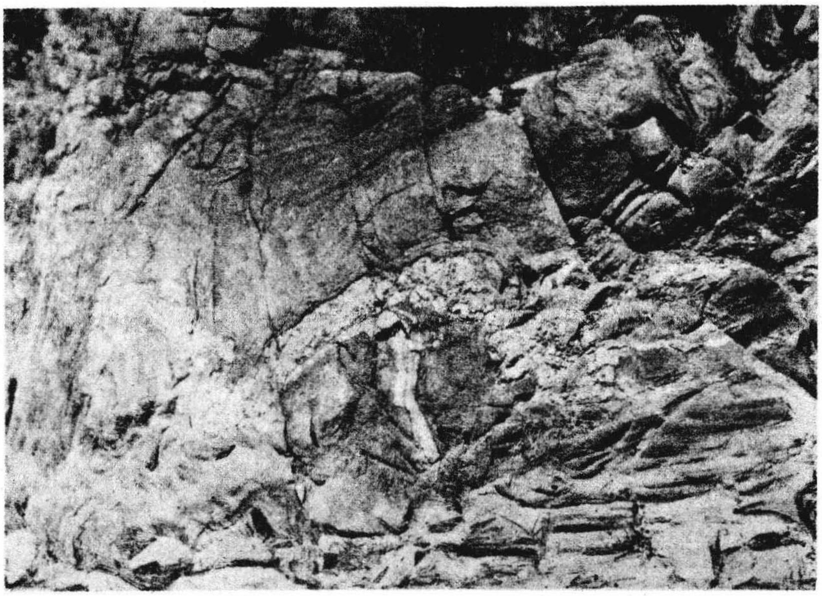


A. The Mongolian village (Shaopuhaitsun) lying on the slope of the gneiss hill, SE of Kuyanghsien.

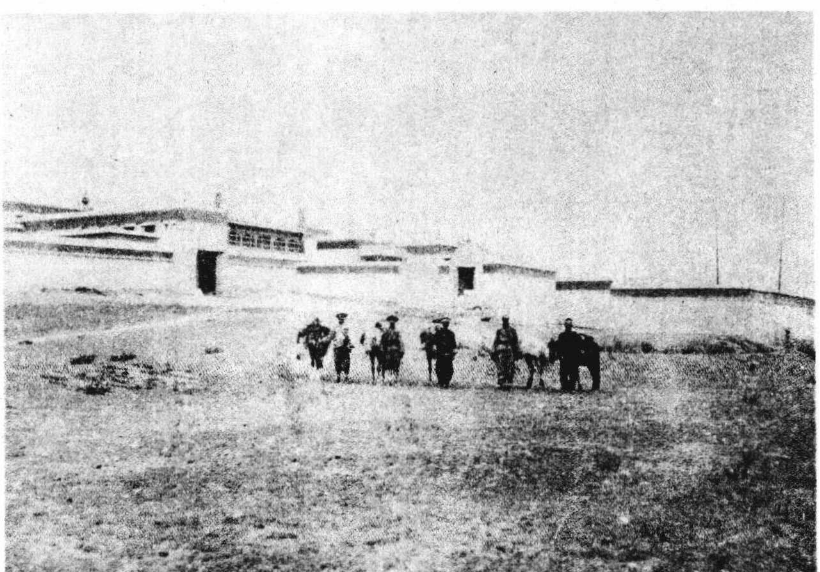
固陽縣東南邵不亥村該村多蒙人皆已漢化廢除包房改建瓦屋蒙古章京駐此

B. The upturned Jurassic strata in the uniclinal fold near Shihmen, N. of Salach'i.

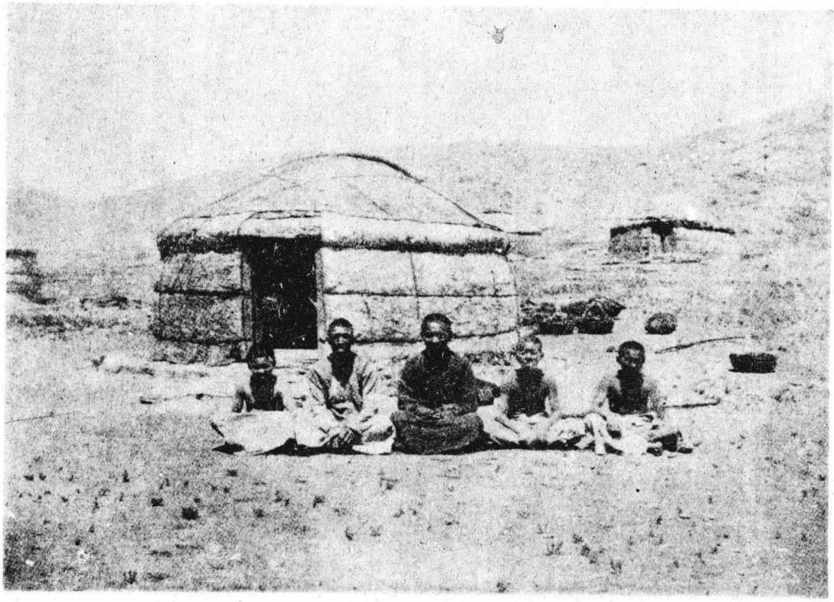
薩拉齊北石門附近侏羅紀地層之扭曲



A. The folded gneiss invaded by the pegmatite.
偉晶花崗岩脉侵入片麻岩內



B. The great temple (Kuntulunchao), N. W. of Paotou.
包頭縣西北崑都崙召（蒙人呼大廟日召）



A. Mongol Lamas sit in the front of their simple hut, in Koshaokou N. of Anpeihsien.

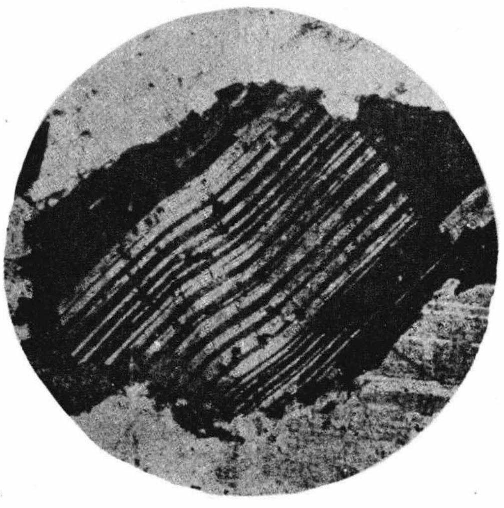
安北縣北葛紹溝內蒙古啦嘛及其包房

B. Hills of metamorphosed Permo-Carboniferous series and canyon of the Koshaokou valley in it, Anpei.

安北縣北葛紹溝兩旁二疊石岩紀變質岩所成之山形

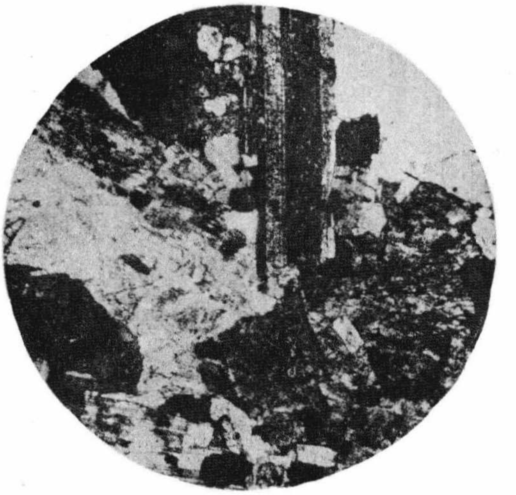
A. Arkosic gneiss — Rounded grains of colourless quartz suspended in felspar (very similar to Barbour's Arkosic injection gneiss in Kalgan Area); specimen from Sangkan system in Kuntulunho. × 32

B. Gneissic granite—mainly orthoclase, microcline, perthite, hornblende and quartz; specimen from Miaoërhkou. × 32 and N +



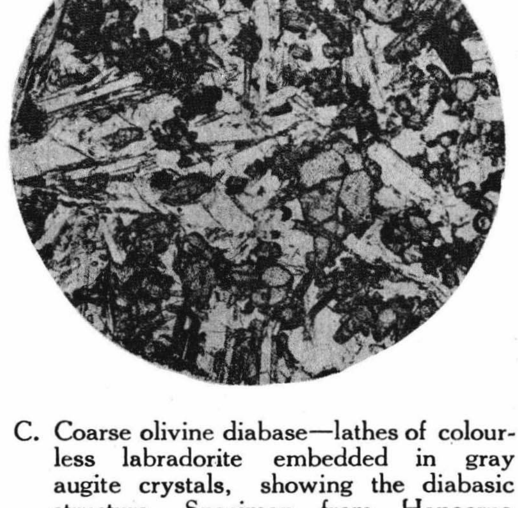
C. The lamellar twinning in plagioclase felspar in gneissic granite of Miaoërhkou, showing mechanical strain. × 45

D. Granite—Quartz filling the interstitial space between the orthoclase. Striated hornblende Specimen from Huanghuakotung. × 32 with crossed nicols.

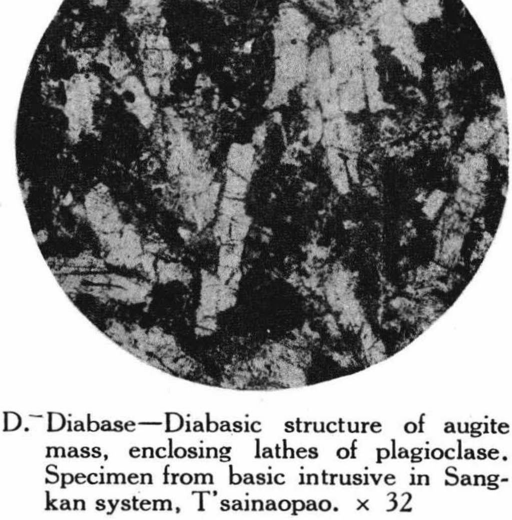


A. Granite—Graphic intergrowth of quartz with orthoclase. Oligoclase of twinning structure. Specimen from Huanghuakotung. × 32 with crossed nicols

B. Porphyritic olivine basalt (after Barbour): —Phenocrysts of andesine-labradorite with clear borders round cores crowded with inclusions, in a groundmass of plagioclase (lathes) augite and magnetite. The dark patches represent former olivine crystals now altered to serpentine and iron-oxide. Specimen from Hanoorpa region. × 25



C. Coarse olivine diabase—lathes of colourless labradorite embedded in gray augite crystals, showing the diabasic structure. Specimen from Hanoorpa formation near Huanghuakotung. × 32



D. Diabase—Diabasic structure of augite mass, enclosing lathes of plagioclase. Specimen from basic intrusive in Sangkan system, T'sainaopao. × 32