地質彙報第二十五號目次

福建廈門龍巖間地質鑛產簡報

侯德封　王曰倫　張兆瑾

一　緒言

民國二十二年秋本所應漳龍（漳州龍巖）鐵路籌備委員會之邀，封等奉派調查閩南地質鑛產，爰于九月十二日離所，事畢於十一月廿八日回平，實地工作凡兩閱月。

鼓浪嶼位於東經一一八度四分四秒，北緯二四度二六分四六秒。龍巖位東經一一七度二分，北緯二五度六分九秒。（根據Land Magnetic Observation Party of the Carneige Institution of Washington）計自廈門出發乘船約三公里至嵩嶼登岸。沿九龍江到龍溪縣（漳州），北折過浦南遇北溪，溯溪而上，經華安漳平兩縣治以抵龍巖，共山路約五百餘里。自龍岩東南行經適中，過兜嶺，沿西溪而下，過南靖以達漳州，有汽車路計二百餘里。華安漳平及漳平龍巖間勘查支線二，以永福鎮為中心，各約二百里　此外漳平東北至奇和百餘里，華安東北之洛陽鎮，龍巖週圍數十里，華安漳平縣城附近及廈門南北沿海一帶，均為調查區域

此行蒙漳龍鐵路籌備委員會黃奕住先生竭誠援助，俾得順利進行，深為感謝。

二　地形及交通

調查區域盡屬山地，東自海岸島嶼挺列，峯巒嶙峋，沿江西上如歷崇塔，直至龍巖永定間之博平嶺，為汀江（韓江上流）與九龍江之分水嶺，該嶺北與武夷仙霞相接。全區山密谷狹，甚少平地，稍足稱者，惟漳州四週之丘陵地，廣袤約四五十里，稻田菓園，尚稱富庶。次有龍巖及永福等地之寬谷，餘則坡堦陂臺，不足述矣。故全區山勢密集，直至海岸，海口如門依然聳壁，廈門南對岸之南太武山高聳達六百公尺勢未稍殺。

主要河流為九龍江亦名鷺江，閩省大川閩江而外此為第一。源分北西二支，會於龍溪東之江東橋。北支西北溯經華安，北至華口會溪南溪，西過漳平，北收九鵬薔溪諸水，南會赤望溪，西南溯至龍巖縣城又會西，西南，及南三源，全系大致瀠轉東南流

總名曰北溪。西支自江東橋西溯，經漳州至南靖有高山溪自西南平和來會，西北溯至保林有深渡溪自西北永福一帶來會，中支曰冷水溪，西北溯達永溪合溪一帶，與龍巖附近之北溪水系隔以分水嶺，即兜嶺。全系東南流，統名西溪亦稱龍溪。

全區山陡谷急，交通困難，自嵩嶼九龍江口溯北溪至浦南，沿西溪至南靖均可行舟、北溪浦南嶺兜間雖通水運，而灘流湍急，輕舟挽曳，日行僅二數十里，已感困難。華安至漳平，雁石至龍巖，水急石多，小舟往返益感不便。且沿江間段行舟，上下不能互通　西溪南靖之上僅可通水潮。

本區交通除船運之外，有漳嵩鐵路，惟嵩嶼江東橋段已舖路軌，前曾行車，現停廢已三載。嵩嶼至漳州，漳州至浦南，漳州至龍巖，龍巖至雁石，龍巖至小池均有汽車路現可通行，惟山勢峻急，頗為艱險，尤以漳龍段合溪適中間之分水嶺為最甚。此外交通惟賴人力，無牲畜輪車之便。

二　地層

此次調查區域內地層頗不完全，元古界及古生代下部地層幾全未見其露頭，中生代亦間有缺失，且常受花崗岩之侵入，致使地層變動過甚，層序上下時礙索尋　且除少數之下二疊紀外，餘多為陸相沉積，化石本甚稀少，因受變動之影響，以致保存欠佳，此次所搜集之化石數雖繁夥，而常難詳細鑑定，地層次序就探尋所及從事劃分，未敢盡以鄰區為準，而確與他區能互通者，則該系名目仍襲其舊，以易比較，玆將所見者列表如左

片麻岩	太古界（?）
南靖（五通）石英岩	石炭紀
棲霞系燧石灰岩	二疊紀下部
大羽植物煤系	二疊紀中部
翠屏山砂頁岩	二疊紀上部

洋坪頁岩	三疊紀？
白沙紅色砂礫岩	白堊紀下部
兜嶺火山岩	白堊紀上部
柳會社玄武岩	第三紀
紅土及礫石層	新第三紀
沙礫層	洪積統
冲積層	現代

太古界——片麻岩

片麻岩在調查區域曾在沿海一帶見之，（第二版地質圖）其露佈區域可分為二帶，一帶在廈門島之南海對岸，島美柳會社附近，向東北延長，經海中之吳嶼帽嶼烈嶼等小島，連接于金門大島，俱為片麻岩之分佈。岩石屬花崗片麻岩，在柳會社附近所見者，晶粒勻細色灰白，主要礦物為長石石英白雲母等，極少黑色礦物。片理清晰，走向略成東西，傾向南。在島美所見之片麻岩，晶地較粗，片麻構造頗清晰，暗綠色角閃石，常呈帶狀或眼球狀構造，其他礦物以石英長石為主，間有雲母，常有石英脈及輝綠岩脈等侵入其間，直接位於第三紀玄武岩之下，迤西至南太武山附近則為較新之巨體花崗岩所侵入。另一帶在嵩嶼之西，板尾石勤之間，亦有片麻岩大致作東北西南之分佈，片麻岩晶理勻細，與在柳會社所見相似。東面與中生代之頁岩成斷層接觸。西面在石礁附近，亦為花崗岩所冲斷而不見

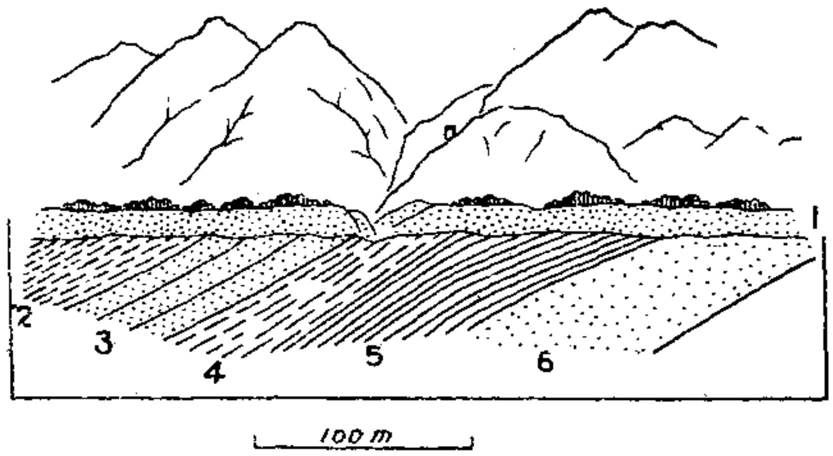
片麻岩與他地層之接觸　在柳會社有第三紀玄武岩不整合的覆於片麻岩之上。在南太武及石勤等處與花崗岩成侵入接觸，與嵩嶼以西之中生代頁岩約成斷層接觸。

石炭紀——南靖石英岩

本系地層在閩南露布甚廣，常爲花崗岩所侵入，深受變質，以其岩石性質上觀之，大體可分爲上中下三部。

下部以厚層石英岩爲主，間夾少量頁岩。石英岩多呈白色及肉灰色，堅硬密緻，閩南之懸崖峭壁，高山狹谷，常爲此等岩石露佈之處。北溪浦南以北，西溪南靖以上爲主要分佈區。嶺兜華安間，此石英岩變質特甚，成千枚岩，質理堅細，常呈美觀。厚度約有三百公尺。

中部則以頁岩，片岩及變質之粘土石及石英岩相間成層，而以粘土石，板頁岩爲最著，多呈紅棕色，間有灰綠黃等色。厚約二百餘公尺，分佈區如北溪之沙闕附近，永福龍巖間之水尾西山，爲最顯著。



第一圖 第三紀：1,泥土礫石及白色鬆砂岩含碎介殼
南靖系：2,黃白色至棕色砂質粘土及頁岩
3,黃白色石英砂岩 4,灰色粘土夾塊狀石英砂岩
5,粘土石 6,石英岩

Fig. 1. Section of Shakuan, north of Lungchi.
Tertiary: 1. Clay, gravel and white loose sandstone with shells of Oystrea.
Nanching Series: 2. Yellowish white and purple sandy shale. 3. Yellowish white quartzite. 4. Gray clay and massive quartz-sandstone. 5. Green and gray claystone. 6. Massive quartzite.

上部爲灰色及黑色砂頁岩，炭質頁岩與石英砂岩相間成層，其底部有時有潔白色石英礫岩一層，在水尾之西嶺，峰脊相連極爲顯著，龍巖龍門之筆尖山，高劍大雲亦具特觀，此部總厚亦不下二百公尺

南靖石英岩系之分佈 龍溪平原以西高山突起首爲此系地層之露佈，（第二版）在北溪露於潭口至吳田口之間，在西溪露於南靖至龍山之間，各成一大向斜層，兩端俱爲花崗岩所侵入，中間大致傾斜平緩，而作成種種小褶皺，潭口至馬其間多爲厚層石英岩，呈紅棕顏色，變質甚烈，頁岩頗少，馬其沙闕間已爲中部岩層，漸變複雜，變質之頁岩及粘土，則較多於石英岩矣，如第一圖。

華安東南石英岩被花崗岩衝擠於高山之頂部，變質極深。華安以北之西陂，沿北溪以至漳平之華口，俱爲該系地層露頭，形成一大背斜層，中間屢爲花岡岩所衝斷，北溪兩岸之懸崖危壁，多爲此系下部之石英岩構成，其中上兩部，在華口附近亦變質頗深，而成爲片岩板岩及石英岩等。

龍巖境內南靖系亦分佈甚廣。（第一版）縣治之北，雁石，大吉一帶之筆架山，高聳雲際，海拔千餘公尺，盡爲該系地層。城西二十里之紫金山，海拔千餘公尺亦爲南靖系上部地層構成，其上部地層之底，有石英礫岩，在此處厚約四十餘公尺，色潔白，礫塊盡爲石英，形圓或橢圓，大小不一，最大者徑可十餘公分，石基亦爲潔白色石英質，膠結堅固，不易受侵蝕，故時成極峰銳脊。

龍巖城東在水尾西嶺及燒灰隔間，石英岩系上部，直位於二疊紀燧石灰岩之下，底部礫岩亦極發育，色潔白爲形狀不定之石英礫膠結而成，礫大者如胡桃，岩質堅硬，蔓延連接組成一帶嶺脊，嶺頭一望，其分佈固歷歷可尋也。此礫岩之下，爲紅棕色粘土頁岩，及黃綠色片岩砂岩等，爲南靖系中部地層，其下與花崗岩成侵入接觸。南靖系下部厚石英岩此處付諸缺如。茲將中上兩部剖面（水尾至燒灰隔）大致列左：

侵入花崗岩

灰色砂岩板岩間互層	三十公尺	南靖系中部
紫色砂岩，厚層紅黃色粘土岩及片岩	八十公尺	
紫色薄片頁岩綠色頁岩棕色砂岩間互層	五十公尺	
灰色及綠色片岩夾薄層石英岩	三十公尺	
綠色雲母片岩，晶片燦爛與板岩互生	二十公尺	
灰黃色硬砂岩灰色片岩及綠色片岩	二十公尺	

純白色堅硬石英礫岩	二十公尺	南靖系上部
灰黃色堅硬石英砂岩	一百公尺以上	
灰色頁岩；粘土層及炭質頁岩	五十公尺	

燧石石灰岩

龍巖城附近，南靖系露頭亦甚廣，展轉曲折，多屬於該系頂部岩層，大部爲石英砂岩，棕色灰色砂質頁岩，泥土質砂頁岩及富含白雲母之變質砂岩等。石英砂岩內常見褐鐵礦斑點，有時成赤鐵礦結核，或成薄層狀，成侵蝕後之殘餘礦床。又此部地層岩隙中多水晶結晶，大小整缺不一，有時成徑二四公分之完好結晶體。

龍巖東南九州和溪間，石英砂岩成薄層，色灰綠，頗發育 新祠孟頭間，南靖系上部直覆於二疊紀燧石灰岩之下，爲薄層之石英砂岩與灰黑綠等色之頁岩，相間成層。

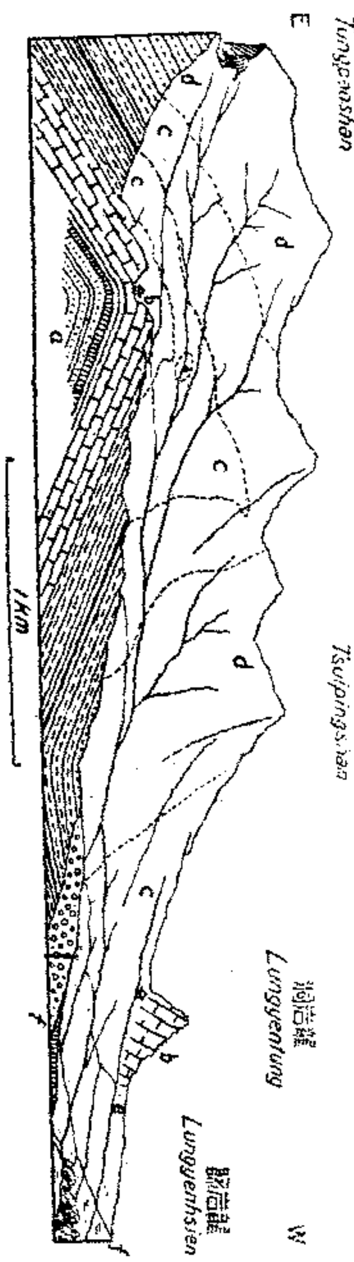
石英岩之時代 至於本系地層之時代，則尚難確定，因其露頭雖廣，而終未採得化石，其下又概未發見任何地層，因常受花崗岩侵入之影響，而與花崗岩成火成岩接觸。其上部則有時直伏於二疊紀石灰岩之下。若按其岩石性質及地層位置，以與中南各省相較，則似與譚壽田君江西之進賢層（此處無煤層），劉季人君浙江西部千里崗砂岩，及南京附近之五通系，不無相當之處。但南京附近之五通系爲下石炭紀之下部，在閩南則石英岩以上，二疊紀石灰岩以下，統未見海相之石灰岩，故不得不另立新名，統歸之於石炭紀。王紹文君閩西地質報告實與本區相隣接，王君之安沙石英岩與本系上部實爲一物，其牛尾嶺砂岩當爲本系之中部，其羊牯卵，羅峰溪，溪口層等系約當於本系之下部也。

二疊紀下部——棲霞燧石石灰岩

燧石灰岩常直位於石英岩系之頂，呈不整一接觸。露頭之處雖多，而零星不連續。厚自數公尺以至一百餘公尺不等 岩石質純性脆，普通層甚厚，時亦呈薄層狀。下部灰色，上部暗黑，燧石結核常散見各層，又常含石墨屑。方解石脈往往甚顯著，多透

明方解石結晶體、按岩石性質與他省所見二疊紀下部石灰岩完全相同、如蘇之棲霞（狹義的棲霞系）鄂之陽新，浙之飛來峰，…等是

龍巖附近之棲霞燧石灰岩　一自城北鐵石洋起，在北溪之東岸，向南延長以至東寶山之半腰，直覆於二疊紀煤系之下（第二



第二圖　a 南靖石英岩　b 棲霞燧石灰岩　c 大羽植物煤系　d 翠屏山頁岩　e 洪積統礫石及紅土

Fig. 2. Section of Tungpaoshan on the east of Lungyen.

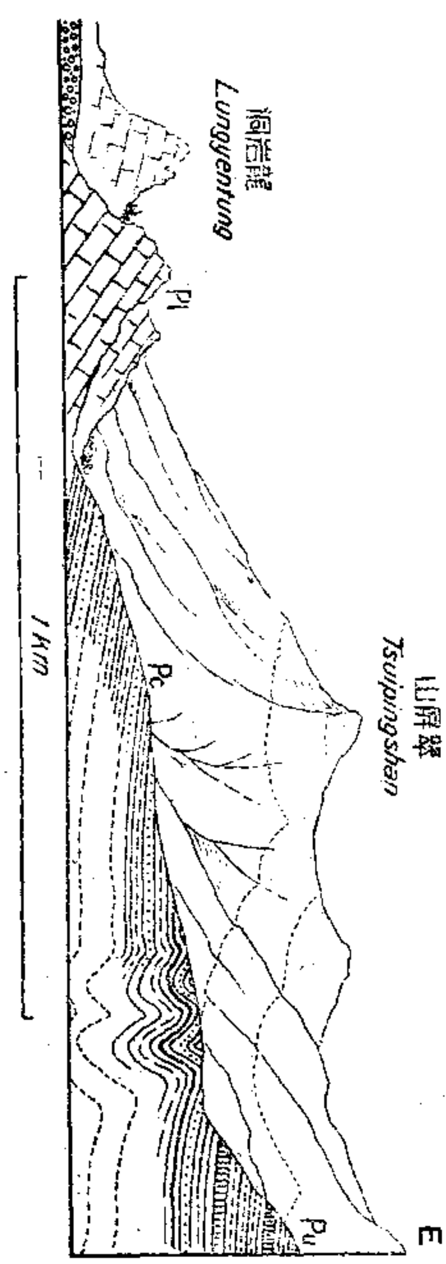
a. Nanching quartzite. b. Chihsia cherty limestone. c. Gigantopteris coal series.

d. Tsuipingshan shale. e. Pleistocene gravel and clay.

圖），其中間時有間斷，或為地相 Facies 變遷所致。在東寶山西坡之臥雲樓附近露出最厚。傾角向東平均五，六十度　下部為厚層結晶石灰岩，色淡灰，富含石墨層。中部為薄層狀燧石結核極多，排列成行，岩石色淡灰，富含砂粒，故質粗而鬆軟，上部為薄層黑灰色石灰岩，含方解石細脈，質純性脆時成立壁。總厚在一百五十公尺左右。

龍岩洞，在龍巖縣東門外一千七百公尺之處，有兩小山並列於龍巖平原之邊際，其岩石俱為燧石灰岩，大致傾向東作二十度

傾角，位於東山大羽植物煤系之下（第三圖）石灰岩共厚約一百五十公尺，下部爲灰色厚層石灰岩，上部顏色較黑，層亦漸薄，含海百合莖化石。有石灰窰數處，工作於此。龍岩城西二里，河之北岸亦有燧石灰岩露於河邊者，岩石色作灰黑色，爲含矽質之簿層，亦間含燧石及方解石　龍巖城西二十五里小池村東，煤系下之石灰岩，大部俱爲厚層，作灰黑色，與花崗岩接觸處，深



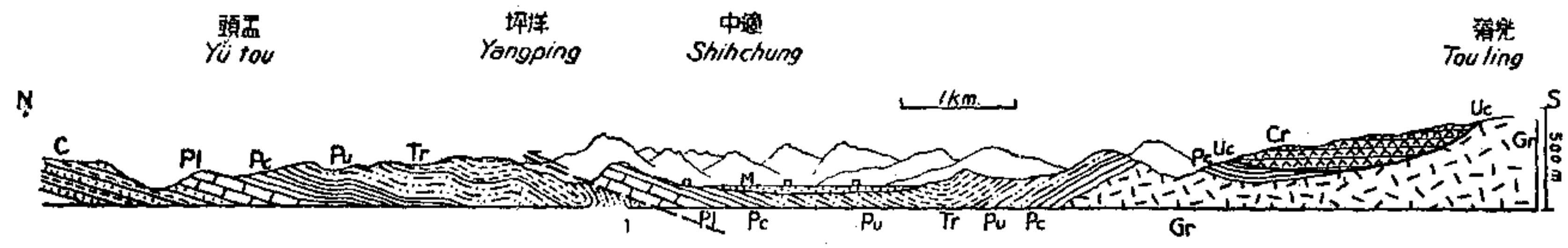
第三圖　Pl 棲霞燧石灰岩　Pc 大羽植物煤系　Pu 翠屏山頁岩

Fig. 3. Section of the coal measure on the eastern hill of Lungyen.

Pl. Chihsia limestone Pc. Gigantopteris coal series. Pu. Tsuipngshan shale.

受變質，於石灰岩層內又見輝綠岩之侵入體。他如漳平西南十五公里洪高山，龍巖東之燒灰隔及龍巖東南新祠適中兩處，亦各有石灰岩之露頭，厚度皆不足百公尺，或僅數公尺，在適中之西燧石灰岩位於二疊紀頁岩之上，爲逆掩斷層之接觸。（第四圖）

閩南燧石灰岩內化石極少，在龍巖之蘇邦，僅採得一腹足類化石，經尹君建猷鑑定爲（Straparollus）。龍岩洞僅見海百合莖及保存不佳之蜓科化石，在新祠於石灰岩之風化面上見類似蜓科之化石甚多，而製片後在顯微鏡下觀察，則因受變質，多成方解石斑點，生物組織狀態模糊不清。據日人報告稱龍岩洞石灰岩中含紡錘蟲化石。



第四圖　C 南靖石英岩　Pl 棲霞石灰岩　Pc 大羽植物煤系　Pu 翠屏山頁岩　Tr 洋坪頁岩
Gr 花崗岩　Cr 兜嶺火山岩　M 冲積層　Uc 不整合

Fig. 4.　Section of Shichung, south of Lungyen.

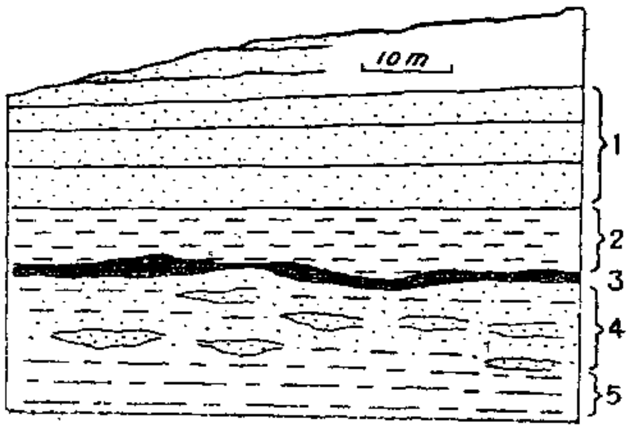
Pl. Chihsia cherty limestone. Pc. Gigantopteri[illegible] coal series. Pu. Tsuipingshan shale. C. Nanching quartzite. Tr. Yangping shale. Gr. Granite. Cr. Tou[illegible] volcanic rocks. M. Alluvium. Uc. Unconformity.

二疊紀中部——大羽植物煤系．

棲霞燧石灰岩以上之煤系，我國南部各省在多有之，於是立名甚多，有樂平，宜陘，龍潭，禮賢，未把口及老虎山等名稱，實則爲同一時代之煤系，不過岩層沉積之相，各處小有差異耳。顧各處煤系多有大羽植物化石，足證其時代。此次閩南調查在龍巖一帶，遇此煤系之處甚多，且亦有數處，採得大羽植物化石，故以其化石而名其煤系

該煤系在龍巖一帶甚爲發達，所含岩層以頁岩及砂岩爲主，全無海相之石灰岩，內含煤僅一層，厚半公尺至一．六公尺，又因各處沉積之現象不同，岩層性質常致隨地而異，有時雖有煤系，而無煤層，且煤層在同一煤田內亦往往現不規則之狀態。（第五圖）

龍巖城東北蘇邦，大吉，葛藤圩一帶煤系之露頭甚多，各有煤窰開採，在葛藤圩煤層上之黑色頁岩內，採有植物化石，經斯



第五圖　1,鐵質石英砂岩 2,黑色頁岩 3,煤層 4,砂質頁岩及扁豆體砂岩 5,灰白色粘土

Fig. 5. A section showing the irregularity of ahe coal seam.

1. Ferruginous quartzose sandstone. 2. Black shale. 3. Coal seam. 4. Sandy shale and lenses of sandstone. 5. Grayish white clay.

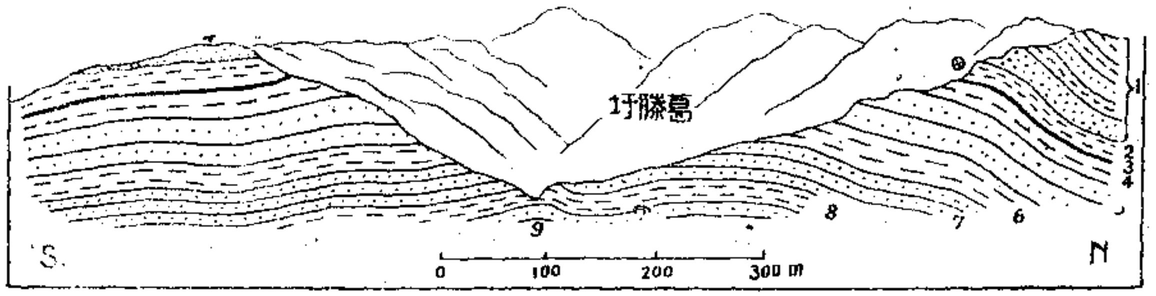
行健君鑑定為 Gigantopteris nicotianaofolia Shenk 及 Sphenophyllum thonii Maler 其地層次序大致如下。厚度以公尺計(參閱第六圖)

一、相間成層之頁岩及砂岩	八〇・〇
二、含大羽植物之黑色頁岩	五・〇
三、煤層	一・六
四、砂質頁岩及粘土	五・〇
五、黃紅色石英砂岩	四〇・〇
六、紫色及灰色頁岩	三〇・〇
七、含鐵質之石英砂岩	四〇・〇
八、變質之黑色頁岩	二五・〇
九、石英砂岩	

白沙之南二里於煤窰內挖出之黑色頁岩內，亦採得大羽植物化石，與在葛藤圩所採者無異。其含煤之頁岩以上為較厚之石英砂岩，不整合的伏於白堊紀之礫岩及砂岩之下。(第七圖)

龍巖城附近煤系露頭最完全，東山之腰部俱為其地層之分佈，北起鐵石洋南經東寶山至翠屏山之東，為一背斜，中間石灰岩露出，兩翼俱為煤系(第二圖)厚約二百五十公尺。龍岩洞之東，煤系露頭甚廣，煤窰林立，地層大致煤層以下為棕紅色及綠黃色之頁岩，與薄層砂岩，中部多為黑色頁岩，夾厚一公尺半之煤層一　上部以砂岩為主，夾少量之頁岩。全層厚亦二百五十公尺(第三圖)其構造稍為複雜，小褶曲甚多，大致為一向斜層

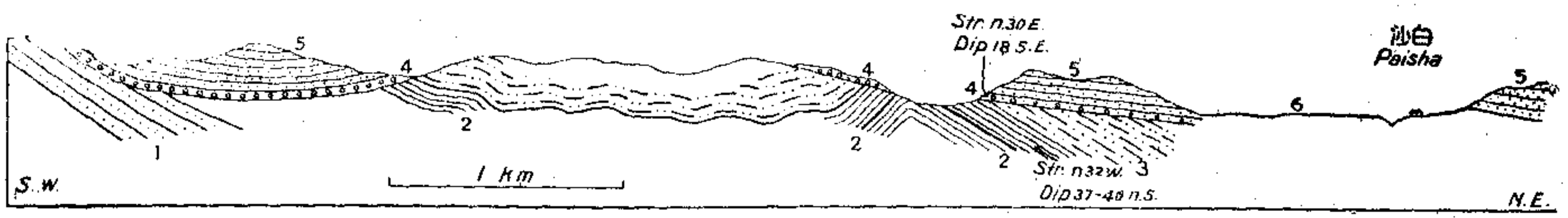
龍巖城西十里，龍門墟附近煤系露於村東南之山坡上，有煤窰數座煤層厚約一公尺，夾於黑色頁岩內，亦有植物化石，而多



第六圖　1，頁岩及砂岩　2，黑頁岩含大羽植物　3，煤層　4，砂質頁岩及粘土　5，黃紅色石英砂岩　6，紫色頁岩　7，鐵質石英砂岩　8，黑頁岩　9，石英砂岩

Fig. 6. Section of Kotengyu coal measure.

1. Shale and sandstone. 2. Black shale with Gigantopteris. 3. Coal seam. 4. Sandy shale and clay. 5. Yellowish red quartz sandstone. 6. Purple shale. 7. Ferruginous quartzose sandstone. 8. Black shale. 9. Quartz sandstone.

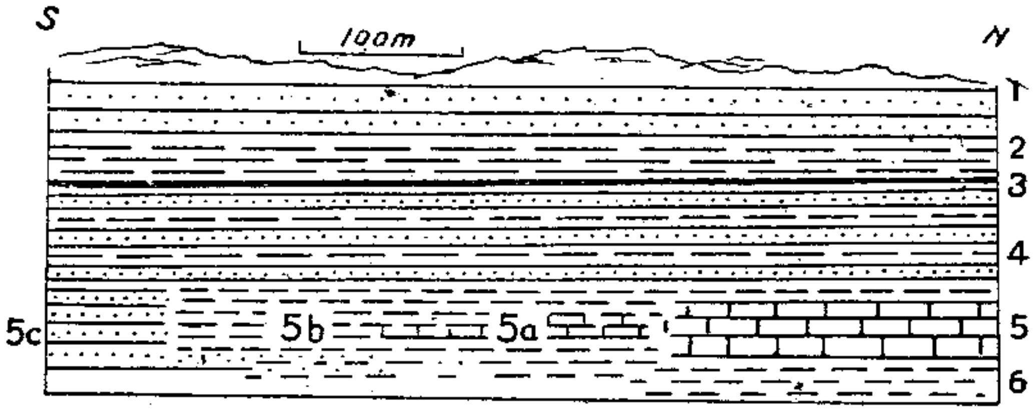


第七圖　1，南靖石英岩　2，大羽植物煤系　3，翠屏山頁岩　4，白堊紀底部礫岩　5，白沙紅色砂岩　6，冲積層

Fig. 7. Section at Paisha showing the unconformity at the bottom of Cretaceous

1. Nanching quartzite. 2. Gigantopteris coal series. 3. Tsuipingshan shale. 4. Basal conglomerate of Cretaceous. 5. Paisha red sandstone. 6. Alluvium.

不完好，難鑒定。煤層上爲砂岩與灰色頁岩相間成層，向東南東作四十餘度之傾角，煤系以上爲翠屏山頁岩，而其下則直覆於南靖石英岩之上，二疊紀燧石灰岩則於此缺如。



第八圖　1,砂岩　2,黑色頁岩含大羽植物　3,煤層　4,紅棕色頁岩及砂岩　5a,黑色燧石石灰岩　5b,砂質頁岩　5c,石英砂岩　6,黑色頁岩含淡水介殼化石

Fig. 8. Section showing the change in facies of the Chinsia limestone.

1. Sandstone. 2. Black shale with Gigantopteris. 3. Coal seam. 4. Purple shale and sandstone. 5a. Black cherty limestone. 5b. Sandy shale. 5c. Quartz sandstone. 6. Black shale with fresh water shells.

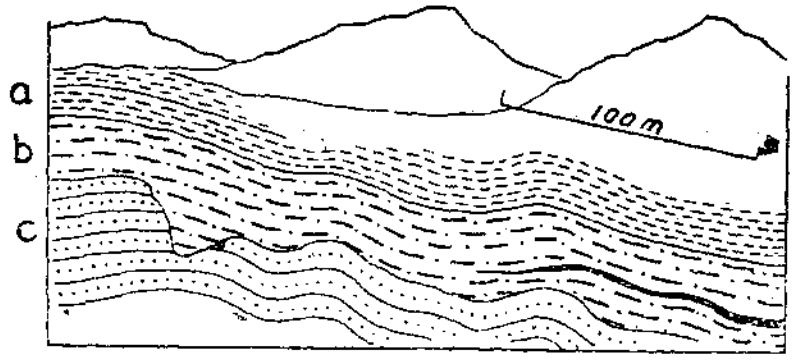
龍巖城與龍門墟間之外洋附近，在河邊見煤系直覆於石灰岩上，雖無人採煤，而與東山爲同一煤系，向西南延長可與城南二十餘里龔邦附近之煤系相聯，與龍門墟之煤系組成一向斜層。煤系以上之翠屏山頁岩內於東山及龍門墟一帶採得化石頗多，經鑑定仍爲二疊紀，俟後詳論之。日本野田勢次郎於支那地學調查報告內，將龍巖東山之煤系作爲下部帶，歸之於二疊石炭紀，龍門墟之煤系作爲上部帶，歸於二疊三疊紀內，實則同爲大羽植物煤系，是一而二，二而一也。

華安附近亦有煤系露頭，其主要岩石爲砂岩頁岩片岩及石英岩等，煤系以下未見燧石灰岩。在城西十五里之處，及綿良社西各有失敗之老煤硐，有厚約五公尺之黑色頁岩，夾煤一層厚五十六公分，已深受變質而成不純之石墨，煤層以上之砂岩及頁岩內曾採得瓣鰓類之化石，惜保存不佳，無法鑑定，大約仍爲二疊紀之物，與龍巖所見者爲同一煤系也

他如漳平之洪高山，龍巖之燒灰隔，和溪及適中之西，常見煤系之露頭，但煤層極薄，又往往有煤系而全無煤層，以是知大羽植物煤系煤層最發達之區，厥在龍巖附近，爲南北延長較遠，東西較窄之煤

田。

大羽植物煤系以前之不連續及地相之變遷　二疊紀以下閩南僅有陸相沉積，至二疊紀始僅見棲霞石灰岩，其露頭又頗零碎，時有時無，厚薄不一，其原因大概有二：(一)爲海陸相之變遷。(二)爲大羽植物煤系及棲霞石灰岩間之不連續 (Disconformity)。如圖八，爲在龍巖東北五十里蘇邦村北之路旁沿地層走向所見之剖面，大羽植物煤系下有含燧石之黑色石灰岩，厚四十餘公尺，但沿走向索尋，至不遠之處，則石灰岩漸次消失，而代以含砂質之薄層石灰岩及頁岩，再漸遠則盡爲頁岩及石英砂岩而無石灰岩之痕跡，（第八圖）以是知此種石灰岩爲淺海或海邊不穩定之海水沉積，海陸相之變更甚爲急劇。龍巖至漳州之汽車路上，九洲和溪間，於修路時所削之剖面見南靖石英岩直伏於大羽植物煤系之下，其接觸處爲一高低不平之面，且煤系之底部亦現不整齊之狀態，（第九圖）棲霞石灰岩則全付缺如，足証二者爲不連續之接觸。閩南棲霞石灰岩，普通僅厚數十公尺，本身又時有變相爲砂岩及頁岩之處，若先被侵蝕，而後始爲煤系掩覆，宜其時有時無厚薄不一，爲頗難摸索之狀也。



第九圖 a,翠屏山頁岩　b,二疊紀煤系　c,南靖石英岩

Fig. 9.　A section at the south of Hochi showing he disconformity.
a. Tsuipingshan shale. b. Permian coal series.
c. Nanching quartzite.

二疊紀上部——翠屏山砂頁岩系

直接覆於大羽植物煤系以上者爲翠屏山頁岩系，兩者成整合狀態。以在龍巖城東翠屏山露頭甚完全故名。以頁岩爲主，砂岩次之，頁岩多呈綠色灰色及黃棕等色，上部則薄層石英砂岩漸多，頁岩次之，有時亦因變質而有片岩及板岩等。總厚可至二百五十公尺，其化石多積聚於下部，爲淺水之沉積物，有時爲海水動物羣，有時爲淡水動物羣，間亦有植物化石，其海陸相變遷之急

劇，可想而知。化石保存不佳，經尹建猷君鑒定大致仍屬上二疊紀之物。

在翠屏山於該系底部紅色頁岩內採得（FC）. Gastrioceras sp. 於稍上之綠色及灰色頁岩內得（F65）. Gastrochaena (?) Anthracomya cff. laevis Dawson 及 Fish spine 與 Ganoid scale 等。又於同層內採得植物化石，經斯行健君鑒定爲 Labatannularia lingulatus Halle 及不能鑒定之破碎枝葉甚多

在白沙之南（圖七）大泐植物煤系以上之綠色灰色及棕色頁岩內得（F59） Gastrioceras 2 sp. Productus gratiosus Waagen. 及不能鑒定之 Arcidae 甚多。

龍巖城西龍門墟煤礦之上綠黃色頁岩內採得（F72）Pelecypod resembling Solenomorpha,（F73） Brachiopod resembling O rthotetes 及 Nautiloid gen. et sp. ind

又在小池煤系以上之黑色及灰色頁岩內採得破碎之化石，大致爲（F80）. Agathiceras (?) Gastrioceras sp. Ammonoid gen. et sp. ind. Brachiopod resembling Orthotetes. Placunopsis sp. 又瓣鰓類及腹足類甚多，苦難鑒定。

又在龍巖東二十餘里之毛嶺峽附近，於翠屏山頁岩內採得（Fc6）Schizodus (?) 及 Pectinidae gen. et sp. ind.

三疊紀？——洋坪頁岩

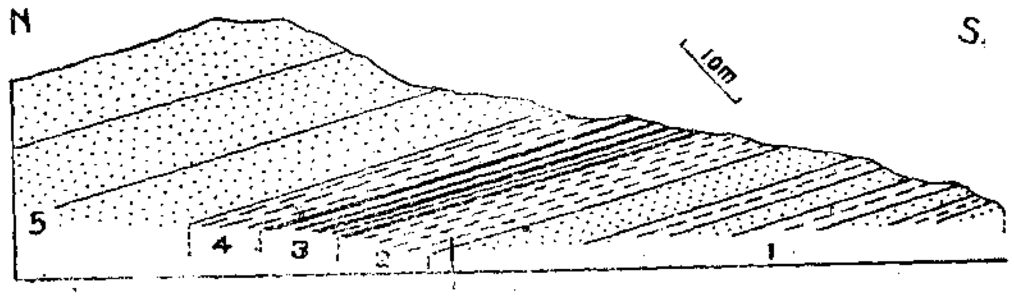
洋坪頁岩系主要岩石爲赭黃，棕，紅及灰綠等色之頁岩夾薄層砂岩，頁岩有時略含鈣質。在適中西洋坪，頗爲發達，厚約一百八十公尺，直接覆於翠屏山頁岩之上，中無間隙可尋，在洋坪村於灰綠色頁岩內發見海水瓣鰓類化石甚多，而皆不易鑒定，大約爲 Anoplophora （？）屬三疊紀，又適中之東於此系頁岩內亦採有同樣之化石，及破碎植物化石，所見厚度約一百七，八十公尺

在嵩嶼海岸西五里許，有變質黑灰色頁岩及石英岩粘土層等，被石英斑岩侵入，厚度僅三四十公尺含不清晰之中生代化石如 Pterophyllum, Ptenis 等，茲亦暫屬於此

白堊紀下部——白沙紅砂岩及頁岩

本系地層最發育於龍巖漳平間之白沙村附近。主要岩石爲赤色砂岩頁岩及礫岩等，砂岩有時亦呈黃灰綠等色，大部成質粗之厚層，頁岩多爲泥質，呈灰黑紅棕黃等色，有時夾極薄之褐性烟炭層，其底部有時見一層頗厚之礫岩，礫塊頗大，多爲石英及砂岩，該系與其下伏之地層爲極顯明之不整合，故其所覆之地層，往往不定，本系岩層未受變質，褶縐亦不劇烈，似未受花崗岩侵入之影響，但未採得能鑒定之化石，時代尙難確知，以其岩石性質及層位觀之，似與浙西之建德系相當，而屬於白堊紀之下部，所見厚度約三百公尺左右。

漳平城附近所見者多爲紫色及黃色頁岩與砂岩相間成層，砂岩有時含礫石甚多，而爲礫岩。漳平南三里白堊紀下部黑色頁岩內夾薄煤一層，厚自十三公分至二十公分經分析爲褐性烟炭，質劣層薄不能開採。含煤層下有灰色之泥土層，內含鱗鯉類化石甚多，惜不能鑑定時代。其一部地層如第十圖所示。

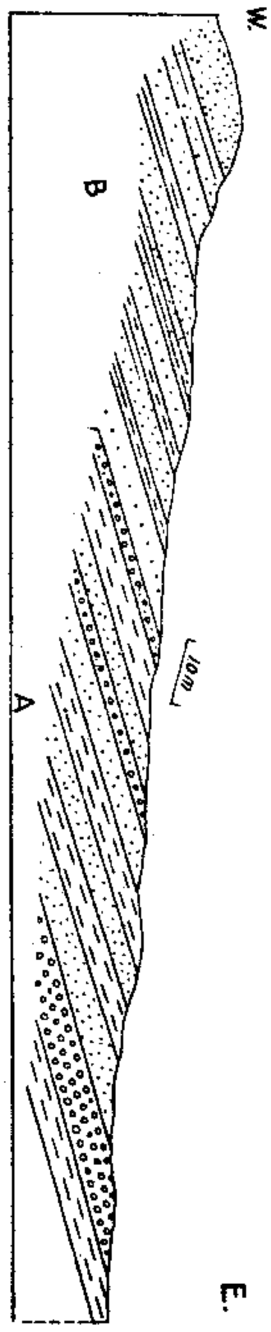


第十圖　1,薄層頁岩及砂岩　2,灰色泥層　3,黑色頁岩夾薄煤層　4,綠色頁岩　5,棕色厚砂岩

Fig. 10. A part of Cretaceous strata at Changping.

1. Thin beds of shale and sandstone. 2. Gray clay 5 m. 3. Black shale with coal seam of 0.13-0.2 m thick. 4. Green shale. 5. Purple sandstone 23 m.

龍巖東北九十里赤眉山河北岸，白堊紀一部地層露頭甚清，（第十一圖）爲粗鬆之砂岩及頁岩相間成層，砂岩多作紅色及灰黃色，岩性軟含砂質，呈紅紫色者爲最多。下部有礫石數層，礫石俱爲石英，厚者可至五公尺。



第十一圖　A 礫岩數層夾黃棕色砂岩及頁岩　B 相間成層之粗鬆砂岩及頁岩

Fig. 11. A Part of Cretaceous strata at Chimeishan.

A. Conglomerates and purple sandstones and shales. B. Interbedded coarse sandstone and shale.

白堊紀以前之不整合　本區白堊紀下部之白沙系與較古地層常呈不整合狀態。在白沙附近所見者（第七圖）該系岩石爲紅色砂頁岩間互層，底部礫石層厚達十公尺，礫石大部爲石英及少許砂岩，直覆於大羽植物煤系之上。礫石走向爲北三十度東，傾角十八度向東南。其下煤系之砂岩走向爲北三十二度西，傾角三十七度向東北，二者爲極明顯之不整合接觸。且此剖面之東北端礫岩直覆於翠屏山頁岩之上，傾角平緩，而其下之頁岩則褶皺甚多，傾斜且急。至此剖面之南端白沙系更直接覆於南靖石英岩之上

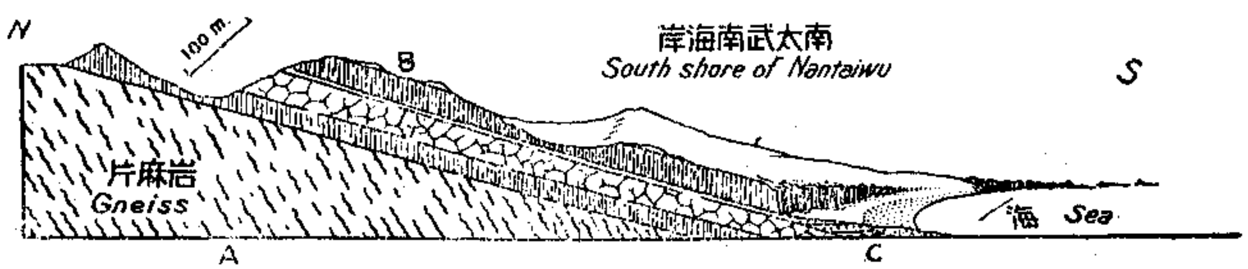
此等不整合接觸在漳平龍巖間固屢見不鮮。又王紹文君閩西地質圖及報告中之官寨紅砂岩，與本系確爲同層，且連城永安區實與本區毗連，該系分佈區南自連城之官寨，北經永安以達沙縣，延長一百數十公里，下與較古各期地層均有接觸，其間爲不整合，甚爲明顯，證之本區，當益無疑問。（王君解以斷層）

白堊紀上部——兜嶺火山岩

白堊紀上部在閩南大部爲流紋岩，凝灰岩及石英斑岩等，漳平西北濟泰附近，見流紋岩夾於紅砂岩內，呈肉紅色或灰綠等色風化頗深，在顯微鏡下觀之，略現流紋狀，晶塊多爲石英。龍岩之南，兜嶺之上，火山岩頗發達，有流紋岩，凝灰岩安山岩等。華安縣北之涵口亦有分佈，下與南靖系石英岩或花崗岩成不整合接觸。石英斑岩，分佈零星常成侵入岩，在南靖龍巖間及嵩嶼海岸常侵入於花崗岩，石英岩，及二疊紀岩層內。

第三紀——柳會社玄武岩

廈門南海澄縣之海邊，柳會社一帶，有玄武岩分佈甚廣，不整合的覆於片麻岩及花崗岩之上，向東作十五度之傾角，（第十二圖）色灰黑至棕黑，呈美麗之六角柱體構造。在顯微鏡下觀察其晶粒頗細，含有橄欖石，輝石及鈣鈉長石。此玄武岩之時代約爲舊第三紀。厚度在二百公尺以上。龍巖城南天馬山爲龍巖平原內突出之小山，全爲火山岩組成，其底部爲黑色火山礫岩，礫塊多石英石灰岩頁岩砂岩及花崗岩等之角礫石與火山灰膠結而成，性堅固，本地人常用作橋石及柱石等建築材料，厚兩公尺，上爲玄武岩，再上爲凝灰砂岩，大致向南作二三度之傾角。此處所見之玄武岩與在柳會社所見者無大差異。



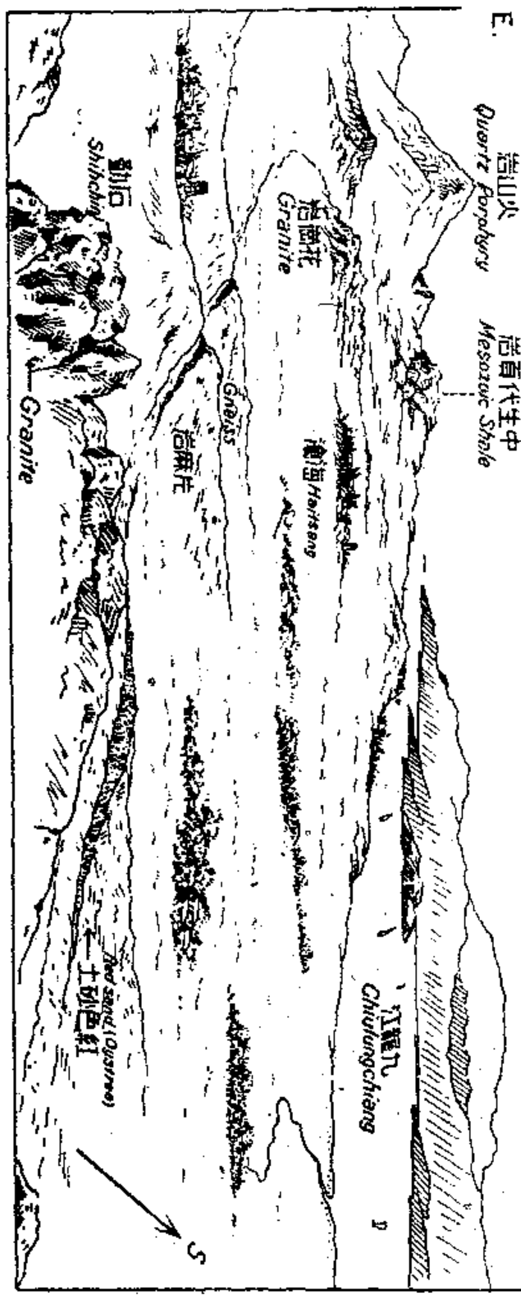
第十二圖　A,片麻岩　B,玄武岩　C,沙泥及泥炭層

Fig. 12.　Section of Nantaiwu, south of Amoy.

A. Gneiss B. Basalt C. Sand, clay and peat

新第三紀——紅土及礫石層

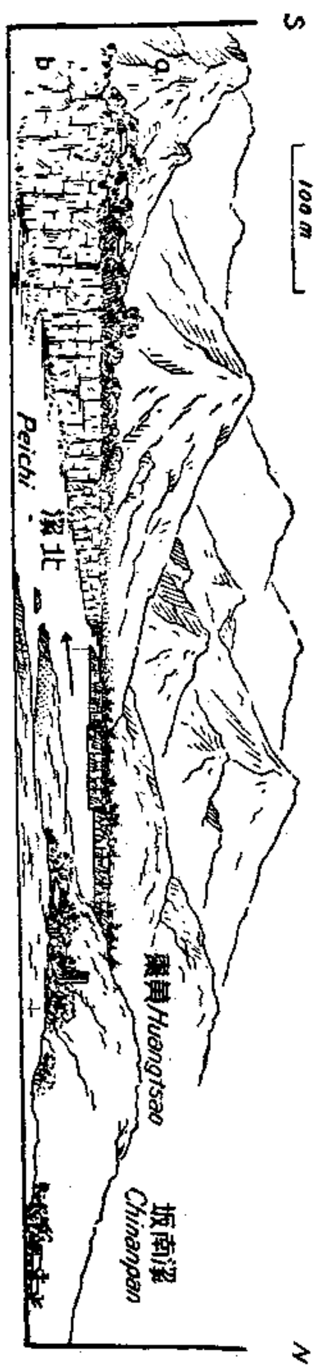
新第三紀地層在閩南沉積之處甚多，在嵩嶼以西及漳州（龍溪）一帶高出海面五十公尺以下之崗阜，時爲該系地層所組成，岩石大部爲紅土與沙礫，在東美西之邱陵上（第十三圖）自紅土內採得蠣殼甚多。爲 Oystrea 約爲新第三紀海中之物，但此處已



第十三圖　九龍江口

Fig. 13.　A sketch at the mouth of Chiulungchiang.

距海甚遠，且高出海面二十餘公尺，與海岸昇降似有關係，漳州一帶當新第三紀時似仍沉於海中，至新第三紀以後始昇爲陸地。由浦南至嶺兜間北溪之兩岸，常見高出河面十餘公尺至三十公尺之臺地，（第十四圖）大致與龍溪之邱陵地在同一水平線上，此臺地之岩石多爲礫石泥土及鬆沙岩，與南靖系地層成不整合之接觸，（第二圖）在沙關河岸鬆沙岩內含破碎之介殼片甚多，似與龍溪嵩嶼間之紅土層爲同一時代之物。



第十四圖　a 南靖砂岩　b 新第三紀砂礫在河谷內所成之臺地

Fig. 14　The terrace of Peichi valley at Chinanpan.

a. Nanching quartzite. b. Young Tertiary sand, clay and conglomerate.

龍巖城南天馬山下，見第三紀地層爲粗鬆紅土礫石及灰色粘土等，常相間成層，粘土呈灰色，間含破碎之植物化石，礫岩有時礫塊頗大，多爲石灰岩，石英及砂岩，略作圓形體，膠結於砂質紅土內。在城西外洋以西河岸臺地上亦有分佈。

洪積統礫石層

沿河或寬谷內，另見一種礫石層，卵石大小不一，岩石複雜常與沙土混合散漫堆積，未經粘結。高出河面可十許公尺，雖已受河水侵成崖壁，而與前述第三紀之礫石層顯成另一台地，生成較晚，大約爲洪積統。在龍巖城北及城西龍門圩一帶，河之兩岸分佈甚廣。北溪河谷中亦時有分佈。在厦門南海對岸，南太武南柳會社海邊，見礫石層及沙土，下有厚一公尺之泥炭一層，夾於白沙粘土及黑泥頁岩中，共厚約四公尺，層位大致水平，不整合的覆於第三紀之玄武岩上。炭質爲泥炭，質鬆層次極不規則（第十二圖）或亦爲洪積統之沉積地層。

沖積層　沖積層爲最新之鬆散粘土沙礫等，膠固不堅，層次不顯，大部呈灰黃黑紅等色，凡低地，平原，河邊，山坡，均其

分佈所在，散見於各系地層之上，厚度不等。

侵入岩

花崗岩　區內花崗岩分佈極廣，成巨體侵入岩，其中心約可分爲三，一、爲漳州附近。二、爲華安漳平龍巖三縣間之永福金山附近。三、爲龍巖以西小池附近，餘則支脈輻輳，備極繁瑣。凡中生代初期（三疊紀）以前地層均受其侵入影響。

按岩石性質及存在狀況，花崗岩可分爲兩類（或兩個時期）。第一類，晶體勻細，色肉紅，石英及正長石爲較整晶體，其他鑛物僅屑碎散見。此種花崗岩長與古水成岩接觸或成墻脈。有時由此項岩體，漸變爲花崗斑岩，如龍溪縣城附近是。此類花崗岩被風化常呈平緩地形，碎石粗砂，常被地表。分佈甚廣，圖中有表明之花崗岩大部屬此種。所採花崗岩標本地點，如龍溪北之浮山，潭口，新圩，嶺兜，華安城北，明良社北，西陂南，小杞南，漳平之奇和，草洋，蔣田，龍巖西小池，龍巖南靖間之洋嶺，板寮，永福以北之蓋多洋，永福南之福田，歸德等均爲此種花崗岩。顯微鏡下之觀察，大致成全結晶質狀態，以正長石及石英爲主要鑛物，黑雲母角閃石次之，磁鐵鑛屑及綠泥石間有存在。第二類爲角閃花崗岩，侵入範圍較小，比第一類侵入時期稍晚，常侵入於第一類及水成岩中，晶體不勻細，色灰白，主要鑛物爲長石，石英，角閃石等。長石多爲斜長石，正長石次之，角閃石成分特多，一部常風化爲綠泥石，其他鑛物有輝石，及磁鐵鑛等，間亦有含黃鐵鑛螢石及燐灰石者，此類花崗岩分佈區域如龍溪之江東橋丹林一帶，龍巖之汪莊及九洲，南靖之石觀音等處是。

石英斑岩　石色淺灰或肉紅，斑晶爲石英，見成條狀之長石。在顯微鏡下觀察，見其石基爲細小之晶粒，除石英及長石外，尙有雲母角閃石及少許之磁鐵鑛。石英斑岩在閩南侵入之處甚多，首見之於海岸廈門及嵩嶼間，侵入於花崗石及中生代頁岩內，東北西南方向延長甚遠，爲沿海之大侵入體，他如南靖龍山間有數處石英斑岩侵入於南靖石英砂岩內，又永溪坂寮及青洋等處石英斑岩侵入於花崗岩內。如此則石英斑岩侵入之時期，自較花岩爲晚，大約與白堊紀火山岩爲同時活動者也。

輝綠岩　在閩南常見之，多爲岩脈或岩墻。色灰綠，或灰黑，結構細緻，鑛物以斜長石輝石角閃石及雲母爲主，橄欖石及磁

鐵鑛次之，凡花崗岩及中生代初期以前之地層，莫不有其侵入之蹤跡。

四　構造

此次調查，係沿綫測製地形地質圖，關於地質構造，時或未能詳到，惟就各路綫上所見構造之主要部分，互相對證，亦不難知其之梗概。其最重要者厥爲褶曲，而斷層次之。褶曲尤以白堊紀以前之地層爲最顯著，大凡一切之大內斜及外斜莫不爲此時褶曲所作成。褶軸方向，多爲東北西南，每呈平行之狀，又因花崗岩侵入之影響，故有時呈紛亂之狀。至於白堊紀岩層則褶曲甚微，與以前之地層顯爲不整合之狀。第三紀地層則僅見傾側，而未見顯明之褶曲矣。玆自沿海西至龍巖分述其地質構造如左。

（一）沿海花崗岩盤　自厦門西經龍溪至南靖一段，爲大塊花崗岩侵入體，東端與片麻岩接觸西端與南靖石英岩接觸將南靖系地層衝爲高山。（第三版）

（二）龍山南靖間之內斜層　該內斜層橫跨北西二溪，軸向東北西南，延長甚遠，在西溪者位於南靖龍山之間，寬約十九公里，在北溪者，位於漳口與吳田口間，寬約十二公里，岩層純爲南靖系石英岩砂岩及頁岩所組成，傾斜大致平緩，褶曲亦不甚劇烈，其兩翼俱爲花崗岩所侵入，故被衝擠爲內斜構造，而巍然突起於龍溪平原之西面。

（三）嶺兜，歸德，水潮及永福一帶之大花崗岩盤　該大塊花崗岩侵入面積甚廣，佔有龍巖，漳平，華安，及南靖數縣之地面，爲此次調查區域內最高之山地，閩南諸水多以此分流。其侵入水成岩之形狀爲一大岩盤，Laccolith 岩盤之邊際不甚整齊有時爲岩脈及岩墻侵入於岩層之中，其中部雖爲大塊花崗岩體，而有時於高山頂部間見侵蝕殘餘之變質石英岩等。

（四）華安內斜層　華安適居上述花崗岩盤之東北邊，岩層組成一不整齊之內斜層，（第六版剖面圖）其中部爲二疊紀地層，兩翼爲南靖系石英岩，因數處受花崗岩之侵入，岩層多變質並零亂。

（五）漳平內斜層　該內斜層居於上述花崗岩盤之西北與華安內斜層遙遙相對，（第一版）軸向爲東北，西南，由漳平東北鄉向西南延長甚遠，伸佈於龍巖城東北津頭一帶，長可二百餘里　其東北端在漳平境內，寬闊平緩，中部爲白堊紀砂岩所覆蓋，

西南入龍巖境內則漸變緊狹，該內斜層之東南翼爲南靖系石英岩，及二疊紀砂頁岩等，間有石灰岩，傾斜大致急劇，向西北約作四十度之角，又因與花崗岩接觸，稍現紛亂之狀。西北翼多爲二疊紀砂頁岩所組成，向東南傾斜極平緩，是兩翼作成不等傾之大內斜層。

（六）易家邦及夏老背斜層　與漳平內斜層相鄰接，亦作東北西南之方向，伸佈於易家邦及夏老一帶，再西南伸至龍巖城東北而沒於斷層（第一版及插圖第十五）

（七）赤眉山內斜層　與上述之背斜層直接鄰接者又爲一內斜層，其延展方向亦爲東北，西南，而東北寬展西南狹窄，與漳平內斜層相對且相似。在赤眉山一帶中部爲白堊紀砂岩所蓋覆，傾斜平緩，西南經揚頭至龍巖以北則變狹窄而沒於斷層。該內斜之兩翼亦不對稱，東南翼傾向甚小，而西北翼則向東南傾斜三十至四十餘度。使煤系及石灰岩露頭於蘇邦大吉一帶，南靖系之石英岩亦巍然矗立，爲高出海面千餘公尺之筆架山。

（八）龍巖東山內斜層　龍巖城東山最高之山峯海拔千餘公尺，成南北方向之山脈，其構造亦爲一大內斜層（第一版）北端本與漳平內斜層接連爲一，惟自龍巖城東北津頭一帶，忽扭折而南，其原來之東北—西南軸向至此則變爲南北，該內斜層之中心在毛嶺峽附近見洋坪頁岩，傾角大致平緩，東翼在郎車水尾一帶，以南靖石英岩與花崗岩接觸，燒灰隔有棲霞石灰岩，吳村林至毛嶺峽間爲大羽植物煤系及翠屏山頁岩，大致皆向西作二十餘度之傾角　西翼在龍巖東山之半腰爲二疊紀煤系及翠屏山頁砂岩所組成，又因褶曲錯綜，復褶爲較小之背斜及內斜層以成複雜之構造，其褶曲狀況又可分述爲（甲）東寶山背斜層，北起龍巖城北之鐵石洋，南經東寶山麓至翠屏山後止爲一背斜構造，脊部爲棲霞石灰岩，兩翼爲二疊紀煤系砂岩及頁岩，軸向大致南北，北端爲龍巖斷層所切，南端傾止於翠屏山之東面。（乙）翠屏山內斜層，龍巖城東翠屏山爲高出城廂四百餘公尺之危峯，其構造爲一內斜層，與東寶山背斜層平行鄰接，頂部爲翠屏山頁岩，兩翼爲煤系，北端亦止於斷層，南端與東山大內斜層相連接，實爲大內斜之分（第三圖）支也。（丙）塔山背斜及內斜層，塔山位於城東南三公里處，山約高於城二百六十公尺，爲南北方向之山脊，

以翠屏山頁岩構成一內斜層，塔之東爲南北方向之深谷，露頭爲二疊紀煤系，又自成一背斜層。（第一版）（丁）龍巖洞半背斜層，龍巖城東龍巖洞露頭之棲霞石灰岩，居於翠屏山及塔山二內斜層之間，其構造本爲一背斜層，但其西面爲斷層所截，以沒於平原，而僅現半背斜之形狀。（第三圖）

（九）龍巖大背斜層　該背斜層之脊部爲南靖石英岩，露於龍巖寬谷內，及城北城西南之低山上（第六版剖面圖）軸向大致爲北東北至南西南，其東翼爲斷層所截，致與東山之一切構造不相連接，西翼在城西二里，見有棲霞石灰岩，及煤系之露頭，傾角向西二十餘度。

（十）龍門墟內斜層　龍門墟之東有一凸出之山脈作南北方向其構造爲內斜層，軸部爲翠屏山頁岩，兩翼爲煤系，各向內傾斜其急。普通作三十至四十度之角，在龍門墟之西煤系下復有南靖石英岩崛起爲筆尖山及紫金山諸高峯而與花崗岩接觸。（第六版剖面圖）

（十一）適中及洋坪兩內斜層　龍巖至南靖之路上，有適中及洋坪兩內斜層，作西北—東南之方向，軸部爲洋坪頁岩，翼部爲南靖石英岩二疊紀石灰岩及砂岩等，（第一版）西北及東南二面俱爲花崗岩所侵入，兩內斜層之構造因之頗爲複雜，洋坪及適中間褶曲倒置，有逆掩斷層發生，棲霞石灰岩（即適中內斜層西北翼）逆掩於洋坪頁岩之上（即洋坪內斜層之中心）如剖面第四圖所示。

統觀以上所述之褶曲，知其運動程序至少應消二個時期，一、在白堊紀以前三疊紀以後，即所謂造成主要內斜及背斜層之運動者也，其褶曲之方向及狀況又往往與花崗岩侵入體相關合，大致向北北東南南西方向延長，與海岸線平行。蓋花崗岩之侵入或與褶曲爲同時活動者也，二、在白堊紀以後及第三紀以前，因白堊紀與其以前地層皆成不整合之狀，又往往於大內斜層內始見之，成爲較底之邱嶺，而統未受花崗岩之侵入，全體未變質，無劇大之變動而有緩和之褶曲，是其褶縐運動顯然又另一時期也。除褶曲外斷層亦間見之，如龍巖城東之斷層，北起於鐵石洋南沒於龍巖寬谷內，（第一版）仰側在西，俯側在東，使兩側一切之褶

曲構造被橫截而不得連續。他如在龍巖東南適中（第四圖）有逆掩斷層，使棲霞石灰岩掩置於三疊紀頁岩之上，此斷層方向爲西北—東南，向東北推動，錯斷面約作二十度角

五　礦產

甲—煤

(一)位置及交通

福建西南煤田，分佈甚廣，在此次調查範圍以內者，大要可分爲五區，一爲龍巖區，包括蝦公山翠屏山及東寶山一帶。位九龍江東岸距城至多不過七八里。二爲龍門區，在龍巖城西十里龍門墟南山。三爲龍巖東北區，包括夏老，蘇邦，大吉，白沙，葛滕圩，蘇板六處。四爲零星區域，散佈於華安漳平及龍巖之邊境，包括赤嶺，綿良社（新流）王莊，桂陽，上板，高明坑及洪高山七處，前二處在華安縣境，後四處屬漳平縣治，而最後則爲龍巖縣境之邊疆。五爲海濱泥炭區，在柳會社附近，在海澄縣南四十餘里，其詳細情形，當於下文分述之。

華安爲華封新名，昔爲龍溪縣屬北鄉之一自治區，民廿始改稱縣。環境皆山，山可高出海面五百公尺至一千公尺以上。運輸貨物，陸路皆仰給於人力，水路有九龍江東南流經龍溪入海。舟楫之利稱便，惟僅通至嶺兜而止，嶺兜至縣城廿里，爲險峽所阻。船隻載運貨物多則二三千斤，少則數百斤，視水量之多寡而定。溯溪而上一百二十里至漳平，灘多水淺，僅能通行可載數百斤之小船，日行數十里。華安東北通安溪，直無舟楫可言，僅有峻峭重疊之山嶺，連綿不絕，交通阻塞。

漳平位華安東北，地當九龍江中流，東北通永春東達安溪，南至南靖，西通龍巖，西北與甯洋大田爲隣，水路僅上通龍巖之白沙雁石下達華安，惟載運甚微，餘則端賴人力運輸，交通異常不便，

龍巖處羣山之中，當九龍江上游，自漳龍公路完成後，交通日便，惟此公路之地形頗爲險峭，自龍巖南行經適中過兜嶺沿西溪至漳州，長約二百餘里，但兜嶺高出龍巖平地六百公尺以上，崎嶇折轉，時感險難。自龍巖沿北溪順流而下，經漳平華安漳州

間有舟揖之利，惟華安嶺兜段，谷狹石多，船隻不能通行，且華安以上均奔流湍急，航行亦殊感不便，故龍巖貨運難恃北溪爲出路，內地搬運，全藉人力，運量旣微，運費亦鉅

(二)煤田分區述要

(1) 龍巖區

龍巖縣城高出海面約三百五十公尺，北溪上游合東南，南，西南三支流，會集於龍巖城下而北流。城東各山，南北連綿聳立高峰達一千公尺以上。其南北西均平緩，迤西至龍門墟以西，山勢始起，故龍巖實山叢中之一小平原也。

本區煤田在龍巖城之東，（第四版）其中可分爲南北兩部：南部自蝦公山煤窰向南延展以達塔山後溝一帶，已知可靠長度約二千二百公尺，寬可二千公尺，北部自翠屏山沿山東麓經東寶山向北延長以至鐵石洋，已知長度約七千公尺，寬一千公尺至二千公尺以上。

煤質　煤質均屬無烟煤，變質較烈，質鬆脆而純潔，光亮可鑑，硫質較底，所採煤樣經本所燃料研究室分析結果，列表如左：表中分類記號則根據翁氏煤炭分類法

分析號數	地名	水分	揮發分	固定炭	灰分	硫分	發熱量	粘性	燃率	分類名稱	記號
九二一	龍巖東山一窰	四·六五	二·七0	八六·一八	四·七五	·七九	七三00	否	一一·00	高級無烟煤	Ah_2^2
九二二	龍巖東山二窰	四·七六	二·一七	八四·九四	七·一一	0·七六	七三四六	否	一0·六五	仝上	Ah_2^2
九二三	龍巖東山三窰	五·00	二·一0	八一·六五	六·二五	0·九一	七三七六	否	六·七0	低級無烟煤	Al_2^3
九二四	龍巖東山嶺四窰	五·二0	二·四0	八七·00	五·六0	0·九四	七三六二	否	一一·八0	高級無烟煤	Ah_2^2
九二五	龍巖東山嶺後	四·八五	二·六二	八六·三三	四·二0	0·九一	七三八0	否	一一·八0	仝上	Ah_2^2
九二六	龍巖東山	四·0七	四·四三	八五·二0	六·二0	一·四一		否	一0·00	高級無烟煤	Ah_2^2

煤量　龍巖區地層構造複雜，折曲變轉備極紛亂，煤層厚度各處不一，主要煤層有一，平均厚度爲一·三公尺，比重一·三，煤層傾角自二十度以至四十度不等，深度以直深二百公尺爲可採限度，則按其構造大致情形分段計算，略如左表。長度厚度皆以公尺計。

區域		長度	煤厚	比重	平均傾角度數	深度	煤量噸數
南部	塔山後溝背斜層之南翼	四四00	1·三	1·三	三0	二00	五,九四八,八00
	蝦公山西坡	三四00	1·三	1·三	二五	二00	二,七三二,六00
北部	東寶山背斜層之東翼	六六00	1·0	1·三	三0	二00	三,五三六,000
	東寶山背斜層之西翼	三000	1·0	1·三	三0	二00	1,五六0 000

按以上計算，龍巖區域內貯煤量共爲一千三百七十七萬餘噸。

開採情形　龍巖區礦業，佔此次調查中最重要之地位，開採煤窰，僅見於離城三里之蝦公山一隅，煤窰凡六，均用土法，規模甚小，毫無機械設備，每窰每日工作人自五，六人至十餘人不等，大致視需要而定，工人合夥採煤，每日多者可出一百餘担，每担一百斤，若在礦區售賣每担一角，城內市價則爲三角。

(2)　龍門區

龍門區含煤地層分佈於龍門寬谷之東坡，（第四版）南北延長爲內斜構造，煤層賦存狀態甚佳，惟僅見煤一層，厚自一公尺至一·八公尺，其下尚有無煤層非經鑽探無從而知。

煤質亦爲高級無烟煤，質地堅硬，與龍巖區所產之煤相同，蓋同屬二疊紀之煤且彼此相距不甚遠也。

煤量　煤系露頭於該內斜層之南翼，南北延長甚遠，（第四版）但二疊紀煤系之煤層生存狀況頗不整齊，雖有煤系地層，而不含煤層者亦常有之，故此煤田河北岸，雖有煤系露頭甚廣，而現無開採者，究有無可採之煤，不敢臆斷，故煤量之估計，暫以龍

門附近可靠之範圍內計算之。其煤層平均厚度一·四公尺，比重爲一·三，可採深度爲二百公尺，則此內斜層兩翼之煤量如下，

1. 內斜層西翼 $2600 \times 1{\cdot}3 \times 1{\cdot}4 \times \mathrm{Cosec}30^\circ \times 200 = 1{,}892{,}800$噸

2. 內斜層東翼 $2000 \times 1{\cdot}3 \times 1{\cdot}4 \times \mathrm{Cosec}30^\circ \times 200 = 1{,}456{,}000$噸

兩翼合計龍門區煤量共爲三百三十四萬餘噸

礦業 龍門墟煤田僅有煤窰數家，均係土法小窰，一切端賴人力，工人每窰僅十餘人，日出煤不過數千斤，均銷售於附近住戶，售價與龍巖東山之煤同。

(3) 龍巖東北區

本區煤田包括夏老，大吉，蘇邦，白砂，葛藤盂及易家邦六處，位龍巖城北東，面積頗廣，煤量估計，詳細情形，分述如左

（a）夏老煤田在雁石之南，位龍巖城北東二十餘里，南北二山各有煤層，二者適成背斜構造煤層微薄，但尙可開採，煤質爲中淨中級無烟煤，硫量低者，其記號Am_3^2茲將北山之煤分析成分列左

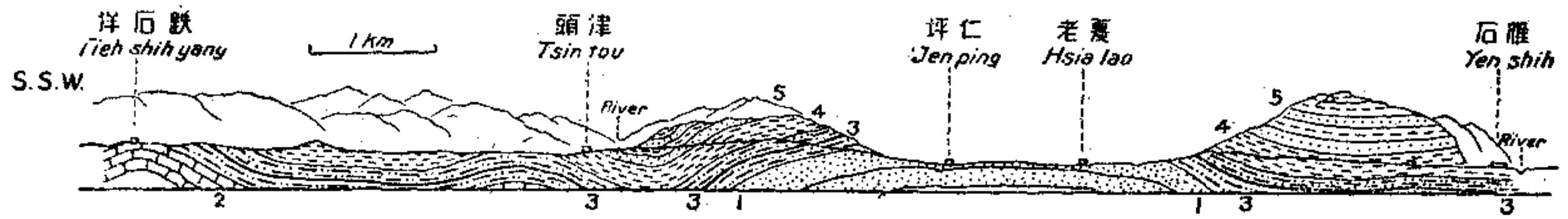
分析號數	地名	水分	揮發分	固定炭	灰分	硫分	發熱量	粘性	燃率	分類名稱	記號
九五七	龍巖夏老北山	一·九四	五·三六	八二·七六	八·六二	〇·九五	七五四二		九·七九	中級無烟煤	Am_3^2

煤量 夏老北山之煤層傾角較急，平均約四十度，南山之煤層傾角約二十度，兩山成不等傾之背斜層，煤層較薄，平均在一公尺上下，煤田東西延長，長度未暇詳測。茲按圖各照四千公尺估計之如下：（可採深度定二百公尺，煤層厚一公尺，比重一三，傾角平均爲二十度與四十度）

北山 $4000 \times 200 \times 1{\cdot}3 \times 1 \times \mathrm{Cosec}40^\circ = 1{,}624{,}000$噸

南山 $4000 \times 200 \times 1{\cdot}3 \times 1 \times \mathrm{Cosec}20^\circ = 3{,}040{,}000$噸

合計爲四百六十六萬餘噸，



第十五圖　1，南靖石英岩　2，棲霞石灰岩　3，二疊紀煤系　4，翠屏山下部頁岩　5，翠屏山上部砂岩

Fig. 15.　Section of Tiehshiyang and Yenshih, north of Lungyen.

1. Nanching quartzite. 2. Chihsia limestone. 3. Permian coal series. 4-5. Tsuipingshan shale

（b）大吉葛籐圩煤田，位水龍潭之西，雁石之北。煤系露頭，南北延長約五十公尺，煤層厚一公尺半，大致尙爲規矩，適於開採，煤質均屬無烟煤，惟揮發分與灰分較高於夏老者，而固定炭稍低，茲將分析結果列左

號數	地名	水分	揮發分	固定炭	灰分	硫分	發熱量	粘性	燃率	分類名稱	記號
九六一	龍巖葛籐孟	二·九七	六·九三	七七·六	一三·九三	0·六五	七三六三		七·八0		

此處煤量以可採深度二百公尺計算，傾斜角爲三十度，平均煤層厚以一·四公尺計，則可得 5000 × 1·4 × 1·3 × 200 × Cosec 30° = 3,640,000噸

（c）蘇邦一帶煤田，南北延長約四千公尺，煤層甚規則，大致傾斜向東，與大吉之煤成向斜層，煤質爲中淨中級無烟炭，硫量低者，其記號應爲 Am^{2}_{3} 茲將分析結果列左。

號數	地名	水分	揮發分	固定炭	灰分	硫質	熱量	粘性	燃率	分類名稱	記號
九六五	龍巖蘇邦	二·三七	四·九三	八三·三五	九·0五	1·11	七三五10	否	八·五0	中淨中級無烟煤含硫低者	Am^{2}_{3}

煤量估計，依煤層厚度一·三公尺計則有， $4000 \times 1{\cdot}3 \times 1{\cdot}3 \times 200 \times \text{Cosec}30^\circ = 2{,}704{,}000$ 噸

（d）白沙煤田在龍巖縣東北，與寧洋縣爲鄰，西南距雁石四十餘里，大羽植物煤系地層自爲拃狹之背斜層，上爲白堊紀礫岩所掩蓋，作不整合狀，煤系之黑色頁岩內夾煤一層，厚一公尺至一公尺六寸，爲無烟煤，所產之煤可由萶溪船運，下銷漳平。煤質分析列左。

號數	地名	水分	揮發分	固定炭	灰分	硫分	發熱量	粘性	燃率	分類名稱	記號
九四一	龍巖白沙南三里	二·三三	六·九六	七四·四〇	一六·三〇	一·〇三〇	七〇二六		八·〇〇	低淨中級無烟煤含硫低者	Am^2_4
九四四	龍巖白沙南河邊	一·七七	六·六三	七一·〇八	二〇·五三	〇·七三	六七八六		八·五〇	極低中級無烟煤含硫甚低者	Am^1_4

煤量　該煤田露於白沙南約三里，煤層隨背斜層之兩翼向南北傾斜甚急，平均約作三十五度角。茲以其長度爲五千公尺，煤厚平均一·三公尺計之，則其兩翼有煤量如左。

$$5000 \times 1{\cdot}3 \times 1{\cdot}3 \times 200 \times \text{Cosec}35^\circ \times 2 = 5{,}800{,}000\text{噸}$$

（e）外洋蘇坂煤田在赤眉山之東，濟泰之西，外洋蘇坂間爲一煤田，煤系地層自爲一平緩之背斜構造，東翼煤層露於外洋附近，西翼於蘇坂附近，煤層甚薄，厚在半公尺上下，開採較難，煤質爲無烟煤，其兩翼煤量約計如下。

$$4000 \times 1{\cdot}3 \times 0{\cdot}5 \times 200 \times \text{Cosec}20^\circ \times 2 = 3{,}040{,}000\text{噸}$$

以上爲龍巖東北區煤田，計有夏老，大吉，蘇邦，白沙及外洋五處，統計有貯煤量共一千九百八十四萬八千噸，再加龍巖及龍門圩兩區之煤量，合計之共有三千六百九十七萬餘噸，此僅爲調查路綫所經過煤田之貯量，均在漳龍鐵路預定路綫之附近，至離路綫稍遠者則未及調查。

(4)　其他煤田

華安煤礦有二，一在城西十五里之赤嶺，昔曾一度開採，惟煤層太薄，且不規則，無價值之可言。一在城北綿良社西之新流，

距華安亦不過十餘里，亦曾開採，斜坑鑛井至今猶存，惟大半爲流水所灌注，煤層厚度不及半公尺，二者同位二叠紀地層之中部，且同爲石墨狀之無烟煤，賦量過貧難資開採。漳平煤田零星分佈而無價値者亦有三處，一在華口之北十餘里，西南距漳平縣城五十里之上坂，煤層旣薄，煤量亦少。二在漳平南之桂陽，煤系露頭不寬，層厚薄不一。三在漳平南之高明坑，距桂陽不甚遠，煤系雖含煤層，但不規則。龍巖縣境內之次等煤田，據調查所得，約有兩處，一在城東九十餘里與漳平境爲隣之洪高山，拔出海面八百公尺，煤層位於高山之上部，層薄不均，露頭雖廣，而含量低微，且煤質疏鬆，多呈粉屑，所採煤樣二件，經分析結果稱爲低淨高級或中級烟煤，其記號應爲 Bh^1_4 與 Bm^1_4。一在龍巖南十五里之王莊一帶，現有煤窰開採，煤質大致與龍巖區相彷彿，惟儲量遠遜，茲將洪高山及漳平東三里所採煤樣分析如左。

號數	地名	水分	揮發分	固定炭	灰分	硫分	發熱量	粘性	燃率	分類名稱	記號
九四九	洪高山	六·九〇	一〇·三五	六六·四五	一六·三〇	〇·五二	六七〇三	否	三·六二	低淨高級烟煤含硫低者	Bh^1_4
九五〇	洪高山	一四·八〇	一四·〇五	五三·六〇	七·五五	〇·六三	五九一三	否	一·八六	低淨中級烟煤含硫低者	Bm^1_4
九三六	漳平東三里桂陽	八·六二	二七·九六	三四·八五	二八·五五	一·一九	四三三三	否	〇·九五	極低淨褐性烟煤含硫低者	Bc^2_4

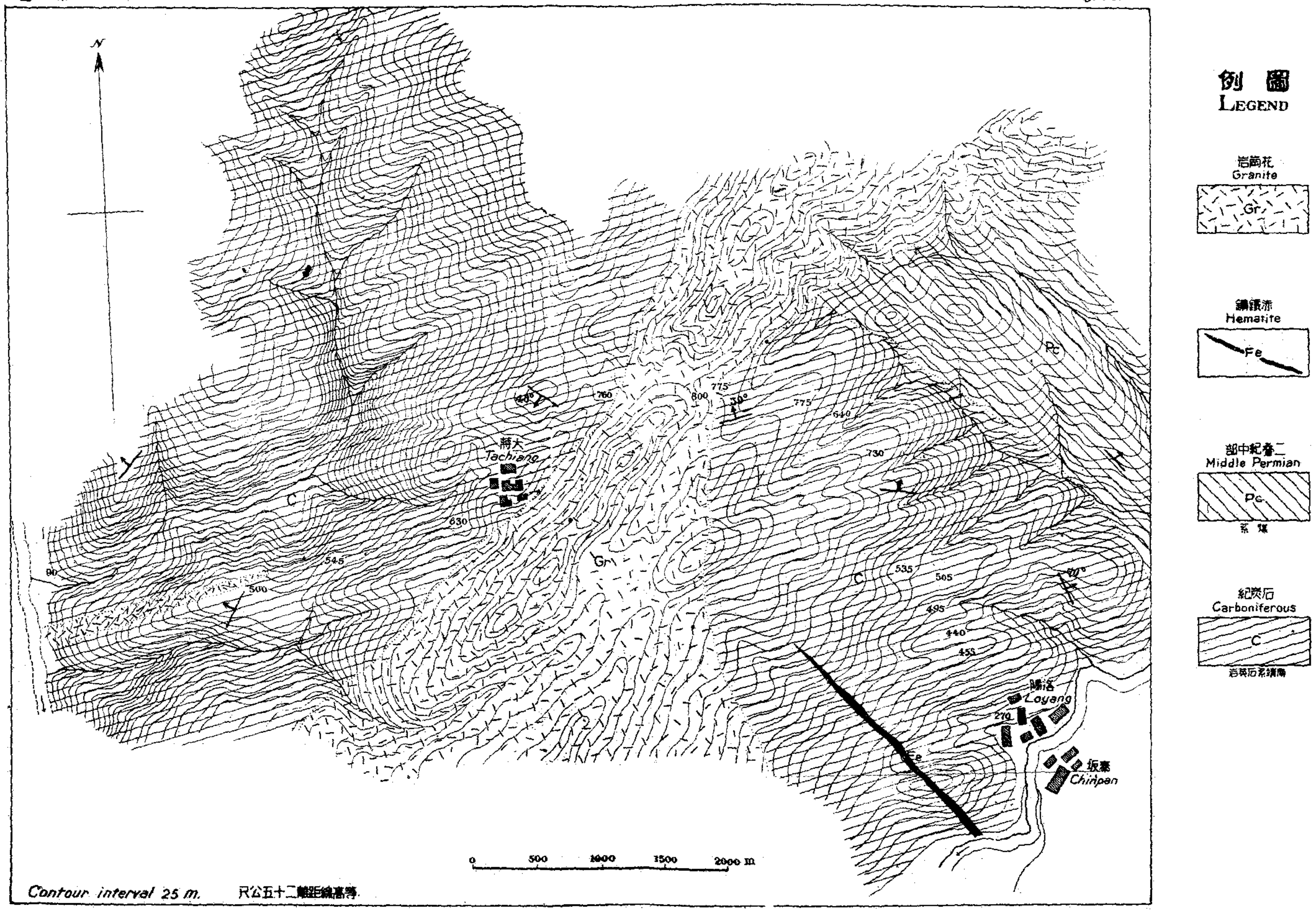
(5)　泥炭

海澄縣屬南端之南太武，其東南二十里之柳會社附近之海濱產泥炭。附近地質，多爲火成岩，片麻岩居最下部，柱狀玄武岩位其上，而含泥炭層之棕色及灰色頁岩則平鋪於此玄武岩之上，最上則覆以礫石及沙土，此泥炭層之厚薄不一，厚者約一公尺半，薄者不足數公分。且沿海分佈區域甚小。此種不規則之煤層，實難估計。詳情在地層章中已言之，故不復贅述。此泥炭曾爲華輿鑛務有限公司開採，已耗費四五萬元，開坑三處，一處深約十數公尺，他二處僅涉及表面卽停。惟深坑中離泥炭層半公尺以下，盡是黑色玄武岩。茲將所採泥炭標本分析結果列左。

福建華安縣洛陽鐵鑛區地質圖
Geological Map of the Iron ore Deposit of Loyang, Hua-an, Fukien

第十六圖

Fig. 16.



號數	地名	水分	揮發分	固定炭	灰分	硫分	發熱量	粘性	燃率	分類名稱	記號
九七	海澄柳會社	五·一五	二六·三二	三二·四八	三三·〇五	一·五三				泥炭	P

乙—鐵

此次調查所見鐵鑛有三處，分述如后。

（一）華安縣屬之洛陽鐵鑛

鑛區位洛陽村西北三里，當北溪支流之北岸（第十六圖）拔出海面約二百餘公尺。此溪由安溪來，向西南流至涵口與北溪會，溪面狹窄，流水湍急不利舟揖。環境皆山，壁立峻峭，山峯海拔多在一千公尺以上，山深林密，險要異常，自昔爲盜匪老巢，故行旅絕跡，吾等受十九路軍之保護，始得冒險前去一探，惟未得詳考，實引爲憾。此地東北距安溪縣一百餘里，西達漳平六十里，南離華安九十里，名雖爲華安縣屬，實則爲該三縣交界之地而劃入特別區範圍之內。

鑛體成一巨大之脉狀，走向爲北五十度西，其東南一端，則深入河中，不復見出露，鑛石全爲暗紅色之赤鐵鑛，產於南靖系石英砂岩中，其西北一帶盡爲花崗岩侵入體。

鑛石之成分甚高，大約含鐵在百分四十五以上，其結構多呈塊狀或粒狀，在顯微鏡下觀察赤鐵鑛多呈紅色，其邊際常有不連續之褐鐵鑛，成飾狀外殼，顯爲風化之結果。於赤鐵鑛鑛體內間見少量之黃鐵鑛及塊狀磁鐵鑛，此外尚有鉀硫鐵鑛（Jarosite）與硫鐵鑛伴生，想爲花崗岩內之鉀長石與風化之硫鐵鑛經天然化學作用而生成者。鐵鑛石之邊緣又常發見結晶完美之柘榴石，足證此鑛爲高熱接觸鑛床，然其圍岩爲砂岩，附近之火成岩又僅見花崗岩，皆與接觸鑛床之成因條件不適宜，其附近或仍有石灰岩，及他項之中性火成岩存在亦未可知，但當時迫於環境未獲詳察，諸待異日之研究。

鑛量之約計　鑛體爲巨脉狀，突出於石英砂岩之上，高約四十公尺，寬五十公尺，惟長度因一端沒於河底，一端向西北延展至何處而止，因時間限制未從確知，茲假定爲二千公尺，以赤鐵鑛比重三·二計之則得其鑛量爲：

2000×50×40×3·2=12,800,000噸

洛陽鐵礦分析表（赤鐵礦）

分析號數	鐵二養三	矽酸	硫	燐二養五	含鐵成分
一八六	九四·九七	一·七五	〇·二一	痕跡	六六·三五
一八七	九三·六四	三·〇〇	〇·四一	痕跡	六五·四九

（註）上列分析爲最優鑛石，平均成分當遜於此。

（二）漳平草洋磁鐵鑛

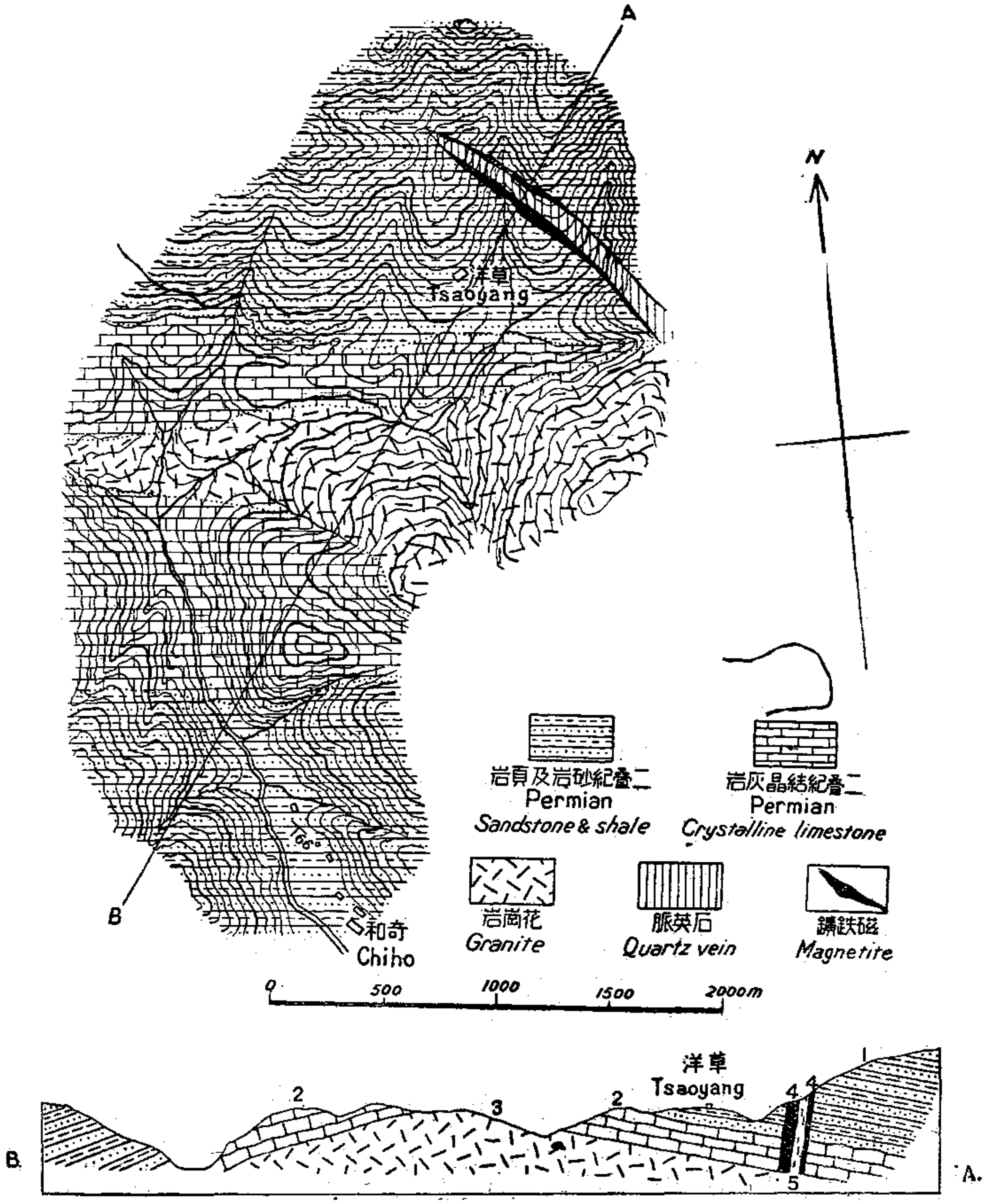
在漳平城東北，一百二十里之處，當華口北九十餘里，華口有北溪之支流名溪南溪者，自東北來會，沿之上行七十里至楊美，再北行二十餘里卽至草洋，山路崎嶇，地勢高峻。鐵鑛在草洋之山坡上，高出海面七百餘公尺，交通至爲不便。

礦區之地層甚簡單，（第十七圖）有二叠紀石灰岩分佈於礦區之中部，有花崗岩侵入於其間，石灰岩衝折爲南北兩段，一高一低，傾斜平緩，惟多變質爲大理岩，呈白色之晶顆，繼石灰岩之上者爲二叠紀砂頁岩，惟未見煤層，岩層亦多變質，一端亦與花崗岩接觸，有石英脈寬約二十公尺，橫貫於其間，該鐵鑛卽生成於石英脈之兩測與砂岩接觸處，（第十七圖）其形體不整齊，厚薄不一，有時成樓狀體，有時僅沿石英脈之邊際而爲脈狀，在石英脈之北面者質劣脈薄，在南面者則形體寬厚鑛質甚佳。

該磁鐵鑛之結構亦不均一，鑛體之東端距花崗岩及石灰石稍近之處，多爲結晶狀，呈三八面體，常包圍於次生之褐鐵鑛內，共生鑛物有石榴石，晶粒不大，風化甚深，在顯微鏡下尚見有稀少之燐灰石，鋯英石，（風信子石）及金紅石等，鑛體之西端距石灰岩及花崗岩較遠處，礦石多呈塊狀及粒狀結構緻密，色黑而光亮，表面常現腎狀或葡萄狀之構造，間有赤鐵鑛與之共生。

該鑛亦爲接觸鑛床，其圍岩雖爲砂岩，而與變質之石灰岩相距甚近，其成因顯與石灰岩有關係。

鑛體之形體既不整齊，故鑛量之估計頗不易，茲將該鑛分段計之。假定石英脈北面之鑛爲過貧之鑛，不加計算，石英脈之南



第 十 七 圖　　漳 平 縣 草 洋 鐵 鑛 圖

Fig. 17. Geological Map of the Iron Ore Deposit of Tsoyang, Changping, Fukien.

面距花崗岩甚近之凸鏡形鑛體，露於地面者甚大，已量得其長爲約百公尺，最寬之處爲十公尺，深度不知，假定其寬平均爲五公尺深爲百公尺，比重爲四，則約計爲 100×5×100×4＝200,000 噸。此鑛體以西爲脈狀鑛，其長度約二百餘公尺，寬不甚一致，平均約二公尺，深度亦以百公尺計之，則約得鑛量 200×2×100×4＝160,000 噸，則二者合計亦不過三十六萬噸，若與洛陽之鑛量相較，則不啻霄壤矣。

草洋磁鐵鑛分析表

分析號數	鐵二養三	矽酸	硫	燐	含鐵成分
一八九	九二·一〇	三·九二	〇·三六	痕跡	六四·四一
一九〇	八七·四〇	三·七六	〇·三八	痕跡	六一·一二

（三）龍溪丹林鏡鐵鑛

丹林位於龍溪城東十五里，南距漳厦汽車路僅二里，居於平原之邊際，三面爲花崗岩小山所環繞，花崗岩有兩類，分佈於邊際者爲斑狀花崗岩，中部爲角閃花崗岩，角閃花崗岩在丹林之東有偉晶花崗岩脈侵入於其中，成東北—西南之走向，寬約五十餘公尺，脈中有鏡鐵鑛，散佈於石英及長石間，有時亦集聚甚富，爲塊狀或脈狀體，顏色灰黑，有金屬光澤，呈雲母狀或纖維狀之構造，質軟易碎，一部常風化爲褐鐵鑛。

觀該鐵鑛生存之狀況應爲岩汁分泌鑛，Magmasegregation 大約爲與偉晶花崗岩同時發生而凝聚較富者也。

礦體分散於火成岩內無一定之形狀，沿母岩之走向索尋，數里以外則告竭枯，故於經濟方面言之無大價值。其鐵鑛成分據本所分析如左。

養化鐵	矽酸	硫	燐	含鐵成分
八九·九四	四·七〇	〇·三〇	痕跡	六二·九〇

此外尚有更小之鐵鑛數處，如龍巖城北有赤鐵鑛沉積於黃色砂岩內，層薄質劣。漳平蓋多洋有鐵砂爲由附近含鐵地層冲聚而來惜皆鑛量太小。

丙—陶土

華安之南六十里北溪右岸天宮地方產粗瓷器不少，多運銷於隣近鄉里，此陶土卽爲花崗岩風化所成之高嶺土，再漳平南七十里永福鎭附近亦產陶土，所製磁器質地較細，運銷外地亦頗可觀，其陶土之成因與天宮所產者同。

丁—石灰

閩南石灰岩甚少，故石灰業不甚發達，其原料僅賴零星露頭之二疊紀石灰岩，據調查所見者，有漳平之赤村燒灰隔，龍巖城東麒麟山，城西小池，及城東北蘇邦等處，業務最發達者，厥推麒麟山一處，有灰窰五座，日可出石灰二千餘斤。濱海一帶則無石灰岩，居民改用海中蠣殼燒之以取石灰。

戊—硫

調查區域內未見可注意之硫鐵鑛，惟二疊紀煤系中有與煤層共生之硫鐵鑛結核，挖煤者揀之以出，再運往他處以煉硫，產地以龍巖東山及龍門圩爲多

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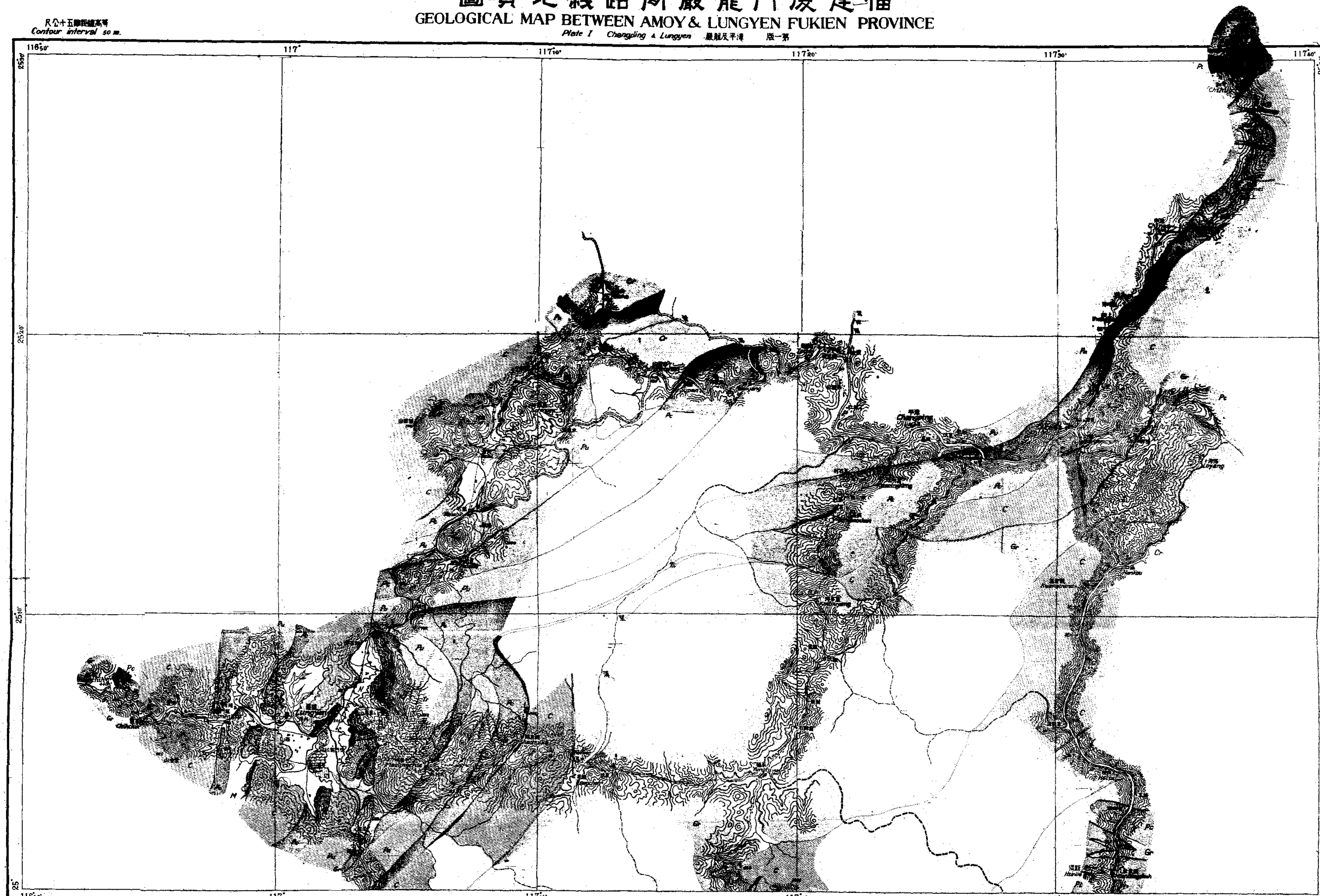
東亞地質圖（東京地學會出版）

福建廈門龍巖間路綫地質圖

GEOLOGICAL MAP BETWEEN AMOY & LUNGYEN FUKIEN PROVINCE

Plate I Changping & Lungyen 第一版 漳平及龍巖

等高線距離五十公尺
Contour interval 50 m.



圖例
Legend

M
第四紀
Quaternary
沖積層
Alluvium

N
洪積統
Pleistocene
沙礫層
Sands and Gravels

E
第三紀
Tertiary
紅土及礫石層
Red clay and Conglomerate

第三紀
Tertiary
柳會社玄武岩
Liuhuisheh Basalt

Cr
白堊紀
Cretaceous
兜嶺火山岩及
白砂紅色砂礫岩
Touling Volcanics and
Paisha Red Sandstone
& Conglomerate

Tr
三疊紀
Triassic(?)
洋坪頁岩
Yangping Shale

Pu
二疊紀上部
U. Permian
翠屏山砂頁岩
Tsuipingshan
Sandstone & Shale

二疊紀中部
M. Permian
大羽羊齒植物煤系
Gigantopteris
Coal Series

二疊紀下部
L. Permian
棲霞燧石石灰岩
Chihsia Cherty
Limestone

C
石炭紀
Carboniferous
南靖石英岩
Nanching Quartzite

Gn
太古界
Archaean
片麻岩
Gneiss

Qp
石英斑岩
Quartz porphyry

花崗岩
Granite

Scale 1:200,000 0 1 2 3 4 8 12 16 20 Km. 比例尺 二十萬分之一

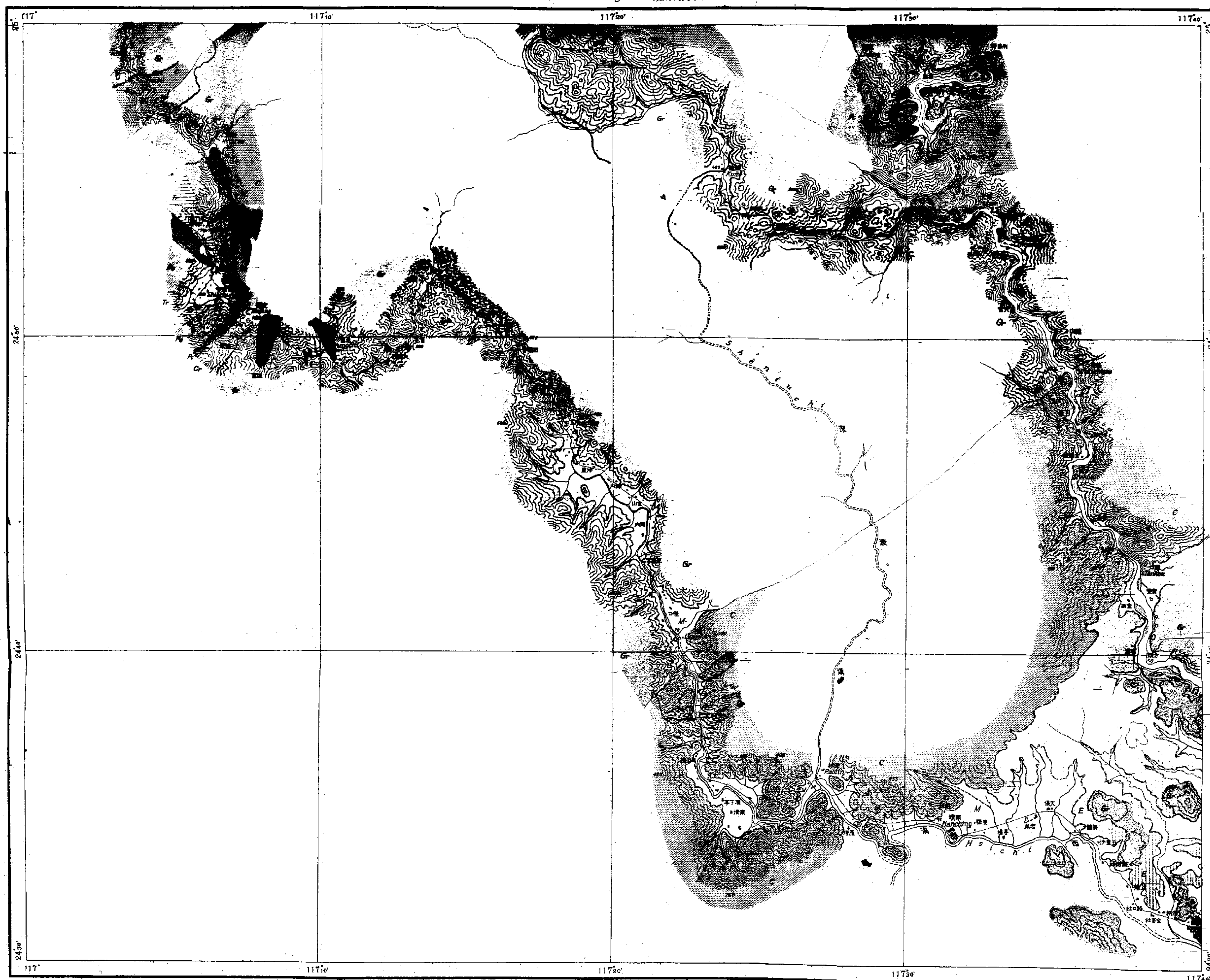
侯德封 王曰倫 張兆瑾 王景睍 測
民國二十二年秋
Surveyed by T. F. Hou, Y. L. Wang, C. C. Cheng & C. K. Wang
In the Autumn of 1933

福建廈門龍巖間路綫地質圖

GEOLOGICAL MAP BETWEEN AMOY & LUNGYEN FUKIEN PROVINCE

Plate II Hua-an & Nanching 第二版 華安及南靖

等高線距離五十公尺
Contour interval 50 m.



二疊紀中部
M. Permian
大羽植物煤系
Gigantopteris Coal Series

二疊紀下部
L. Permian
棲霞燧石石灰岩
Chihsia Cherty Limestone

石炭紀
Carboniferous
南靖石英岩
Nanching Quartzite

Gn
太古界
Archaean
片麻岩
Gneiss

石英斑岩
Quartz porphyry

G
花崗岩
Granite

圖例
Legend

M
第四紀
Quaternary
沖積層
Alluvium

N
洪積統
Pleistocene
沙礫層
Sands and Gravels

E
第三紀
Tertiary
紅土及礫石層
Red clay and Conglomerate

Vb
第三紀
Tertiary
柳會社玄武岩
Liuhuisheh Basalt

Cr
白堊紀
Cretaceous
兜嶺火山岩及
白砂紅色砂礫岩
Touling Volcanics and Paisha Red Sandstone & Conglomerate

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三疊紀
Triassic(?)
洋坪頁岩
Yangping Shale

Pu
二疊紀上部
U. Permian
翠屏山砂頁岩
Tsuipingshan Sandstone & Shale

Scale 1 : 200,000 0 1 2 3 4 8 12 16 20 Km. 比例尺二十萬分之一

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福建厦門龍巖間路線地質圖

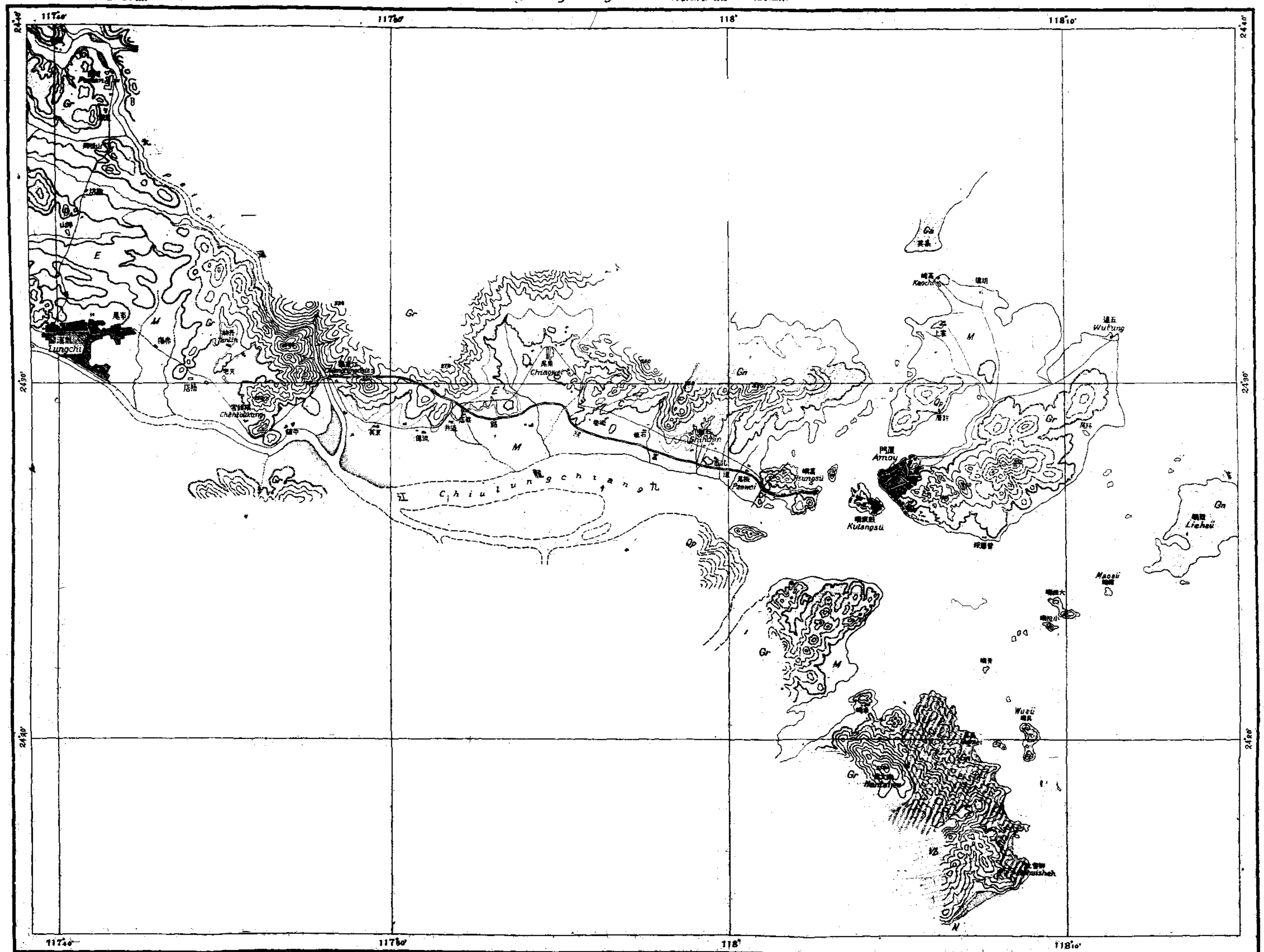
GEOLOGICAL MAP BETWEEN AMOY & LUNGYEN FUKIEN PROVINCE

第三版 厦門及龍溪

Plate III — Amoy & Lungchi

等高線距離五十公尺

Contour interval 50 m.



圖例
Legend

M — 第四紀 *Quaternary* 冲積層 *Alluvium*

N — 洪積統 *Pleistocene* 沙礫層 *Sands and Gravels*

E — 第三紀 *Tertiary* 紅土及礫石層 *Red clay and Conglomerate*

Vb — 第三紀 *Tertiary* 柳會社玄武岩 *Liuhuisheh Basalt*

Cr — 白堊紀 *Cretaceous* 兜嶺火山岩及白砂紅色砂礫岩 *Touling Volcanics and Paisha Red Sandstone & Conglomerate*

Tr — 三疊紀 *Triassic(?)* 洋坪頁岩 *Yangping Shale*

Pu — 二疊紀上部 *U. Permian* 翠屏山砂頁岩 *Tsuipingshan Sandstone & Shale*

Pc — 二疊紀中部 *M. Permian* 大羽羊齒植物煤系 *Gigantopteris Coal Series*

Pl — 二疊紀下部 *L. Permian* 棲霞燧石石灰岩 *Chihsia. Cherty Limestone*

C — 石炭紀 *Carboniferous.* 南靖石英岩 *Nanching Quartzite*

Gn — 太古界 *Archaean* 片麻岩 *Gneiss*

Qp — 石英斑岩 *Quartz porphyry*

Gr — 花崗岩 *Granite*

Scale 1 : 200,000 0 1 2 3 4 8 12 16 20 Km. 比例尺二十萬分之一

侯德封 王曰倫 張兆瑾 王景尊 測

民國二十二年秋

Surveyed by T. F. Hou, Y. L. Wang, C. C. Cheng & C. K. Wang

In the Autumn of 1933

Plate IV 第四圖

福建龍岩煤田地質圖

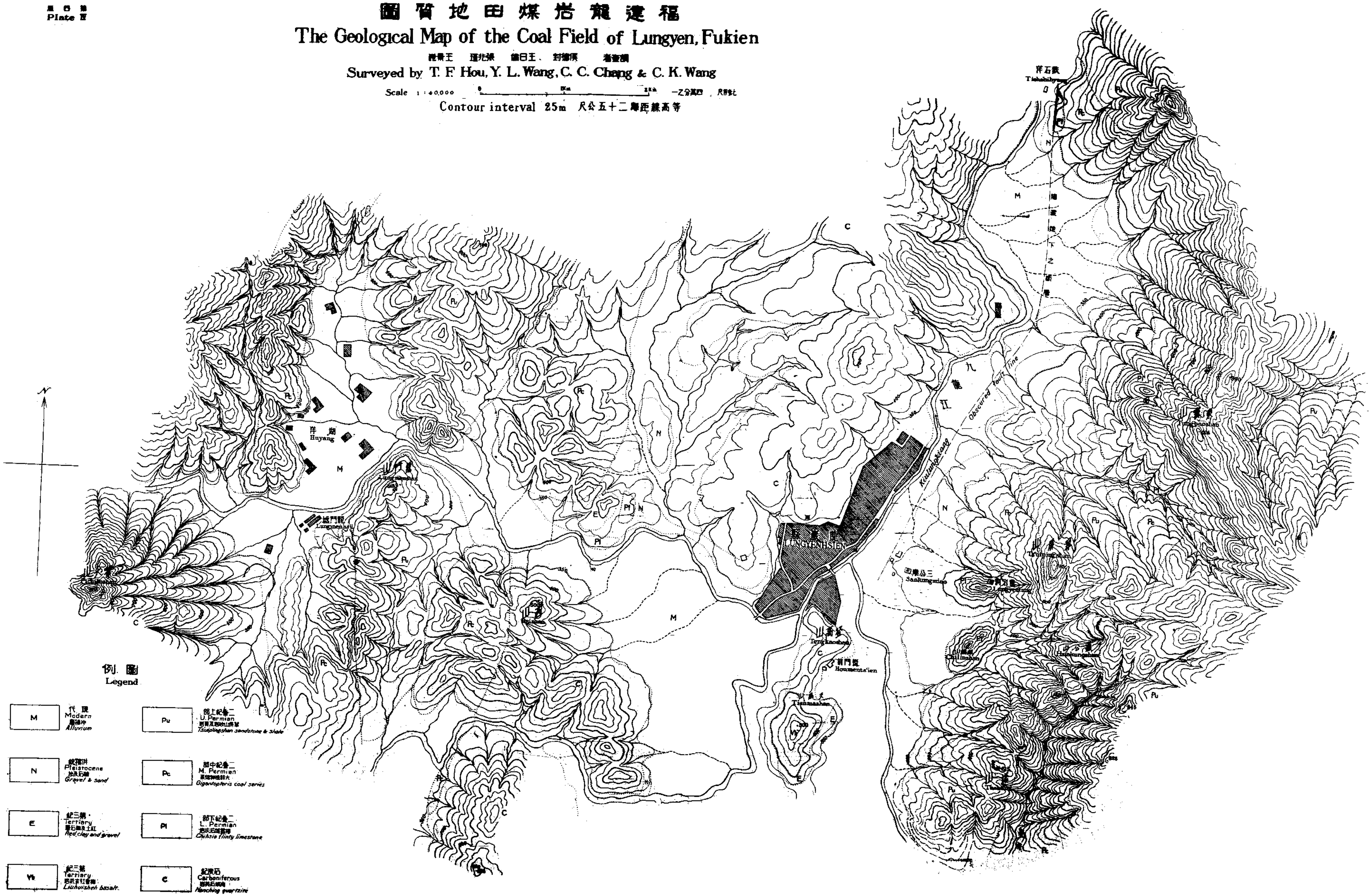
The Geological Map of the Coal Field of Lungyen, Fukien

侯德封、王日倫、張兆瑾、王景尊 調查

Surveyed by T. F Hou, Y. L. Wang, C. C. Chang & C. K. Wang

Scale 1 : 40,000 比例尺 四萬分之一

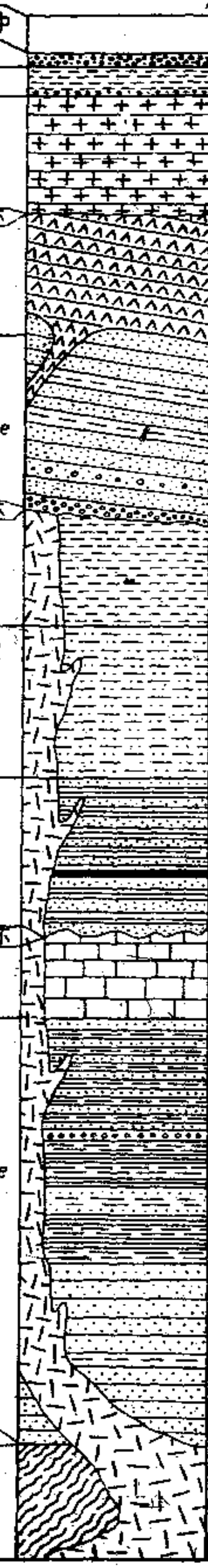
Contour interval 25m 等高線距離二十五公尺



福建西南部地質柱狀剖面圖

Generalized Columnar Section of the Geological Formations of S. W. Fukien

第五版
Plate V



		Meters		
Modern 現代	Alluvium 沖積層		Loose sand clay and gravel	最新之鬆散粘土沙礫等
Pleistocene 洪積統		20	Sand and gravel beds above the river bank or in broad valley	沿河或寬谷內之沙土及礫石
第三紀 Tertiary		50	Red clay and conglomerate contain shells of oystrea	紅土及礫石含有古代之蠣殼
	柳會社玄武岩 Liuhuisheh basalt	200	Basalt	玄武岩
	Unconformity 不整合			
白堊紀 Cretaceous	兜嶺火山岩 Touling volcanics	200	Rhgolite, tuff, andesite and quartz porphyry	流紋岩凝灰岩安山岩及石英斑岩等
	白沙紅砂岩 Paisha red sandstone	300	Red sandstone, mostly in massive form, intercalates with shales in which one thin layer of brown coal occassionally occurs & one bed of quartz conglomerate exists at the base	紅砂岩及少量之頁岩有時夾極薄之褐性烟煤一層又常見石英礫岩於砂岩之底部
	Unconformity 不整合			
三疊紀 Triassic	洋坪頁岩 Yangping shale	180	Ochre, brown and greenish gray shales, some part calcareous, and some thin sandstones	黃紅及綠灰色頁岩有時畧帶鈣質並夾薄層砂岩
二疊紀 Permian	翠屏山砂頁岩 Tsuipingshan Sandstone & shale	250	Green, gray and yellowish brown shales with a few intercalatings of sandstone, fresh and saline water faune were found alternatly or sometimes combined	綠灰黃等色頁岩及少量之砂岩下部富含化石淡水動物群與海水動物群常相混而生
	大羽植物煤系 Gigantopteris coal series	250	Interbedding shales and sandstones embed one seam of anthracite from 0.5–1.6 m thick and gigantopteris nicotianaofolia was found in the black shale just above the coal seam	砂岩與頁岩相間成層產無烟煤一層厚自半公尺至一公尺六寸不等煤層之上黑色頁岩內盛產大羽植物化石
	Disconformity 不連續			
	棲霞石灰岩 Chihsia limestone	0–150	Dark gray limestone with flint nodules	含燧石之灰岩
石炭紀 Carboniferous	南靖石英岩 Nanching quartzite	200	Gray and green coloured shales interbedding with quartzose sandstone and a bed of quartz conglomerate occurs in the base	黑灰綠等色之頁岩夾石英砂岩底部有時見石英礫岩一層
		200	Shale, slate and claystone interbedding with thin beds of quartzite	頁岩片岩及粘土石與石英岩相間成層
		300	Massive quartzite, white to flesh colour	白色及肉紅色之厚層石英岩
	Unconformity 不整合			
太古界 Archaean	片麻岩 Gneiss		Mesozoic granite intrussion	新生代之花崗岩侵入體

閩南地層構造剖面圖

General Sections of S. W. Fukien showing the Structural Features

Horizontal scale 2 Km   Vertical scale 1 Km

第六版
Plate VI

6

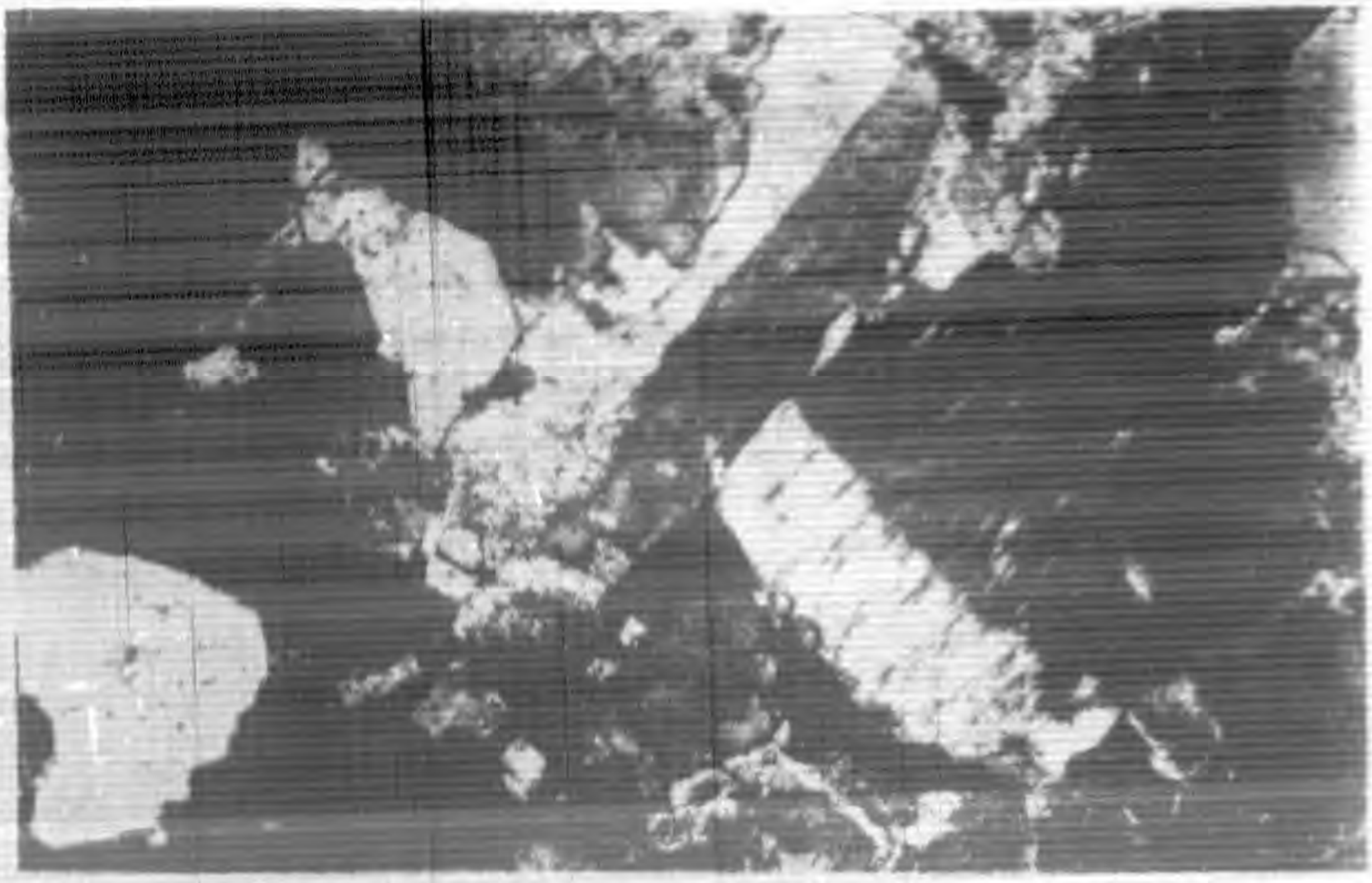


Fig. 1. 龍岩九洲花崗岩. 其長石雙晶與六方晶體之雲母甚明顯.
(在正交偏光鏡下放大 52 倍)

Granite ×52. +N. Showing the Carlsbad twin of orthoclase, hexagonal muscovite and angular fragments of quartz (white).

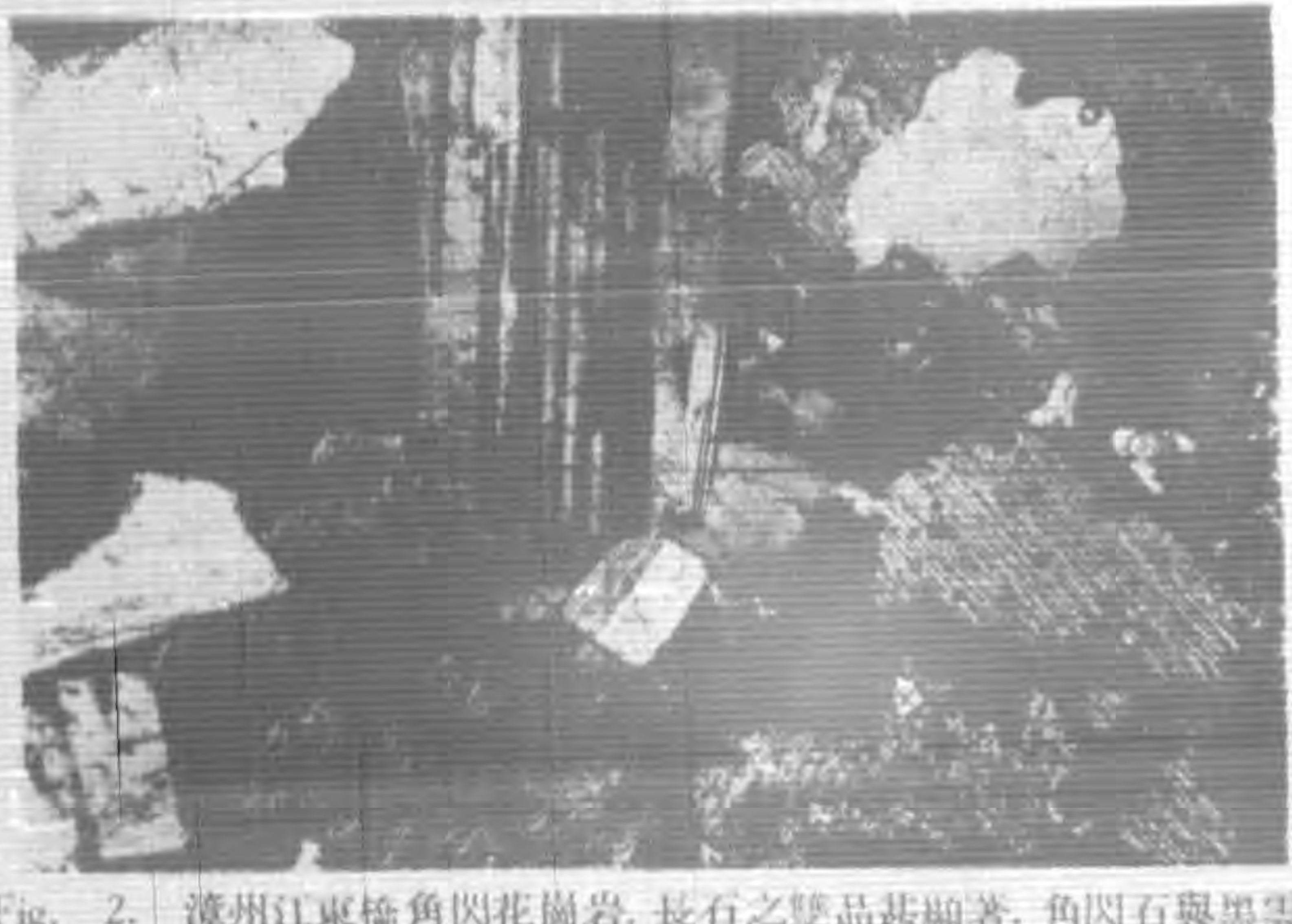


Fig. 2. 漳州江東橋角閃花崗岩. 長石之雙晶甚顯著. 角閃石與黑雲母均呈黑色 (在正交偏光鏡下放大 52 倍)

Hornblende granite ×52. +N. Kiangtungchiao. Albite showing the Carlsbad twin intergrowing with orthoclase, angular fragments of quartz (white). Hornblende and biotite show the dark gray or black colour.

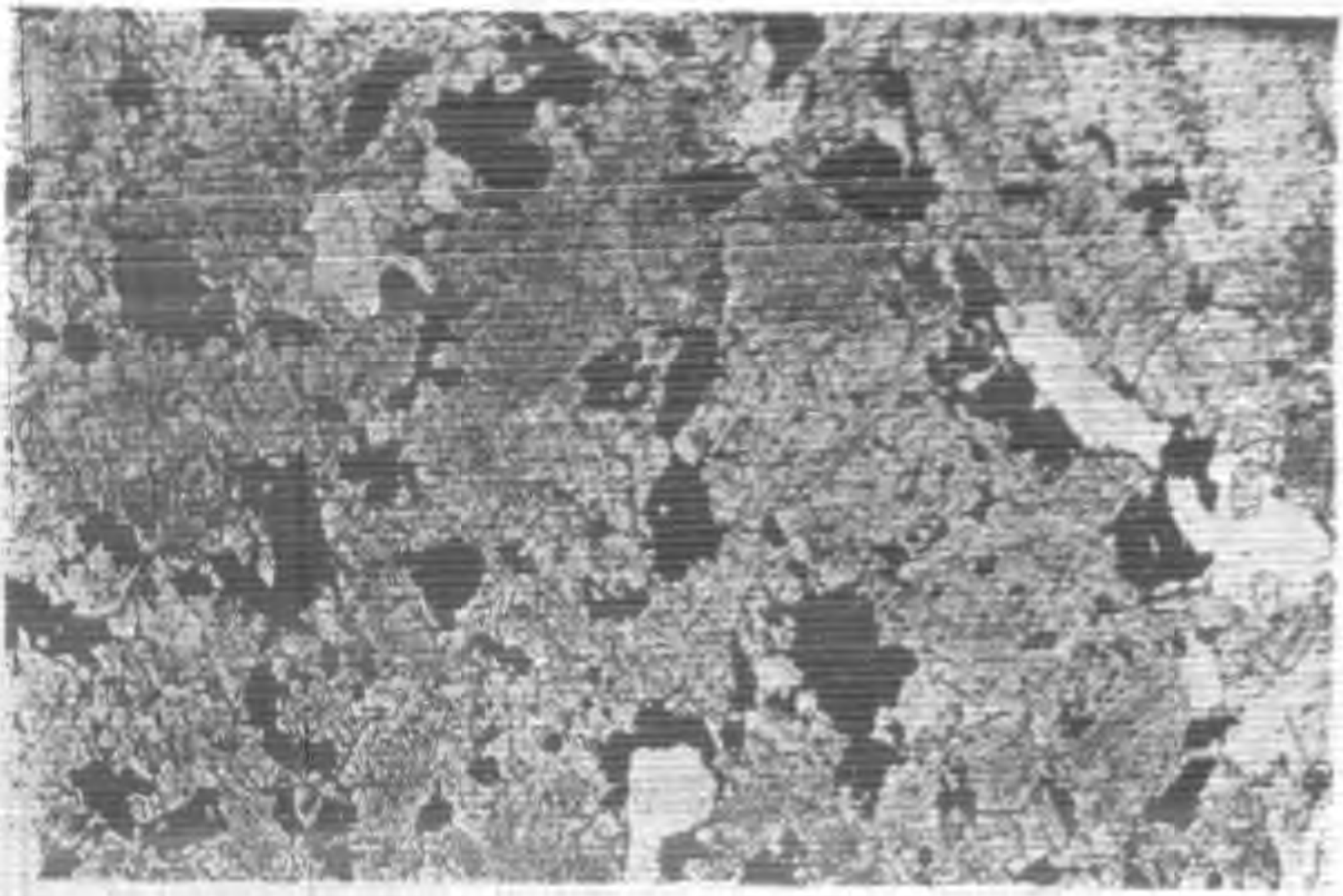


Fig. 3. 龍岩兜嶺花崗岩. 石英與長石皆成碎片狀. 磁鐵鑛呈黑色塊狀(放大8倍)

Granite ×8. Touling, Lungyen. Showing the crushed quartz (white) and feldspar (gray), magnetite and titanite (black) with granular and prismatic form.

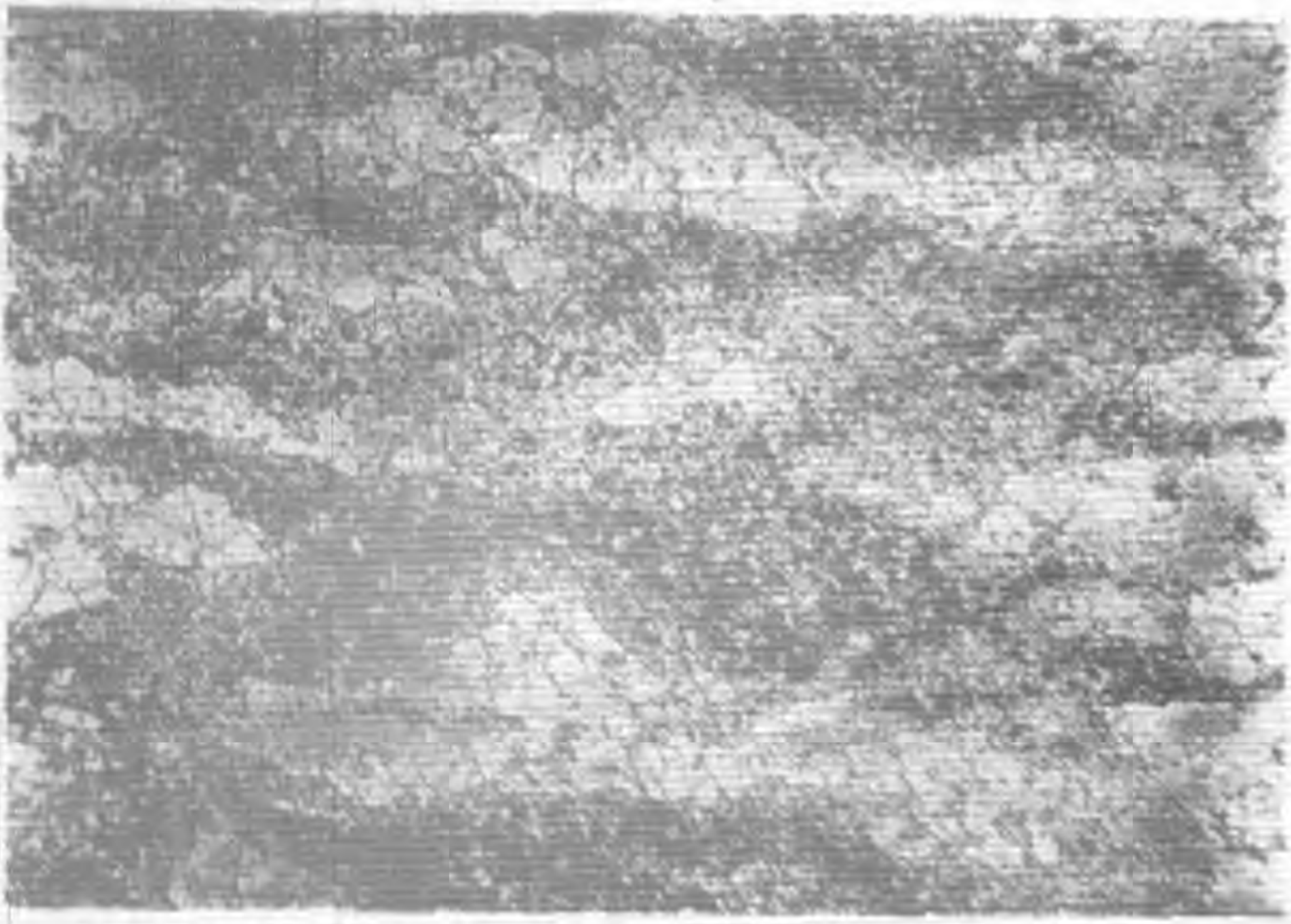


Fig. 4. 海澄海倉亭片麻岩(在正交偏光鏡下放大42倍)

Gneiss ×42. +N. Haitsonting, Haich'enghsien. Showing the granitic or orthogneiss with distinct gneissic structure.

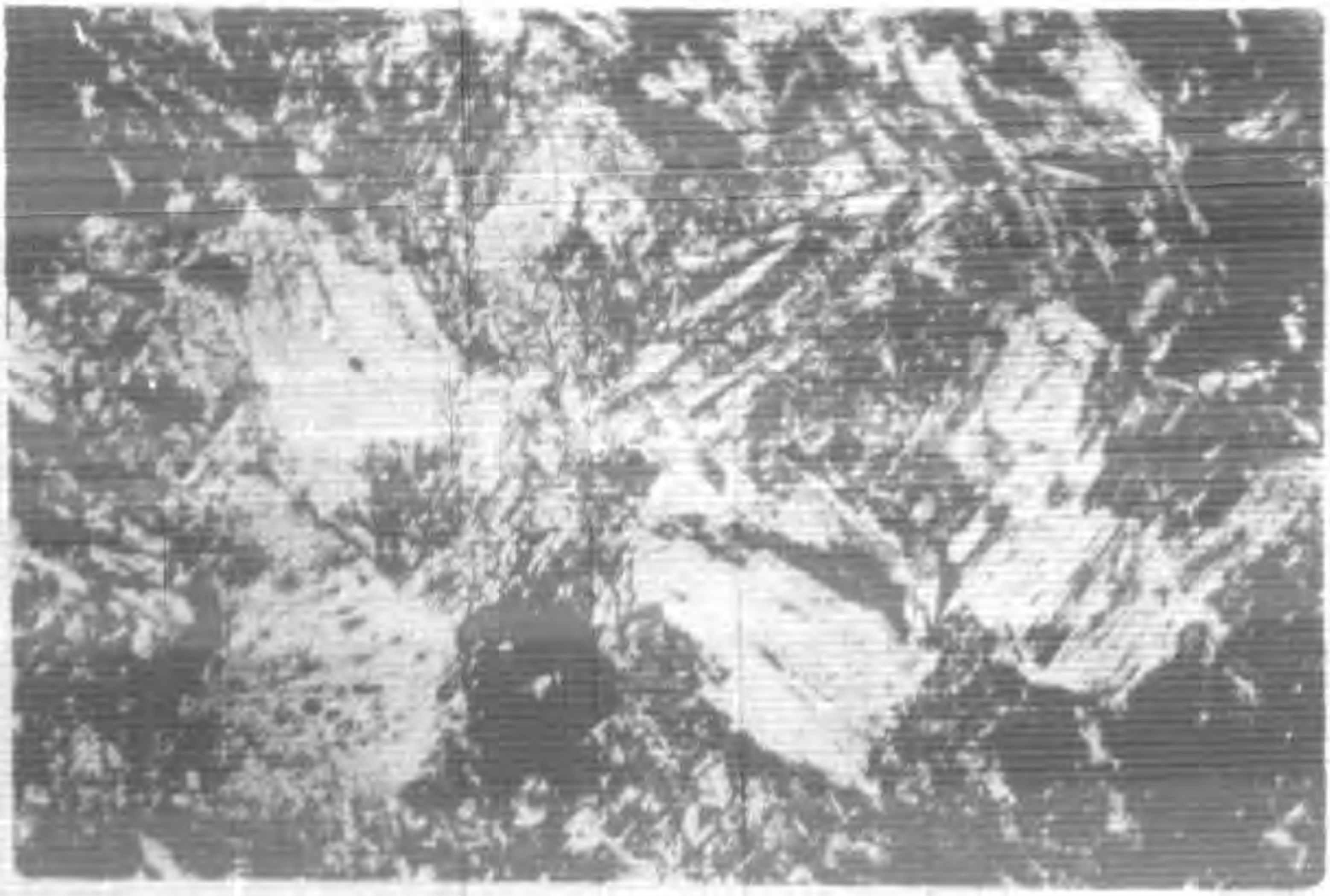


Fig. 5. 龍岩大橋頭閃長煌斑岩. 柱狀角閃石(已變成綠泥石)與長石共生. 中含少量磁鐵鑛(在正交偏光鏡下放大42倍)

Camptonite ×42. +N. Tach'iaot'ou, Lungyen. Prismatic hornblende (gray) partly altered to chlorite, feldspar (mostly plagioclase) and few magnetites are present.

Fig. 6. 漳州江東橋文像斑岩. 石英與長石共生顯文像結構. 中有一結晶顯著之長石斑晶. 並有其雙晶存在. (在正交偏光鏡下放大42倍)

Granophyre. ×42. +N. S. Kiangtungch'iao, Changchow. Showing the graphic texture and intergrowth of quartz and feldspar. Phenocryst of orthoclase with conspicuously fine crystal form and Carlsbad twin.

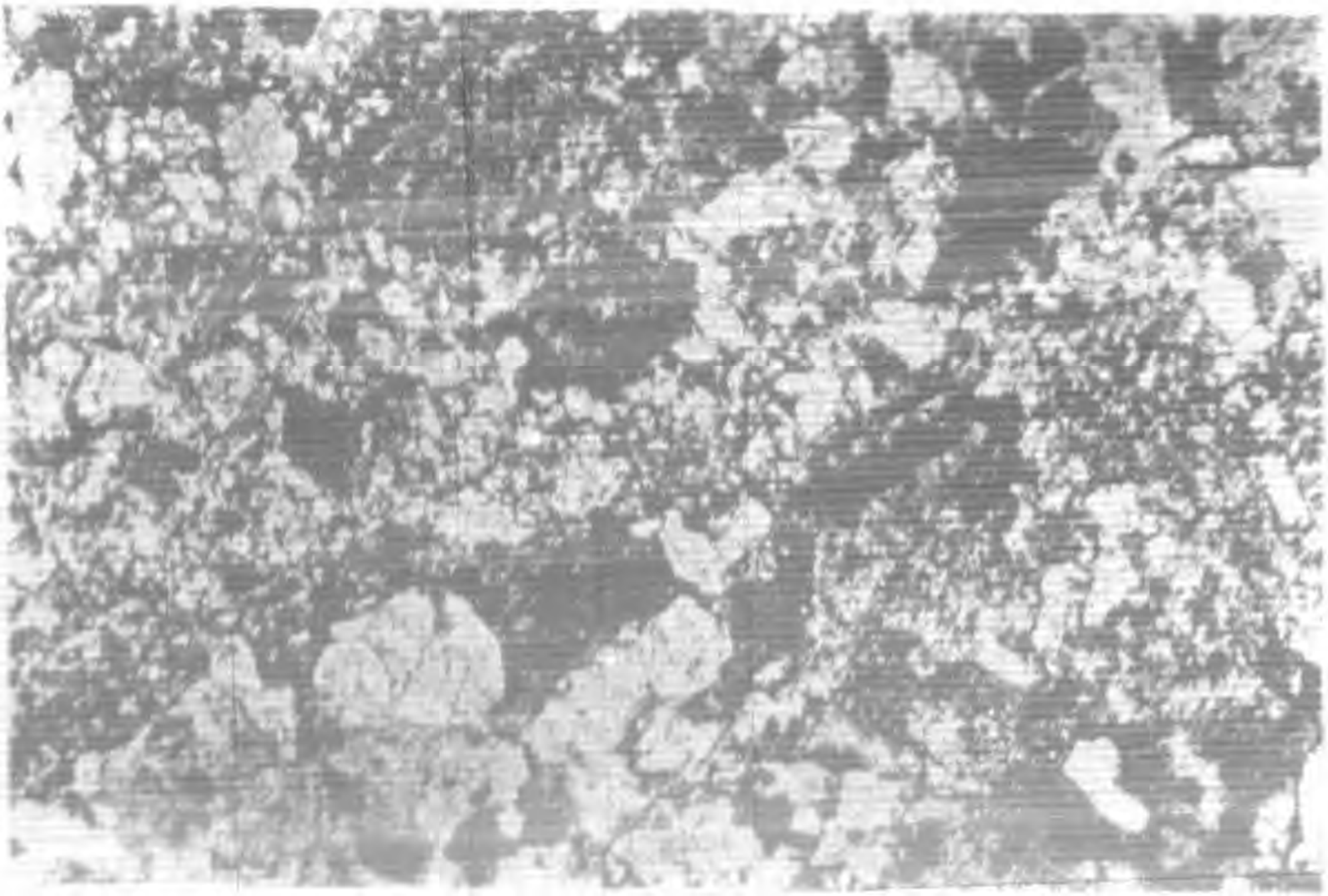


Fig. 7. 龍岩大橋頭花崗斑岩. 主要斑晶為長石與角狀石英(放大8倍)
Granite porphyry ×8. Tach'iaot'ou, Lungyen. Phenocrysts chiefly feldspar and angular fragmental quartz with coarsely crystalline groundmass of biotite, feldspar and quartz.

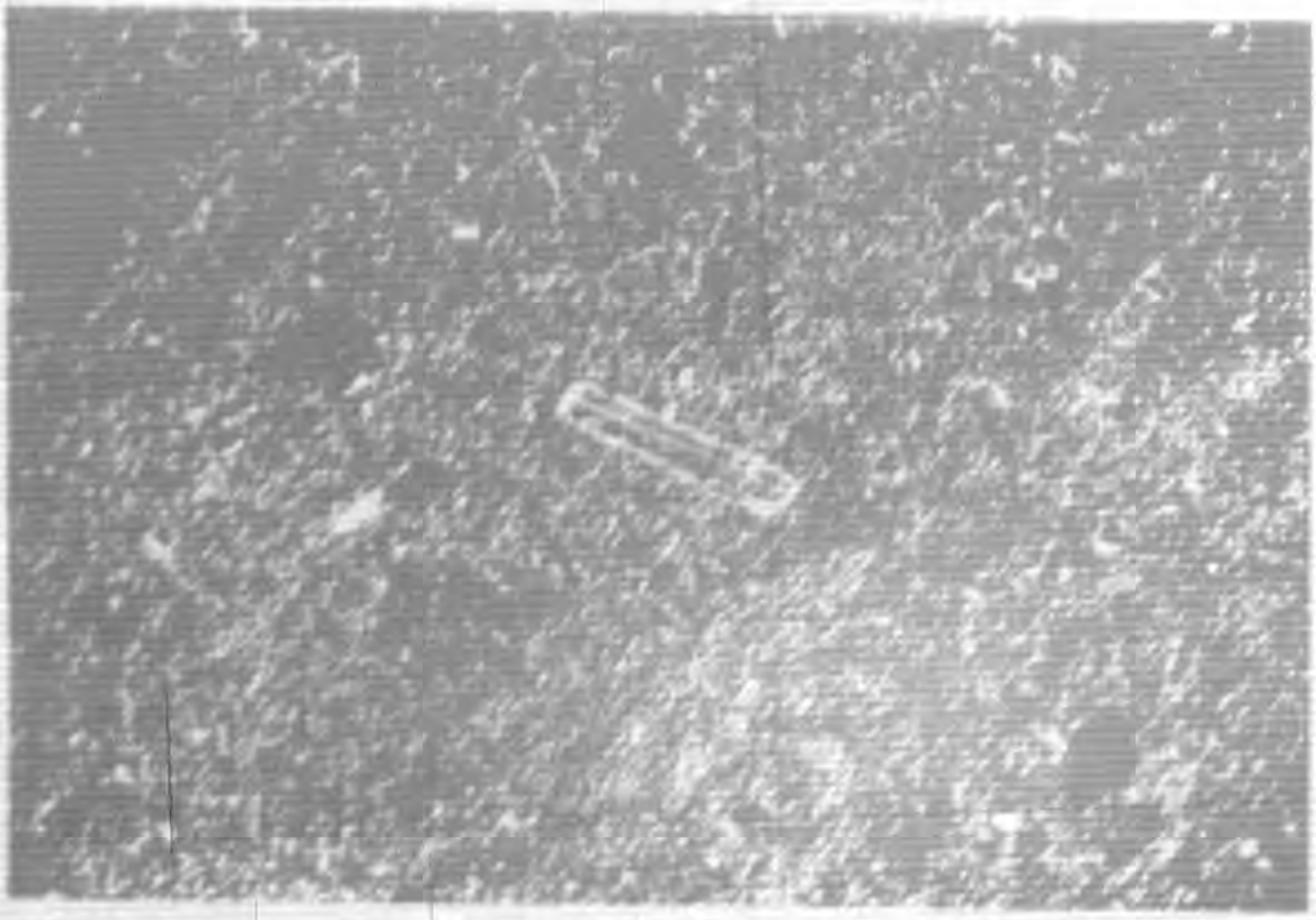


Fig. 8. 龍岩洋頓火山凝灰岩. 柱狀呈平行劈開面之斑晶, 包在微小之基晶中.(在正交偏光鏡下放大42倍)
Volcanic tuff ×42. +N. N. Yangtun, Lungyen. Uniform arrangement of quartz and feldspar in groundmass, in which biotite crystal showing the parallel cleavages.

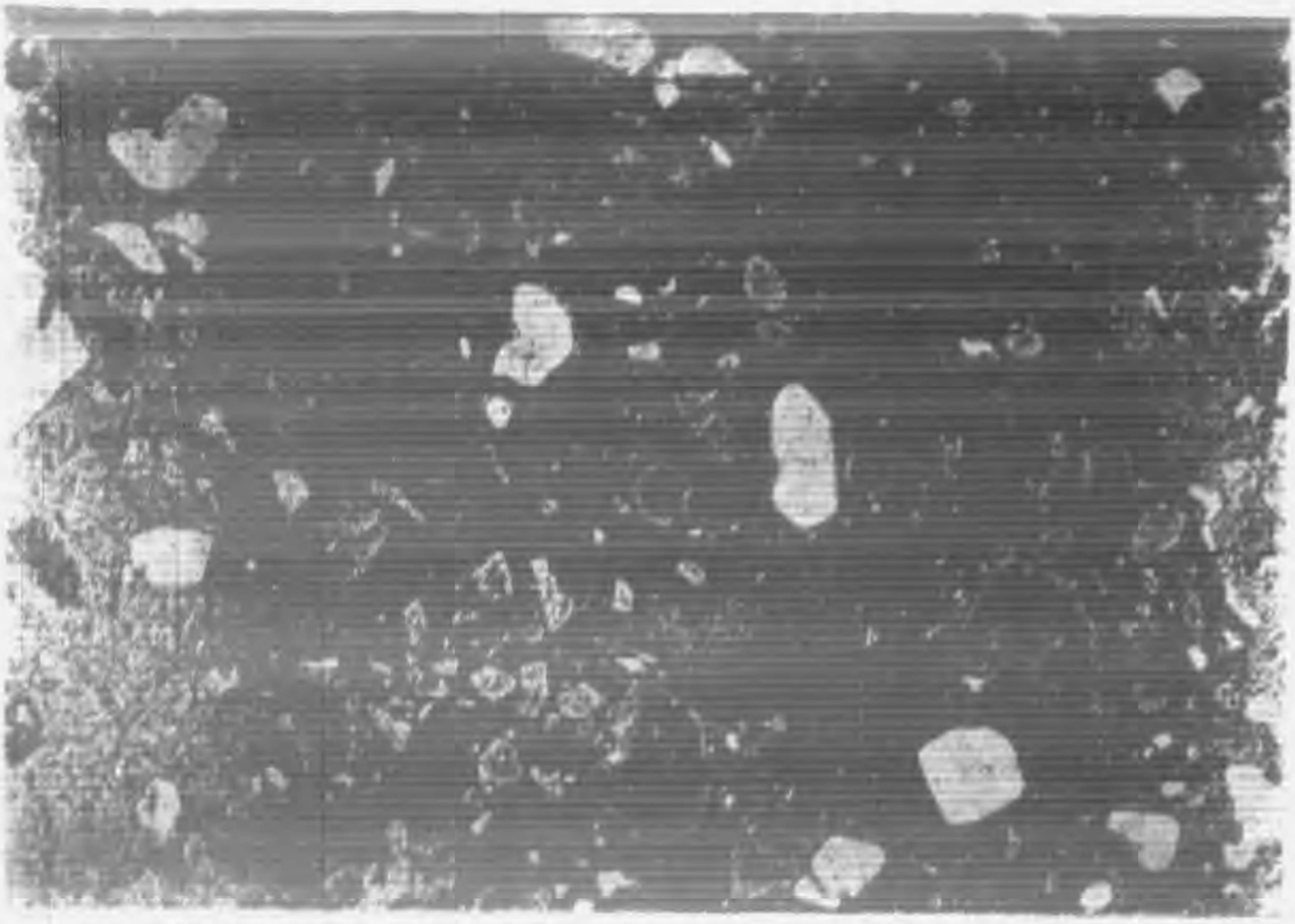


Fig. 9. 華安涵口流紋岩(放大8倍)顯示流紋狀結構及玻璃質基晶.
Rhyolite × 8. Hank'ou, Huaan. Showing the conspicuous flow structure. Phenocrysts of hexagonal mica and fragmental feldspar with twinning and angular fragmental quartz among the glassy groundmass (dark gray).

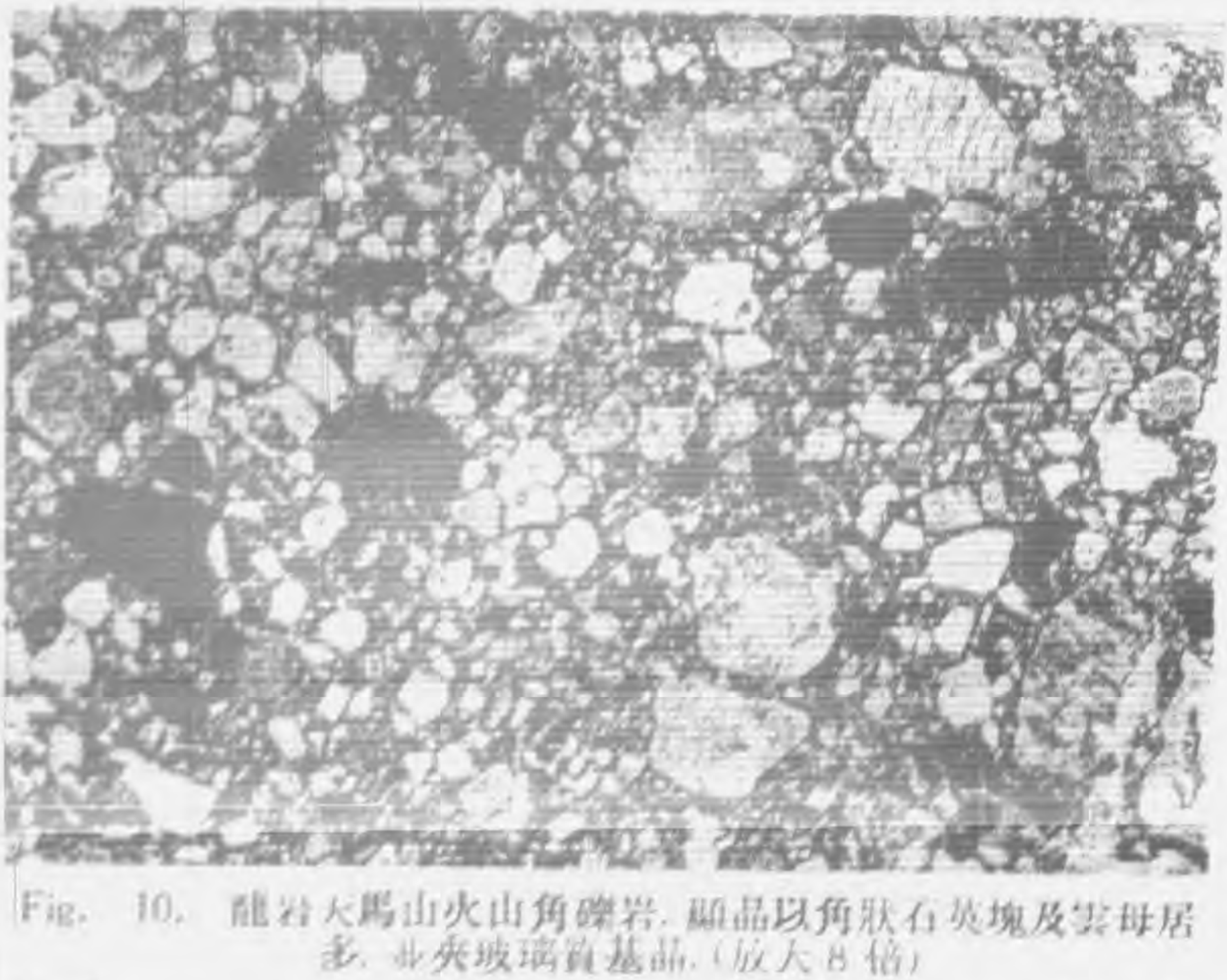


Fig. 10. 龍岩天馬山火山角礫岩. 顯晶以角狀石英塊及雲母居多. 並夾玻璃質基晶. (放大8倍)
Agglomerate × 8. Tienmashan, Lungyen. Phenocrysts of angular fragments of quartz and hexagonal mica, feldspar (gray), and some ferruginous minerals (black). Quartz and mica [illegible] texture around the volcanic ash. (dark gray).

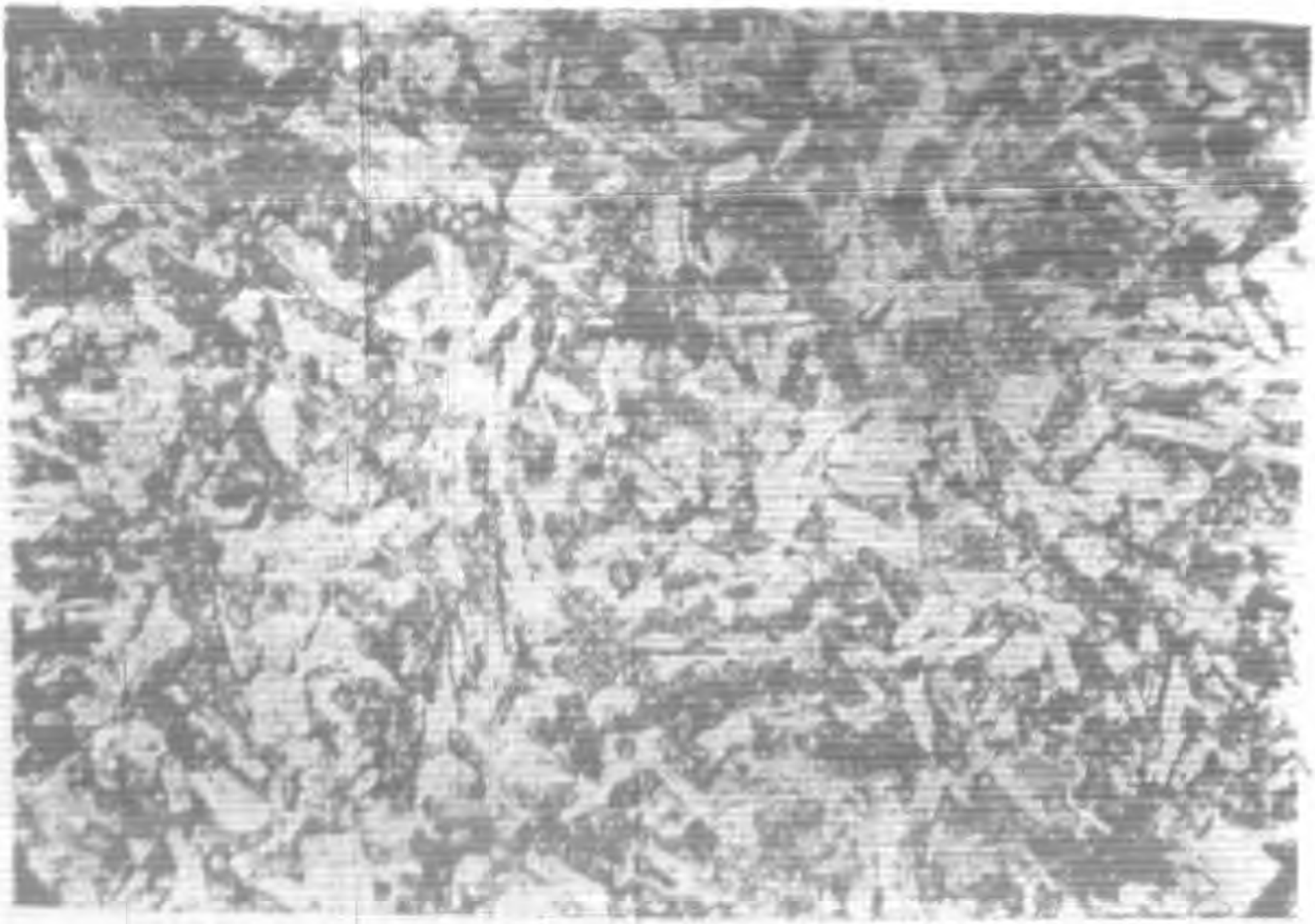


Fig. 11. 海澄柳會社玄武岩. (在平行偏光鏡下放大 42 倍)
Basalt ×42. ∥N. Liuhuisheh, Haichenghsien. Showing the prismatic olivine and polysynthetic twin of andesine.

Fig. 12. 漳州丹林鏡鐵礦 在反光鏡下放大 120 倍. 常與石英小粒組成纖維狀褶皺之結構.

Specularite. ×120. Polished section under R. L. Tanling, Changchow. Showing the fine lamination being folded fibrous structure with crypto-crystalline quartz and specularites.

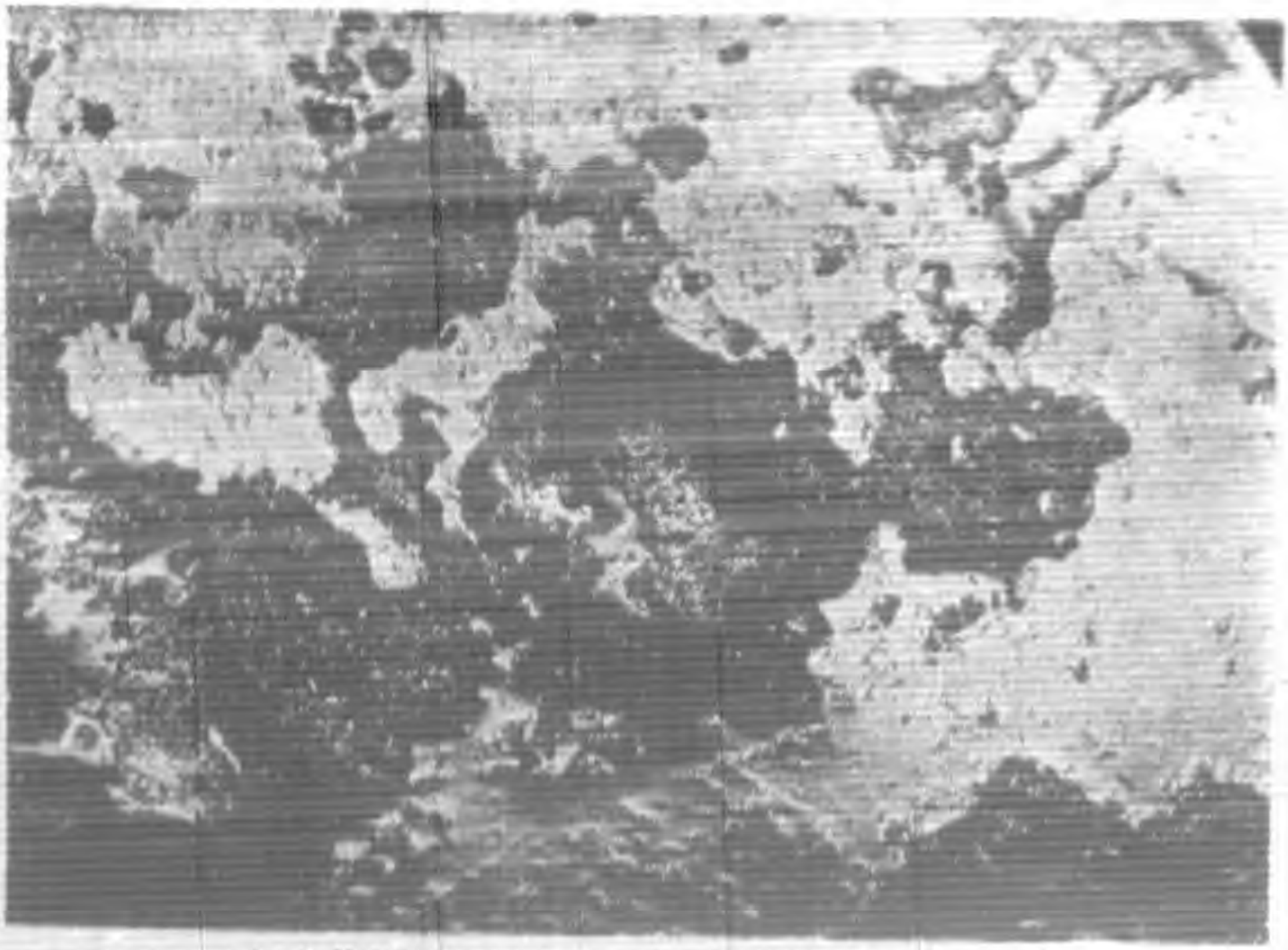


Fig. 13. 漳平草洋褐鐵鑛由磁鐵鑛變來之情狀. 有小六方晶形之石榴子石間雜其內. (在反光鏡下放大 120 倍)

Limonite after magnetite. ×120. R. L. Tsaoyang, Changping. Limonite (gray) around the margin of magnetite (dark gray) with small crystals of garnets.

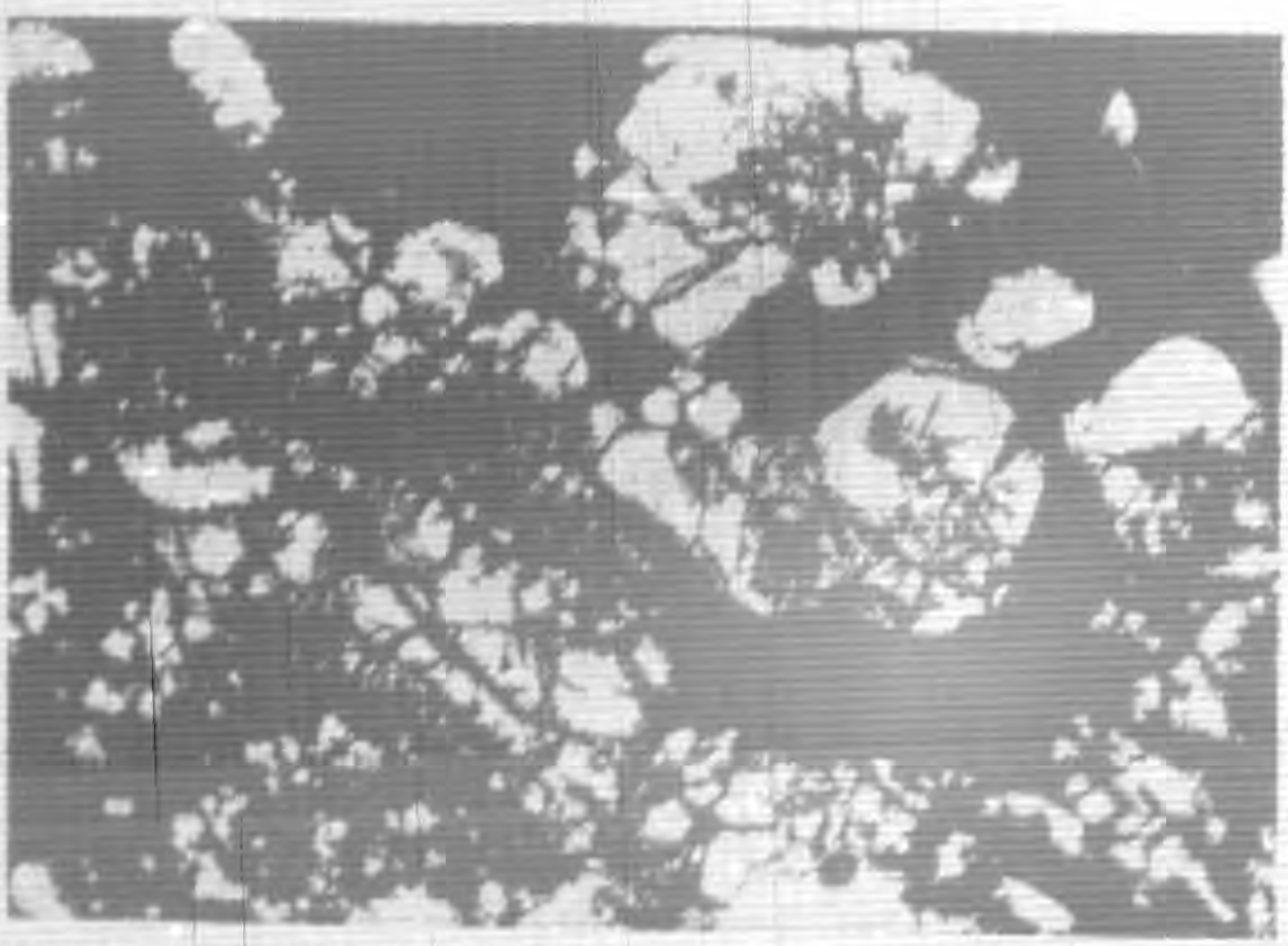


Fig. 14. 華安洛陽赤鐵鑛. 此赤鐵鑛與呈六方晶體之石榴子石共生 (在平行偏光鏡下放大 42 倍)

Hematite ×42. ∥N. Loyang, Huaan. Hematite (dark gray) associated with crystals of garnet (six-sided, whitish gray color). Some small grains or angular fragments of quartz are present (light gray).

秦嶺東部地質觀察

巴爾博　德日進　卞美年著　卞美年節要

引言

秦嶺已久經學者視為華北華南之天然地質界綫，但前人之觀察多集中於陝西甘肅境內，而秦嶺東部則尚乏調查。今夏吾人遵新生代研究室已故名譽主任步達生先生之計劃，以便與黃河揚子江流域之新生代地質互相比較參證，遂作秦嶺東部地質之觀察（註一）

河南省地質調查所曹世祿君已於河南西部及中部作有詳細之地質礦產調查（河南省地質調查所地質報告書第二號）。吾人於此行中未得與之一見，頗覺悵然！

第一章　分段觀察

（一）洛陽至長水　洛河於此段中大致東流而稍向北偏，河谷寬闊，南岸多絕壁，或為斷層所致，於宜陽見鯿狀石灰岩（寒武紀），其上部或為奧陶紀之石灰岩與石炭紀之煤系，與山西古生代之層系相似（河南省地質調查所彙刊第一期王猷君之宜陽地質報告），北岸多低丘，範圍甚廣，為新生代複雜地層所成，由長水西南高處回顧，見丘頂連亘成平面地形，高出現時之河谷約三百公尺（卽巴爾博之洛河侵蝕面—地質學會誌第十三卷第三期，見第一版第一圖），地層大致可分上下兩部，下部以粗散砂礫岩為多，內含安山岩礫，而細質沉積則較少，在延秋境內之下部地層傾度甚大（第一圖），而他處則頗似水平（第二第四圖），由風化之程度與變動之情形觀之，新生代複雜地層之下部，或與山西垣曲縣之始新統地層相近（安特生—地質專報甲種第三號）。上部為土狀之堆積覆蓋於下部之上，內含底礫岩與有結核之紅壤土，由岩石性質與地文情形觀之，上部之堆積可謂與山西下更新統含丁氏田鼠（*Siphneus tingi*）之紅色土相當

洛陽長水間有似黃土之堆積，層序大致如第三第五圖。

(二)長水至盧氏　於此段中洛河多穿行峽谷中。安山岩成二山脈，作東北西南走向，斜度三十向東南，有石英脈橫穿其中，想附近必有侵入花崗岩，在故縣西南之十八盤，於稍變質之砂岩，板岩與白粘土中見有安山岩流(第十圖)，由沉積岩與安山岩之岩性觀之，其為期似中生代(侏羅紀)，但山西垣曲縣相類之安山岩，據安特生之觀察(地質專報甲種第三號)為震旦紀石英岩中之岩流。若安特生未以侵入岩層作岩流，洛河之安山岩則又可為寒武紀前之岩流，河南魯山縣亦有相似之震旦紀岩流（高振西，熊永先，高平，地質學會誌第十三卷二六五頁)。

洛河之安山岩為一次重要之岩流，其噴發時期不可確定，先受第三紀早期之劇烈切蝕，後為斷層所分裂，再後為洛河侵蝕所平。

於安山岩斷裂塊中有第三紀之盆地二，卽崇陽(第八圖)與盧氏盆地，亦作東北西南之走向(參閱秦嶺東部路線地質圖)地層傾向為西南，而斜度不一。堆積甚厚(約三千公尺)，大部為粗散碎塊之堆積或粗面礫岩，下部常有細質之沉積，如紅粘土與白泥灰，覆蓋於安山岩與掀斜之第三紀地層上者，為分佈普遍之含結核紅壤土(下更新統)，黃土期之堆積間或見之（第七，九，十，十一圖)。

(三)盧氏至峪堂溝(參閱地質剖面圖A）　盧氏南第三紀之地層，大部為礫岩與砂岩，間疊而成，礫岩多含石灰岩礫而無安山岩，此砂礫岩系顯然與秦嶺本部之地層作斷層之之接觸，但近洛河本身礫岩下之粘土，雖無底礫岩，可認與未變質之石灰岩（震旦紀？）作不整一之接觸。

嶺根南則入秦嶺山之北軸部(第一版第二圖)。由第三紀之礫岩一變而為石灰片岩。老尖嶺北，岩石多受花崗岩化之作用，大部為片麻及角閃岩，並有藍色黑雲母花崗岩間雜其中，後者更多為後期較紅之花崗岩所侵入。岩石雖受花崗岩化作用，然變質並不完全，因近嶺根與老尖嶺尚有未變質石灰岩之露頭，其岩性無異與尋常古生代之石灰岩也。

老尖嶺南，初為變質石灰岩與礫岩，二者全受石英之侵入，並極為絹雲母化，又時被東西走向之花崗岩脈所侵入。往南二十

里，變質作用則較小，多微綠色之板岩，傾度甚烈，繼之有堅硬之底礫岩（厚度十公尺，礫石大抵圓滑，多石英，石英岩，砂岩，但無石灰岩），礫岩之上爲厚層之石灰岩(厚度過一千公尺)，傾向南，斜度甚大，與下部之板岩相整合。

吾人因無化石之根據，故不能確定上述板岩與石灰岩二系之地層位置，但由岩石性質觀之，其時期似爲古生代，因震旦紀前之岩系中，含有幾未變質之石灰岩者，實屬罕見。

更據趙亞曾黃汲清二君之調查(地質專報甲種第九號)，秦嶺中部東西走向之古生代地層，下爲寒武奧陶紀之板岩與志留紀之石灰岩，上有泥盆紀之底礫岩與厚層石灰岩 大致情形與吾人所見者相同，故厚層石灰岩系與其底礫岩可暫定爲泥盆紀地層。底礫岩下部之板岩系爲志留紀。

若此假設，能一旦證實，則秦嶺東部實無趙黃二君所謂之秦嶺系(五台系)，甚或秦嶺系之能否存在，尚屬疑問！

(四)峪堂溝至黃沙　石灰岩系所成之山脈南，爲五道河第三紀斷層盆地，作西北東南走向，堆積大部爲礫岩，多含花崗岩礫，時有薄層紅白粘土間隔其間，底部紅色粗散之長石砂與花崗岩成堆積之接觸。地層之傾斜向盆地中軸，盆地南北兩旁斷層接觸處，斜度較大 花崗岩受風化之程度甚烈，與石灰岩之關係不能確定，但斷層接觸之解說，似較妥當，因近花崗岩之石灰岩並未受變質之作用也。於此盆地中，吾人並未見晚期堆積覆蓋於礫岩之上。

(五)黃沙至北峪(參閱地質剖面圖B)　五道河與灌河之間爲秦嶺山之中軸部，山地多深谷，似爲隆起侵蝕平原，再受劇烈之切蝕作用所成。岩石以結晶片岩爲多，如灰色條紋之角閃岩，間雜其中有黑雲母花崗岩或白雲母偉晶花崗岩，又時有變質石灰岩(純潔或不潔之大理岩，多含透輝石與異剝石之結晶)。灌河盆地北有如是之變質石灰岩組成山嶺，作東北傾向，似與南陽區之大理岩有相連之關係。秦嶺山北軸部之地層大致作東西走向。於中軸部則顯然轉爲西北東南向。

於灌河上游之蜿曲河谷中，得見二十公尺之階段，尚有稍固結之礫石掩覆於其上。

(六)北峪至西峽口　灌河斷層盆地中第三紀之堆積，礫岩較少而多粗散之砂岩。地文甚爲顯著，河旁可分三階段如下，其他

情形則與五道河盆地相似：

(甲)一百公尺之高階段(第十二圖)，範圍甚廣，但上無保存之礫石。

(乙)二十公尺之中階段，有稍固結之礫石保存於其上，與灌河上遊所見之二十公尺階段相當，為含結核紅壤土時期所成（下更新統）

(丙)十公尺之低階段，稍高於現時之氾濫平原，多礫石與灰色壤土(黃土時期)。

(七)西峽口至淅川(參閱地質剖面圖C) 西峽口南，灌河會淅川而南流，橫穿東西走向直立之剝層雲母片岩，成為淺峽谷。片岩有石英之侵入，並多薄層純淨之石墨，可認為秦嶺山南軸部之地層。

上集北七里許，秦嶺山軸部之地質於此告終，而華中華南古生代之厚層岩系則由此起始。界線作西北東南之走向，無逆掩斷層之確證，而顯然為垂直斷層之接觸，無噴出岩之侵入，而岩石受動力變質之作用甚大，近接觸處，數百公尺之石灰岩，因壓力所致，成淺紅色之堅硬斷層角礫岩，稍有結晶之作用，往南有顯明之摺曲(內斜層?)，內多片狀石印灰岩，吾人根據曹君之觀察，並以內鄉西部有泥盆紀之地層，暫定其時代為志留紀

由上集往南，直至淅川縣，淅川穿行於多穴灰岩之高原，石灰岩摺曲甚緩，稍有結晶與矽質之集合，但無化石。由曹君與李捷，朱森二君(中央研究院地質研究所集刊第九號)之調查觀之，此岩系可屬於震旦紀。

西峽口與淅川之間，地文情形與灌河所見者相同，覆蓋於中階段之上為含結核之紅壤土與其底礫岩。在秦嶺南坡，此為紅壤土之初次發現，雖無化石之證據，吾人認其與華北丁氏田鼠層 (*Siphneus tingi* Beds) 之紅色土相當。

淅川縣北於王莊之附近，高出中階段之上，尚有較古之階段保存，範圍甚小，覆蓋其上為十二公尺厚之白砂及砂岩，砂岩下為底礫岩(第十三圖)，未受掀斜，或為上新統之堆積。

(八)淅川盆地　湖北東北與河南西南界之第三紀地層已由李朱二君所發現之奇蹄類化石 (*Lophialetes* sp.)，德日進，地

實學會誌第十一卷三三一頁），確定爲上始新統。淅川境之地質曹君已有報告。由地層之岩石性質與構造觀之，淅川盆地與五道河及灌河盆地當爲同時所成。

淅川盆地之西北隅，面積狹窄，位於震旦紀石灰岩層之中，大部爲礫岩與紅粘土間疊而成，因受擠迫而成內斜層，東南部多紅，白色之細砂及灰泥。掩覆於山坡上爲含結核之紅壤土，近丹江，紅壤土則與二十公尺中階段上之礫石相連(第十四圖)

(九)淅川至內鄉　於此段中，因乘汽車，觀察殊屬倉卒，但可注意者凡三點．

(甲)古山鋪之東，紅壤土之下有泥灰岩，未受掀斜，或爲上新統之沉積並與下述之南陽系相當。

(乙)於杏樹眼，自石灰岩塊中得泥盆紀腕足類化石少許：*Cyrtiopsis* sp: *Sinospirifer sinensis* (爲葛利普所鑑定)，泥盆紀，石灰岩下爲厚層之深紅板岩及片狀石灰岩(志留紀?)吾人雖未得詳細考察該地之地質，但據此發現，可證實泥盆紀岩層之分佈較前人所觀察者，頗爲東展。

(丙)於內鄉附近見有厚層含結核之湖相(?)石灰岩，爲期或與南陽系相同。

(十)由內鄉經南陽至許昌(參閱第十五圖)　南陽縣城附近有孤立之小山嶺。城北十五里之獨山爲閃長岩所成，本地人多於斯山採掘所謂獨山玉之似玉質礦石，其他如蒲山及豐山大部爲條紋大理岩所成，內含似藻類 (*Collenia-like*) 之結核團集，南陽變質區或爲秦嶺山軸部地質之東展而稍南折。

南陽東北，沿平原之秦嶺山脈，多爲震旦紀之紅色與灰色石英岩所組成。

由內鄉至許昌，秦嶺南坡下之冲積平原多緩坡之低丘，爲白色或綠色之砂性粘土所組成，少有礫石，而粘土中常有綠色之豌曲斑點(第十六圖)，似湖河相之沉積，吾人命名爲南陽系 (上新統，註二) 。南陽系之上部因久經熱帶氣候之風化而變深紅色並含多數之鐵質豆石。

於南陽系沉積之上爲分佈普遍之含石灰質結核紅壤土所掩覆，土下時有固結之礫石。

馬蘭期之堆積爲灰色散砂或壤土

第二章　總述

(一)秦嶺東段軸部地層性質與構造

軸部多花崗岩及受花崗岩作用之地層，南北以斷層線爲界，而無逆掩斷層之確證，南面(上集)之界限較北面(盧氏)爲顯明。

軸部外之安山岩稍受花崗岩化之作用

吾人以秦嶺軸部之地層，或完全或大部爲變質之古生代岩系所組成，如震旦紀前之變質岩系(卽趙黃二君之秦嶺系)亦在內，此系必因擠迫而與古生代岩系聯合而成一變質岩系。

於秦嶺山軸部中未見有石英岩之發展及斑岩之侵入。由北往南，變質岩系之走向，大致先爲東西，後漸轉爲西北東南。

(二)秦嶺第三紀早期之掩覆

秦嶺南部與北部之第三紀地層已經前人觀察(楊鍾健—地質學會誌第十三卷第三號)，則不如盧氏淅川間之第三紀地層有連續性，斷層盆地中有數百或數千公尺之砂礫岩及粘土，可使吾人推想秦嶺於新生代之早期(中新統前)，必爲其侵蝕產物所掩覆。

雖僅於垣曲，淅川有始新統化石之發現，但由構造與地文之相類，新生代早期之堆積，可暫定爲成於始新統至漸新統之時期

(三)上新統之問題

秦嶺東部地質觀察中最難解之一點，乃上新統(蓬蒂及三門系)堆積之缺乏。吾人可暫定洛河侵蝕平面與灌河之一百公尺高階段，及南陽系之堆積爲屬於上新統。

(四)含結核紅壤土之分佈

秦嶺北坡與南坡，最顯著之新生代晚期堆積，爲含結核之紅壤土，北坡之堆積較南坡上者爲厚，但由土性(含多數圓形石灰

質之結核）與地文情形（掩覆於山坡之上並與二十公尺之中階段有密切之關係）觀之，南北坡紅壤土之堆積當為同時（下更新統）。

（五）黃土之範圍

於此行中未見馬蘭期之真正黃土，所見之低階段及其灰色砂土，或可屬於清水及馬蘭期。

（六）秦嶺地質略史

（甲）古生代地層受劇烈花崗岩化之作用。

（乙）第三紀早期（與白堊紀晚期？）有巨厚之堆積。

（丙）在上新統時期之前有劇烈垂直運動。

（丁）上新統時期有緩和之侵蝕作用，繼之有下更新統含結核紅壤土之堆積。

（戊）上更新統稍有扭曲運動。

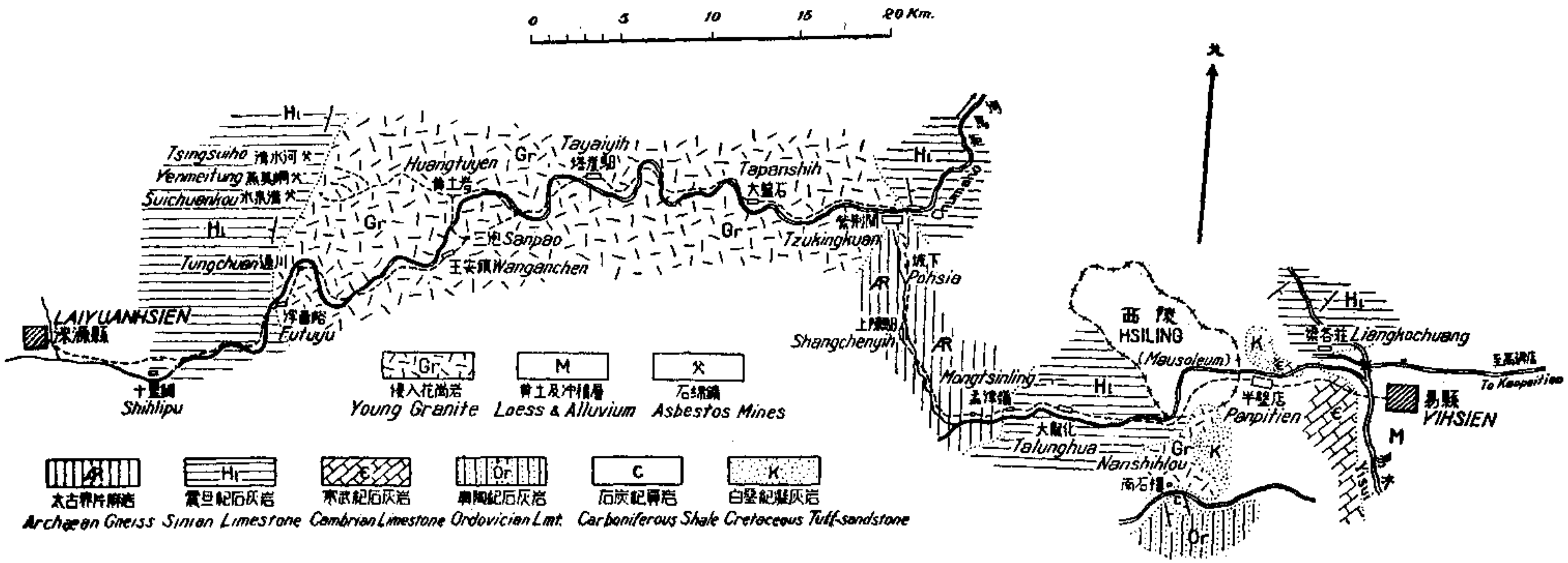
（註一）報告中所用秦嶺之名稱，為廣義的而非狹義的，吾人所經之山脈，由北往南，實為熊耳山與外方山之西段及伏牛山之南部。

（註二）譯者今秋於山東泰安境之紅壤土堆積下亦見綠色蜿曲斑點之粘土，但粘土並非上新統之堆積，乃始新統地層上面之風化帶。由此點究之則河南省之南陽系尚屬疑問。

第一圖　河北省淶源縣石綿產地位置簡圖

Map I. A sketch-map showing the asbestos mines in Laiyuan district, Hopei province.

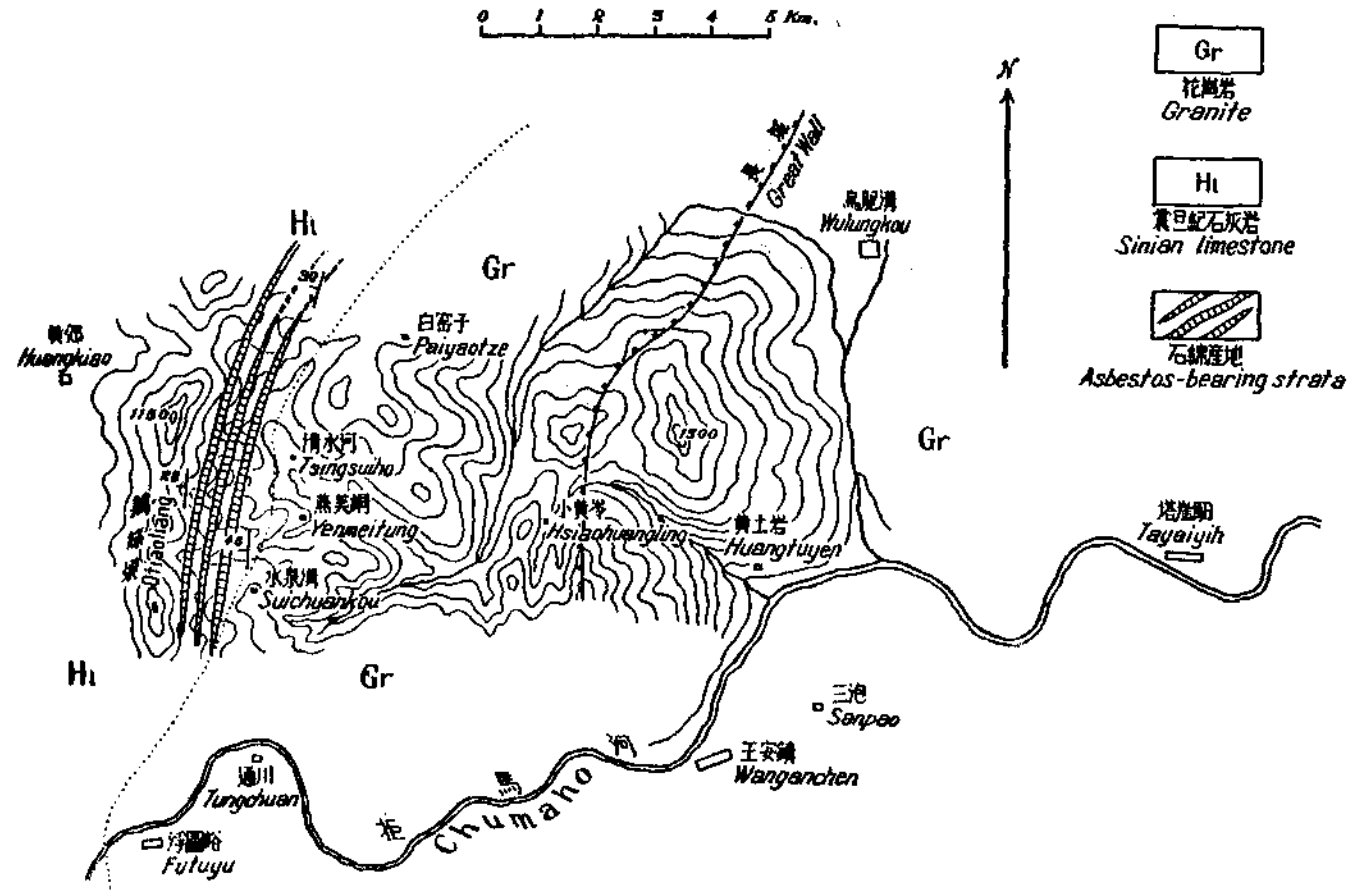
比例尺　四十萬分之一　Scale 1 : 400,000

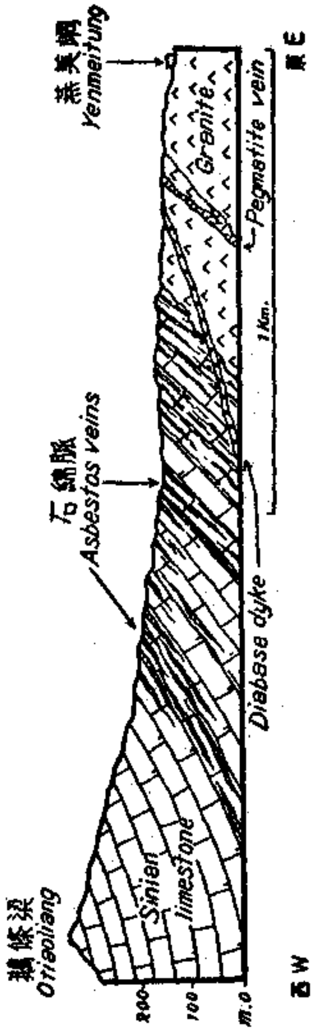


第二圖　河北省淶源縣燕美峒石綿鑛畧圖

Map II. The asbestos deposit of Yanmeitung in Laiyuan district, Hopei province.

比例尺十五萬分之一　Scale 1:150,000





中華民國卅四年兩月廿貳日收到

河北省淶源縣石綿礦調查報告附中國石綿產地表

侯德封

民國二十二年春，封奉命調查河北省淶源縣石綿礦，出發後適値長城戰事吃緊，匆匆返平，未克詳查，諸待以後研究，玆將所見，綜記於此。

一、產地

調查地點爲淶源縣東北五十里之燕美洞。在拒馬河之北，東南距易縣約一百八十里。（圖一）此外紫荆關北八里及淶源城南二十里處均有石綿礦，但質劣未採，此次未能調查。其地質情形約與燕美洞所見者相似。

二、地質述略

紫荆關至燕美洞間爲巨體花崗岩區，燕美洞之西山爲震旦紀石灰岩。石灰岩與花崗岩接觸帶產石綿。在燕美洞區接觸帶爲北北東南南西方向，石灰岩走向南北，傾角二十八至四十六度向西。在矽質石灰岩中石綿脈集中處有數帶，方向大致互相平行，自南而北分佈於燕美洞村西鵝條梁之東坡。（圖二）

石灰岩與花崗岩接觸處，石灰岩之底部爲帶狀深灰色結晶石灰岩，夾黃綠色蛇紋石，白色滑石及燧石等。此部共厚一百五十公尺。此部之上爲厚約一百公尺之結晶石灰岩，夾無數石綿脈，石綿脈最富處約有三帶，第一帶在本部岩層之底部厚三至五公尺，上隔四十至六十公尺爲第二帶，厚五至七公尺。第三帶厚十數公尺，下距第二帶約二十公尺。其分佈雖不甚規則，但第二、三兩帶，北自清水河南至水泉溝延長在三公里以上，均經開採，平均共厚不下十五公尺。至石灰岩之上部則漸無蛇紋石及石綿踪跡。

石綿脈在石灰岩中，呈不延續之層狀或餅狀，但參差錯綜，互相銜疊，在礦床豐富處，各脈間距離不過數公分。石綿纖維與脈壁垂直，長半公分以至二公分，最長者達三公分。第一帶及第二帶所產石綿呈金黃色，光如絲，纖維細柔有力，第三帶所產石

綿色潔白質較脆劣。

此處石綿當屬於蛇紋石類之纖維蛇紋石 Chrysotile（含水之鎂質矽酸鹽，硬度爲三，比重二·二）。石綿纖維不甚長，然光澤堅柔，質尙不劣。石綿脈之兩旁，常爲塊狀蛇紋石，因含雜質故，（如鐵及綠泥石等）呈紅色或綠色不等，厚可四、五公分，過此遂爲大理石。以上各質，排列齊整，成對稱之式。

據本所南延宗君在顯微鏡下研究，此項石綿之折光率約在一·五〇至一·五二二之間，成細脉穿越於塊狀蛇紋石之間，有時脉內纖維幷夾有方解石細片，與石綿相互共生。於塊狀蛇紋石間常見有磁鐵礦及赤鐵礦細粒，其含赤鐵礦較多者因之呈紅色，此外尙有含少量之綠泥石（Antigorite 與 Pennite俱有）者則呈綠色，有時因風化作用，則一部變爲高嶺土，遂使蛇紋石呈黃色土狀之象。至於接觸變質礦物若角閃石類或橄欖石等礦物，則無論在蛇紋石，或大理岩內均未見及。

淶源石綿之由於蛇紋石重新結晶而成，當無疑義，但蛇紋石如何發生，因在顯微鏡下尙未找到如橄欖石等之原生礦物，故尙屬問題，但據研究河北昌平禾子澗之石綿標本，則見塊狀蛇紋石中，尙遺有未變之橄欖石粒（Forsterite）按禾子澗礦床情形，與淶源相似，同爲產於富於鎂質之震旦紀石灰岩，則淶源石綿礦之成因，當亦相類。

上述石綿纖維內常夾有方解石細片，此點殊足注意，粗視之頗若石綿能直接自方解石化變而來，但此殊不可能。解說之法，當謂先有石綿，其後含炭酸鈣之溶液，逐漸浸入於石綿纖維之間，遂結成方解石，其甚者，全部石綿俱被交換但仍保存原來纖維之組織。

由於上述之研究，我人對於淶源石綿礦之成因，可作如左之結論：（一）花崗岩侵入於含鎂質及矽質之震旦紀石灰岩中，因熱力之影響，遂使矽鎂質結晶而成橄欖石同時石灰岩變質爲大理岩。（二）花崗岩漿之餘液上昇，使橄欖石悉數變爲蛇紋石，一部亦變爲綠泥石，鐵質分出，則成爲磁鐵礦赤鐵礦等。（三）蛇紋石被水溶解經流於裂縫中，重新結晶而成纖維狀之石綿，此項作用仍爲熱液變質之結果。（四）含炭酸鈣之冷水侵入石綿纖維間，與之交換而成爲纖維狀方解石。

可採礦量約可達四十萬噸，鑛床之長北自淸水河南至水泉溝，沿趨向之寬度爲五十公尺，岩石含礦平均百分之十至二十，因該處地形所受侵蝕之損失爲三分之二及二分之一，其約數有如下列。

	長度	厚	寬	比重	岩石所含成分	侵蝕損失	儲量約數（噸）
第一帶	一、五〇〇公尺	四公尺	五〇公尺	二·二	一五%	2/3	四九、五〇〇
第二帶	三、〇〇〇	六	五〇	二·二	二〇%	1/2	一九八、〇〇〇
第三帶	三、〇〇〇	一〇	五〇	二·二	一〇%	1/2	一六五、〇〇〇
共計							四一二、五〇〇

三、鑛業

此處石綿開採始自民國三年，有裕榮平原華北仲達等公司。民八及十一，前列兩公司相繼停頓，當調查時僅仲達公司開採。由農人農暇採掘，每年作工三個月至五個月。方法用人工，錘，鑽，沿鑛脈開斜洞，洞寬高各一公尺餘，深者約三十公尺。人工最多時達三百至五百，每人日採六十至一百斤。

石綿由鑛洞採出後，分爲兩種，第一種爲塊石綿，纖維長在一·五公分之上。第二種爲碎屑不淨粉等。第一種常佔總數百分之七。公司由採鑛工人收買，第一種每百斤價銅元二百四十枚。第二種每百斤價銅元八十至一百五十枚。再經選，碾，篩之後所得產品及成本如左列：

原料　產品	手選	選	選	碾	篩	之後	佔全額百分數	每噸成本（元）
	1		2	3	4	5		
第一種（	手選後得純塊							

每噸成本八十九元六角）	針百分之五十					三・五%	九一・六
	碎屑百分之五十	一等絲				二・三%	九四・二九
				三等絲		〇・八%	九一・六二
					粉	〇・四%	八九・六
第二種（每噸成本四十八元六角）			二等絲			一八・六%	五二・八
				三等絲		一七・九%	五〇・六二
					粉	四八・六%	四八・六
選鑛費	二・〇〇(元)	四・六九(元)	四・二(元)	二・〇二(元)			

自鑛場至易縣運費每噸二三・五二元，易縣至天津火車運費每噸二十八元，若在定興（易縣南六十里）裝船至天津每噸須費二二・四元。據是年三月該公司所稱在天津成本及市價如左列：

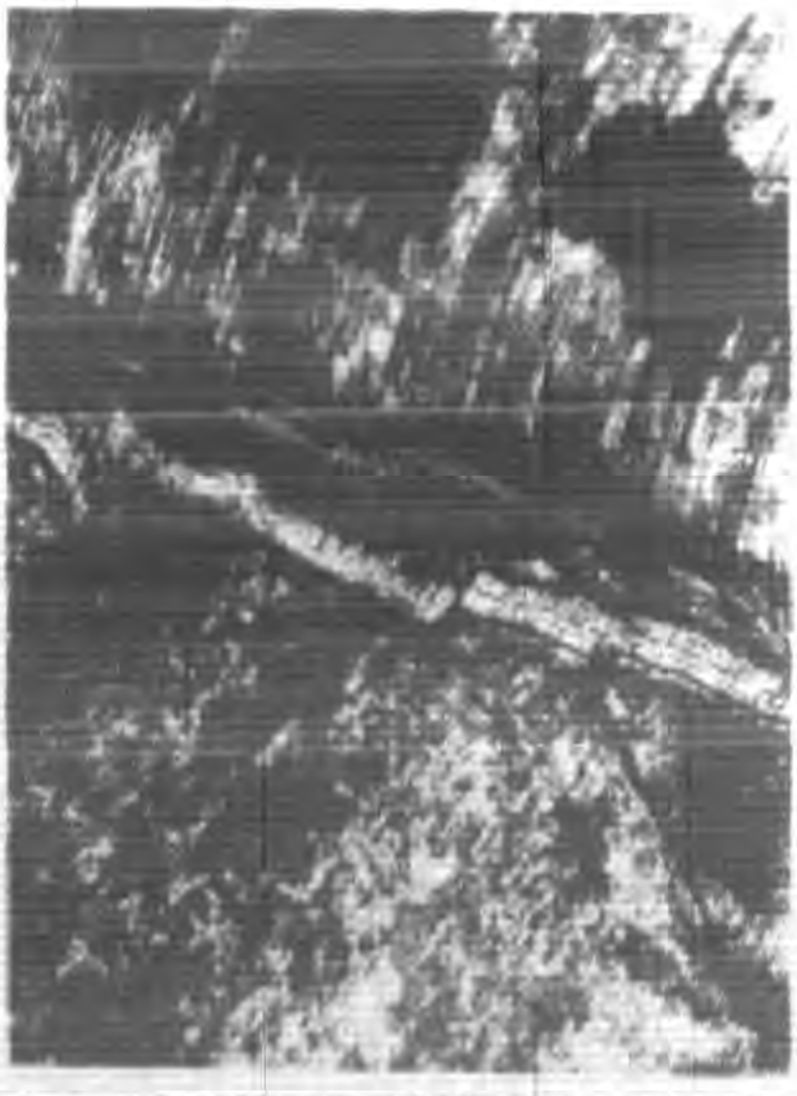
種別	每噸成本	每噸市價
1. 純塊及針	一三七・三三元	三六五・〇〇元
2. 一等絲	一四〇・二二	二二四・〇〇
3. 二等絲	九八・七二	一二〇・〇〇
4. 三等絲	九六・五四	七五・〇〇
5. 粉		無市

附中國石綿產地表

產地	種別	附註

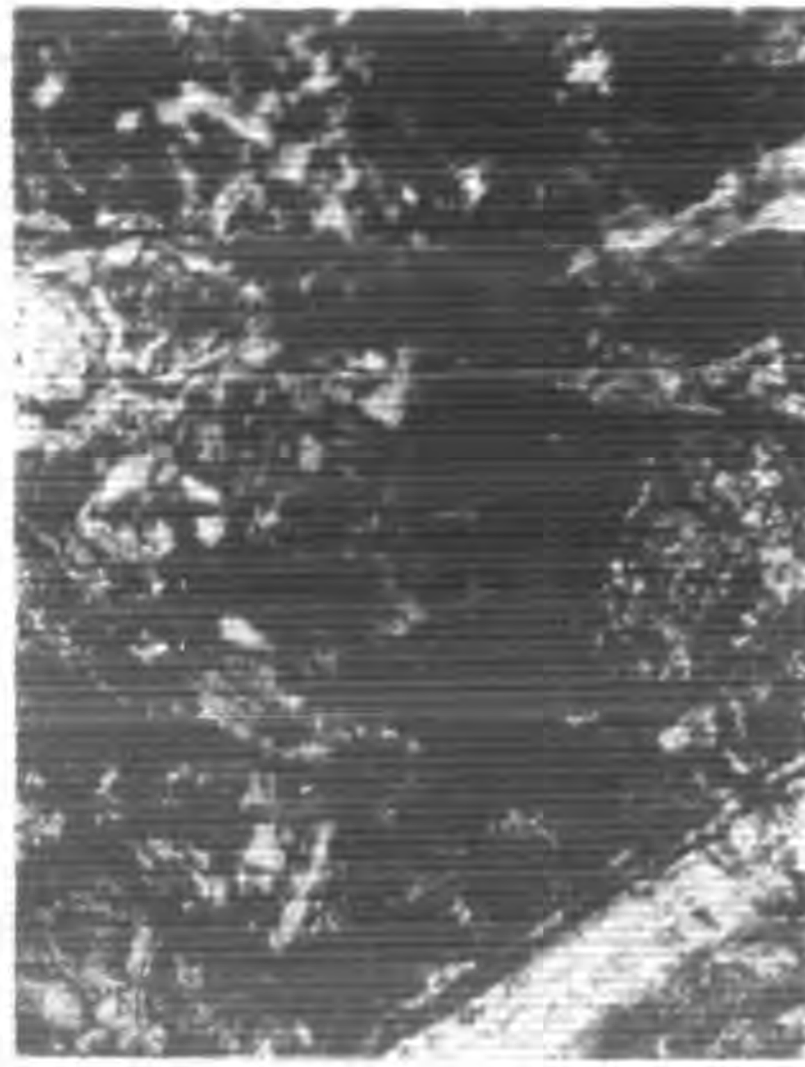
綏遠	武川西南牛溝	蛇紋石	石綿生於桑乾片麻岩之大理石中絨長可三公分
	武川西北六洲溝	蛇紋石	大理石出露於花崗岩內，石綿即生於其中，絨長五公分，質柔色白。
	察素齊北五十里石灰窯	蛇紋石	生於大理石及蛇紋石中
	包頭西北沙壩子	蛇紋石	生於大理石中
	固陽郡不亥 板申兎涼城三道營子 包頭雞毛窰子	蛇紋石	同 上
	安北毋哈溝	陽起石	
河北	淶源	蛇紋石	生於花崗岩接近之震旦紀石灰岩中
	昌平禾子澗 密雲銀冶嶺	蛇紋石	
	井陘 獲鹿金銖嶺	蛇紋石	生於元古界變質岩中
貴州	水城歸集河	蛇紋石	色白微黃質柔似 Mountain leather
山東	膠縣南灰村，即墨		生於五台系大理石中脈厚二、三公分
雲南	武定祿勸		
四川	越巂草八排		
西康	丹巴銀廠溝，理化	陽起石	夾於大理石中
山西	聞喜垣曲五台	蛇紋石	生於元古界變質地層中
	繁峙羊圈村	陽起石	

陝西	平利南鄉獅子坪		
	鎮平北三十里石河堡		變質岩中
	略陽東登雲舖		同　上
	雒南齊山河山		
湖北	黃安獅子山		綠泥片岩及絹雲母片岩間夾石綿
河南	內鄉西北黃龍寨	蛇紋石	生於元古界變質石灰岩中爲脈狀
	內鄉城北一百五十里之青竹扒及城南方山	蛇紋石	仝　上
	淅川西北寺灣村又城北二集鎮閻溝	蛇紋石	仝　上
	淅川東北西坪頭及魏家溝	蛇紋石	仝　上
	唐河羊冊山		仝　上
	南召水藏寺及留山丹霞寺		仝　上
	信陽東南鐵佛寺		
湖南	郙陽劉家坪德北坪		



1. 溫石綿纖脈橫穿塊狀蛇紋石，稍具錯斷痕跡．正交偏光鏡下 38 倍.

Slightly flexed chrysotile-asbestos veins cut through massive serpentine. Cross nicol, × 38.

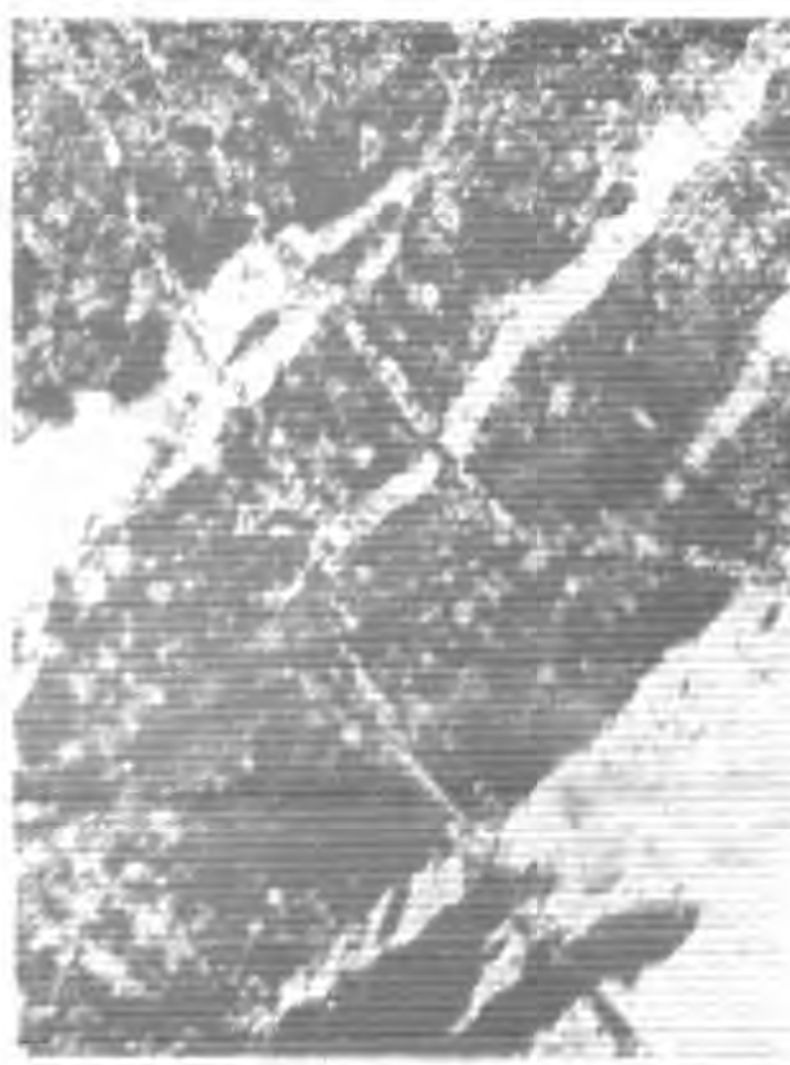


2. 滑石細脈交換束狀蛇紋石及綠泥石．同上 38 倍.

Talc or steatite veinlets replacing sheaf-like serpentine and chlorite. do. × 38.

3. 方解石（溫石綿之假晶體）同上，38 倍.

Calcite pseudomorphous after chrysotile-asbestos. do. × 38.



4. 石英細脈橫貫塊狀蛇紋石及溫石綿．同上．38 倍.

Quartz veinlets cut across massive serpentine and chrysotile-asbestos. do. × 38.

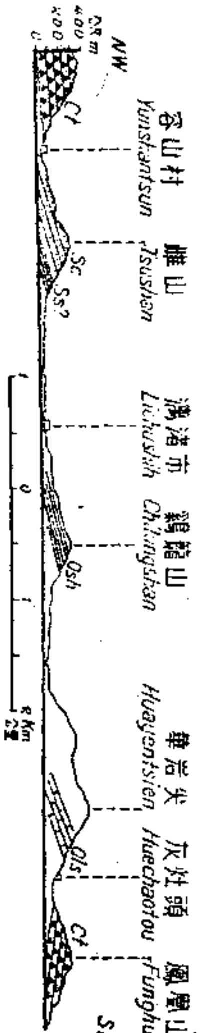
浙江東部之地質

高平

第一章 沿途觀察

杭州至紹興

自杭州渡錢塘江至西興，由運河可通紹興，沿河公路，亦早完成，故由杭至紹，路程一百二十里，三小時即可到達。自杭州隔江所望見之一片小山，均爲凝灰岩所成，蕭山沿湘湖兩排較高之山，則成自泥盆紀之千里岡砂岩。由蕭山而東，則均爲凝灰岩及凝灰角礫岩所掩覆，此類岩石，普通呈灰綠色，其角礫則時呈紫色，每層厚約一公寸，走向大致爲東東北—西西南，傾斜甚緩，有時幾成水平，故易於開鑿，石坑隨處皆是，浙省建築及舖路石料，幾盡取材於此類岩石，蓋取其能耐侵蝕，易於工鑿也。岩石中多橫斷裂縫，且易於呼取水份，故於此種岩石露頭之旁，往往有清泉流出，以灰質甚少，水質純潔，石坑開鑿之年深月久者，麤壁巨洞，造成風景勝地，如柯橋鎮南三里之柯岩（第一版圖三）。柯橋西南，爲一片高約二三百公尺之連續小山，均爲上述之



第一圖 紹興縣漓渚市附近地質剖面圖

Fig. 1. Section across Lichushih, Shaohsin district.

凝灰角礫岩所成，直至柯橋西南約十五里之封里村溝中，見有硬性較基性之噴出岩出露，按層次論，當在凝灰角礫岩之下，惟層面不明。自柯橋南行約二十里抵容山村（第一圖），沿途均係凝灰岩及凝灰角礫岩，容山村之南，有一列東北西南向之小山脈，曰

雌山，雄山，頂部爲石英質砂岩及礫岩，傾向西北，傾角約二十餘度，其下爲黃棕色硬砂岩，二者應相當於千里岡砂岩，屬泥盆紀。再南至濟渚市兩旁，則有奧陶紀石灰岩斷續露出，柯橋鎮迤北及東北一帶，遠望皆爲平原，蓋屬錢塘江下游之冲積平原也，僅有極少數之凝灰岩所成小山。此冲積平原中，土質多屬細砂土，湖渠甚多，如狹獴湖，瓜渚湖等，周圍均數十里，環視杭州紹興一帶湖泊，由地形上及各種推測，其成因似不外海水之後退，與夫錢塘江之改道有以致之也，昔日錢塘江下流，柯橋鎮以北之江流，當在今日地位之南，江面亦當較今日爲寬，此點可由今日該段錢江北岸之猛烈洗刷衝擊，與夫江南之沙灘累積之速度可知也。

柯橋鎮沿運河東南行至紹興，路程四十里，所見亦爲凝灰岩及凝灰角礫岩，與柯岩附近同，城東十里許，有東湖焉，越郡名勝也，爲一凝灰岩所成之絕壁，湖適臨其陰，故湖中不見日光，夏間極爲凉爽，附近石坑林立，層次微傾向北，烏門山一帶，地層幾爲水平。紹興城南禹陵一帶，均屬凝灰岩及凝灰角礫岩，香爐峰山脚亦復如是，至半坡即有礫岩露出，卵石多爲紫色砂岩，膠合物則均爲紫色凝灰砂岩，風化面呈紫黑色，層次顯然，向西北傾斜，斜角二十度左右。由該地層次觀察，礫岩自應在凝灰岩之下。

紹興城西南約三十里有蘭亭古蹟，其西有奧陶紀岩層露出，灰灶頭附近，居民以奧陶紀之石灰岩燒石灰，經營頗爲發達，蓋紹興全縣，石灰岩之露頭極少，而石灰之消耗甚廣。灰灶頭之石灰，可沿小溪用竹筏順水而下至婁古，換小船直達縣城。

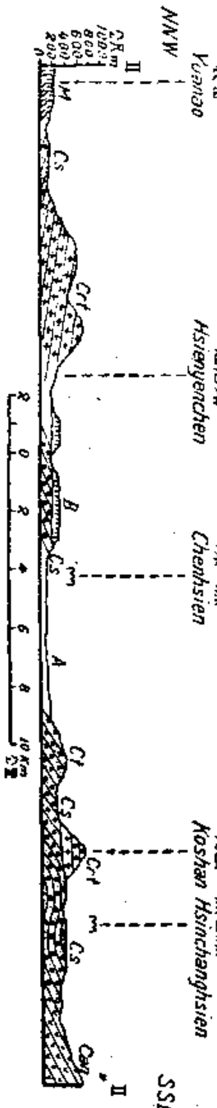
紹興至新昌

自紹興南行，三十五里至平水鎮，有小船可通，平水鎮以南，則水淺流急，僅竹筏通行，蓋漸入山嶺叢雜區矣。平水鎮迤西一帶，大致爲一小範圍之花崗岩侵入體，兩旁有灰綠色之流紋凝灰岩露出，接觸帶上，流紋凝灰岩成石英岩狀，似受花崗岩之接觸而局部受變質作用者，是則花崗岩侵入之時期，當後於流紋凝灰岩之噴發也。

平水鎮之東，直至湯浦鎮，概爲紫棕色之石英斑岩，石英結晶巨而密，長石均呈紅色長方形結晶，層面傾斜甚緩，傾向北北

西，斜角十度左右，粗計其厚度，約在四百公尺左右，岩石頗堅硬，垂直層面之節理甚發達，常因流水侵入水漲裂開而崩塌，故常成光滑之蟲壁，平水鎮南行，越上述之石英斑岩所成之桃園嶺，而至王檀市，渡河卽有紫色及綠色凝灰砂岩及頁岩所成之低坡，分佈於妙渚寺前一帶，與石英斑岩隔河谷相望，接觸面爲河床所淹，其東南則有大批變質岩，不整合被覆於其下，變質岩大部爲雲母片岩，雲母石英片岩，及角閃石片岩，變質甚深，片狀組織極顯，斑岩岩脈甚多，片狀層理間，常夾有石英脈，王檀市西南一帶，爲一片酸性及中性噴出岩，有紫黑色之流紋岩，粗面岩，及粗面安山岩，及堅硬細密之粗面凝灰岩，不整合覆於變質岩之上。

自王城市以南，大體均爲硬質灰黑色粗面岩，及粗面凝灰岩，間有流紋岩薄層，傾斜普通爲北北西，斜角十度左右。自此越十畝嶺，則見有大片似平原，成一東東北—西西南之帶狀盆地，佔有嵊縣新昌兩縣，寬約二十餘里，延長凡百餘里。盆地四周，岩爲較堅硬之石英斑岩，粗面凝灰角礫岩，而盆地內大致均以灰綠色凝灰岩及紫色礫岩爲底，成一侵蝕平原，而玄武岩流不整合覆於其上。玄武岩作深黑色，氣孔甚多，結構甚緊密，玄武岩掩蓋之處，均成平頂小山阜，玄武岩下之凝灰岩及礫岩拗曲頗烈，



第二圖　嵊縣新昌一帶地質剖面圖

Fig. 2. Section across Chenhsien and Sinchang districts.

傾角普通在二三十度間，而玄武岩則幾成水平層（剖面第二圖）盆地內一帶小山之高度，均在一二百公尺間，僅新昌縣城西南約十里之壳山，突出高二百八十公尺，山脚爲礫岩，傾向西北，傾角二十五度，離平地約五十公尺，山坡驟陡立，岩石已變爲流紋

極清淅之流紋岩，流紋岩之層次雖不甚顯，但與礫岩接觸面幾爲水平，可知流紋岩之掩蓋，當在礫岩受拗曲作用及侵蝕作用之後，兩者之不整合，固甚顯明，（剖面第二圖）流紋岩厚度在壳山約爲一百五十公尺。

盆地南部，卽嵊縣南鄉一帶，凝灰角礫岩造成較高之山嶺，未見有玄武岩掩覆其上，烏岩一帶，亦開有大石坑，從事開採大批凝灰岩石料，且鐫刻有精緻之石櫈及各種用具。

新昌以北，爲一玄武岩所掩蓋之侵蝕平原，距新昌城旁河谷高約一百公尺，登山頂一望，則平坦廣闊，村落農田一如平地，且極宜種植桑樹，故嵊縣新昌一帶絲業頗爲發達。新昌城東北約五里之青山下，玄武岩下之綠色凝灰岩內，產黑色焦炭層顯係古代木塊受火山岩之灼熱作用而成，土人以爲煤苗，正從事開掘焉。

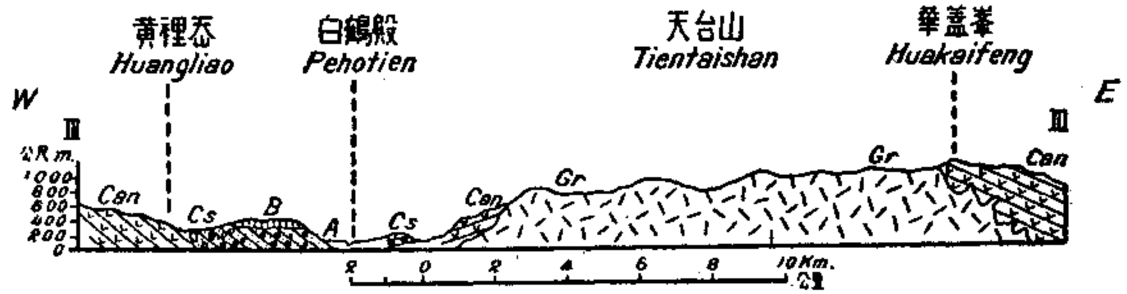
新昌至臨海（新昌—天台—臨海）

新昌南至天台路程，凡一百二十里，以隔天台山之主脈，山路崎嶇，現公路局正從事轟炸沿大道旁山坡，修築公路，工程至巨大也。

新昌南行，經石溪姚宮至白里，均爲礫岩。白里以南，爲紫色及綠色凝灰頁岩及砂岩間夾礫岩，傾向北西西，傾角有達七十度者，惟時有小變更。陳岩北二三里溝中，傾斜二十四度北北東。陳岩東南，其下部硬質較基性岩流漸露出，有安山岩粗面岩及粗面凝灰岩，紫色凝灰砂頁岩，亦時有其遺留物。自此東南至儒岙市，大率如此，儒岙西南，玄武岩不整合平鋪於上述較基性岩流之上，且在仰船嶺見玄武岩與上述較基岩流之間，尙有一層厚約十公尺之流紋岩，流紋極清淅，與新昌壳山所見者，完全相同，層面傾斜甚緩，顯與其上下岩層均成不整合接觸。

儒岙東南，橫板橋東二里，有花崗岩露頭，與圍岩接觸處，晶粒較細。接引寺附近，花崗岩之結晶甚粗，風化亦深，石英及長石，結晶有長至一公分者，長石普通作肉紅色，雲母片岩更有數公分大者。自此上尼姑嶺，山麓至半坡之清涼寺，均爲花崗岩，清涼寺以上，則結晶漸細，微晶質增加，而爲流紋岩矣。考其成分，實相差無幾，不過前者以當時離地面較深，冷却較緩，故

有充分之時間及機會盡行結晶，後者離地面甚近，冷却較速，大部無暇結晶，故由該地情形觀察，頗若流紋岩之噴發屬於 Areal Eruption 之一類，而與花崗岩侵入有密切之關係矣。尼姑嶺頂之流紋岩結晶甚細，除石英結晶肉眼尚能見及，餘均成石英岩狀。尼姑嶺南坡，花崗岩重行出露，自此直與天台山花崗岩主體相連。山溝中巨石累叠，蓋由於沿花崗岩本身之節理起風化作用而崩裂也。



第三圖　天台山地質剖面圖

Fig. 3. Section across Tientaishan.

儒岙南行經王渡橋，而至天台縣之關嶺，沿大道爲花崗岩與粗面岩等噴出岩之接觸帶。至山口村，則出山谷而入寬廣盆地，兩旁有階級梯地，直至天台縣城之東西兩方，成一三角形盆地。此盆地之構造，大致與新昌嵊縣盆地相似，盆地內爲礫岩所成之低山，一部分爲玄武岩所掩蓋。盆地西北隅，玄武岩礫岩及粗面岩等較基性岩流三者之關係甚爲清晰，(第三圖)礫岩緊貼於安山粗面岩之上，礫岩中巨大卵石，皆爲安山粗面岩，其間當經過一期侵蝕作用。玄武岩在該處厚二十五公尺，與礫岩之不整合更爲顯明，(第一版圖二)礫岩之傾斜角大至五六十度，而玄武岩幾水平。

盆地東北之大片高山，爲天台山主脈，亦卽花崗岩之主體也。天台山爲中國四大名山之一，最高山峰，曰華頂山，高出海面一千一百四十公尺。天台之勝，並不在高，而在山之四周，多成峭壁，獨山頂地勢甚平坦，且周圍數百方里內，不過小山起伏，

良田千頃，村落井然，故一登其頂，則幾忘已置身於千公尺之高山上，惟囘顧山下，則見雲霧迷漫，飄飄然若登仙境，此昔年天台山頂之所以能容萬千僧徒，成爲釋教根據地也。以地文言，天台山頂自爲一古代侵蝕平原之遺跡。

天台山岩石，以花崗岩爲主，四周有安山粗面岩及礫岩系地層，一部分掩蓋於花崗岩之上，故天台山花崗岩，實爲一顯著之岩盤（Laccolith）花崗岩結構之粗細，常因離圍岩之遠近而異，而其成分大致相同，長石均爲肉紅色，石英結晶甚多，黑色礦物甚少，僅少數之角閃石及黑雲母。此種花崗岩，抵抗風化力並不過強，但以時代甚新，未受長時間之侵蝕，故其主體尚能巍然高聳，又以其垂直節理甚發育，故山水衝蝕結果，常成狹谷深溝，而瀑布因以成焉。如石樑飛瀑，（第一版圖四）銅壺滴漏，（第二版圖一）水珠簾，（第二版圖二）其著者也。天台山頂華頂寺以東，有黑色安山岩覆於花崗岩之上，質堅硬，造成華頂山之最高峰。天台山南蒼山雞籠山一帶，均爲安山岩，而沿山谷河溝，花崗岩仍不時出露，是則花崗岩之侵蝕，當後於安山岩之凝結也。

天台以南，爲大批凝灰岩及凝灰角礫岩，其下更時有礫岩露出，岩性與紹興西南一帶相似。城南約二十里之前洋下湯一帶，有花崗閃長岩露出，沿小溪兩旁，均有極新鮮露頭，岩質以長石及角閃石爲主，石英次之，角閃石常成柱狀細長結晶，縱橫排列。黃鐵礦細晶甚多，此侵入體向東南延展，直至臨海縣河頭鎮東北一帶，其間雖僅有斷續露頭，但由岩性及侵入情形觀之，似屬一體漸次遞變。河頭鎮東北宜山一帶，爲角閃石花崗岩，正長石與石英互生，成文像花崗岩，表示二者達 Eutectic Composition 而同時結晶。同時角閃石減少，黃鐵礦結晶極發達，其圍岩爲流紋岩及流紋凝灰岩，亦因接觸而局部變質，且常有綠簾石產生。侵入岩內，常含有角塊狀凝灰岩，及流紋岩之包體。河頭鎮赤峰山及宜山一帶，高山頂均爲灰色細緻之流紋岩，石英顆粒肉眼均能見及，惟與侵入體接觸處，似均受局部變質作用，失其晶，形接觸帶上時，有石榴子石結晶。此侵入體再向東南延展，角閃石漸少，正長石作肉紅色，變爲與天台山相同之花崗岩。

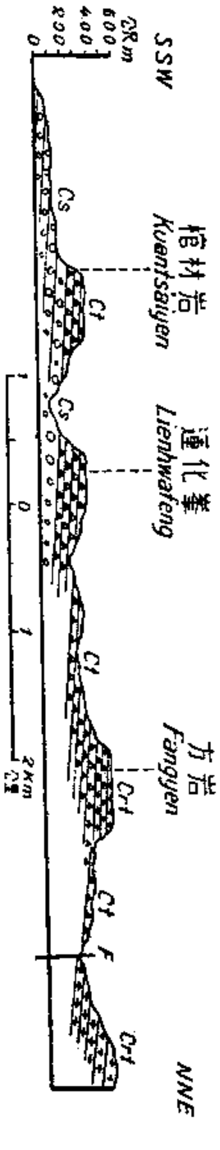
河頭鎮東烏岩嶺頂，則有流紋灰凝岩露出，河頭鎮南山有黑色凝灰砂岩，時有石英脈，含黃鐵鑛細晶甚多，其上則有灰色流紋岩。自此至臨海帶縣城一帶，大率如此，卽流紋岩掩蓋高山之頂也。

臨海至温州（臨海—黃岩—温嶺樂清—温州）

臨海以南，大致仍爲凝灰岩，其底部常有安山凝灰角礫岩出露，惟高山頂常有流紋岩掩蓋。貓兒畏凹巔山頂，皆有石英結晶甚顯之流紋岩掩蓋，以傾斜甚平，故山坡所見仍爲凝灰角礫岩直至黃岩城北之黃土坡，大率如是。黃岩城西南一片高山，曰畫山，矗壁百丈，曰石仙人，曰松岩，台屬名勝也，岩石大致爲粗面凝灰岩及凝灰角礫岩，傾斜甚緩，低抗風化力尙強，故常沿節理侵蝕風化而成矗壁。縣城東南之方山，亦爲同樣岩石構成，方山以東，則爲大片冲積平原及沙地，直至海岸，僅零星小山低坡。黃岩城南二十里之蕎麥尖一帶山脈，均爲石英斑岩亦屬噴出岩，覆於凝灰岩系之上走向爲東東北—西西南，向東南緩斜。岩石作灰藍色，石英結晶巨而多，長石次之，長石結晶有時長至一公分，自此而南，均爲此種石英斑岩，直至離黃岩縣城四十五里之大溪鎭。大溪鎭西南有方岩，四面峭壁，（第二版圖四及挿圖第四圖）而山頂則爲一片平地，風景甚佳，半坡有一寺曰玉蟾宮，背懸崖而築，望之雄偉突兀。方岩頂之矗壁，係成自流紋甚顯之流紋岩，及灰白色流紋凝灰岩，質甚堅硬，層次幾水平，矗壁以下，則爲開石坑之凝灰岩及凝灰角礫岩，傾斜甚緩。揣想當流紋岩熔岩流冷縮之季，則同時發生與層面垂直之橫斷裂縫，而水力風力之侵蝕，依此項裂縫進行，因以造成此四面峭壁之地形焉，方岩以南至胡霧道上，漸由凝灰岩而見其下之礫岩系，礫岩作塊集狀，卵石大小極不勻，直徑自數糎至數公分不等，有大至一公寸者。該處因受海水衝擊，亦成甚陡之山坡。胡霧街一帶之矗壁，如百丈崖等，皆成自礫岩系，並造成階段瀑布，如白龍潭，烏龍潭，幽蘭潭等。胡霧街北溝，石英斑岩與凝灰岩系及礫岩系接觸處，似爲一斷層，西面下降，東面上昇。胡霧街附近一帶，面海之山坡，受海水洗刷衝盪甚烈，此種現象，在乍浦海邊所見更爲清浙，是爲浙省海岸在近時代有逐漸上昇，或卽海水面漸次下降之明証。大溪鎭西北及西南，直至樂清縣之大荊鎭，均爲石英斑岩所掩覆，大荊鎭東南文昌閣海邊，凝灰岩系被覆於流紋岩之下，甚爲顯明。

大荊之西南，聞名浙省之雁蕩山在焉，山脈作東北西南向，峯巒突出，矗壁千尺，均屬意想不到之奇景。自大荊鎭西南行，約五里，卽至山口，有高約三百尺之巨石，矗立山脚，其上覆以圓形巨石，宛若一老僧作拱手狀，名之曰接客僧，（第三版圖一）

其旁巨石甚多，各以其形而名，如金鐘岩蟹眼峯，其西里許有石樑洞，越謝公嶺，則見沿溪澗兩旁，皆為奇形怪狀之巨石，如合掌峯，（第三版圖二）雙笋峯，金雞岩，伏虎岩，犀牛望月，均極類肖。雁蕩山之所以成孝此類山形，一方固因係幼年期地形，山



第四圖　溫嶺縣方岩附近地質剖面圖

Fig. 4. Section across Fangyen, Wenlinghsien.

水衝擊之力甚巨，而一則由於地質情形之特殊有以致之也。蓋雁蕩山為粗面凝灰岩及凝灰角礫岩所造成，間夾粗面岩流，岩質尚為堅韌層次幾水平，富於垂直層面之橫斷裂縫進行，遂沿此裂縫逐漸侵蝕作用，故山形大致若溫嶺之方岩，黃岩之童山，紹興之柯岩，而雁蕩其尤著者也。全山最高處曰百岡尖，高出海面一千一百五十公尺，距山麓亦有一千公尺。其西有南，山峯高一千零四十公尺，山頂有一圓形窪地，曰雁蕩，周圍可半里，其間青草繁茂，泥鬆蓄水，該地在昔貯水甚深，蘆葦極茂，一羣雁居焉，故名雁蕩，全山亦因以名焉。以地形論，固甚奇突，千公尺高之山頂，何能成一圓形窪地，又何能貯水而成蕩，此種現象，頗似一火山口之遺跡。考諸地質，雁蕩四周岩石，較諸附近一帶，無甚變化，亦無其他現象可以証明為火山口遺跡。雁蕩山東南樓頭嶺山頂有石英斑岩露出，氣孔甚多，且有瑪瑙包含其中，而樓頭嶺之南，則有礫岩狀岩石被覆於石英斑岩之下，此類岩石，其基體多為酸性火成，岩質故岩性上似難與他處之礫岩比較，似為石英斑岩之基底角礫岩也。清江渡市北岸及西南一帶山脈，均為石英斑岩及流紋岩，越烏石嶺，至虹橋一帶，為一片平地，東望隔一南北向之小山嶺而臨海，西望則山嶺叢雜，括蒼山脈之東翼也。

自虹橋西北行，山嶺重叠，初見石英斑岩，繼見其下之粗面凝灰岩，及凝灰角礫岩，傾斜甚緩，走向大致作東北北—西南

向。

虹橋西約四十里之潭頭村南山，有一硬錳鑛脈，沿地層面而生，周圍岩石爲粗面凝灰岩，似爲一裂縫停積。(Fissnre deposite)脈長六十餘公尺，最厚處達五公尺，寬度不明。該地爲土法開採，浮面開鑿，成本甚輕，惟常因銷路停滯而歇工，與錳鑛共生者有黃鐵礦及閃鋅礦等。

虹橋西南行，直至樂淸縣城，均爲凝灰岩系，樂淸城東北山有流紋凝灰岩及含角礫之流紋岩，樂淸縣城西北及西南直至溫州北岸，大致均爲凝灰角礫岩，惟夾有粗面岩流。

臨海至東陽(臨海—仙居—東陽)

調查計劃中，原擬至溫州後，折向北行，越括蒼主脈而至仙居縣，奈以溫州北鄉與仙居交界一帶，土匪盤踞，且地質似甚簡單，故改由溫州趁輪赴海門，轉臨海，自此沿永安溪西上，經白水洋鎭而至仙居縣，再越大盤嶺，而至東陽。計自臨海至東陽，路程凡凡三百二十里。

臨海以西，沿永安溪兩岸，均係凝灰岩及凝灰角礫岩，南岸爲括蒼山脈，東北端，山峯突兀偉大，最高處達一千四百公尺，爲石英斑岩所成。祝家山上，石英斑岩作黑色，斑晶多屬正長石及鈉長石，石英晶粒甚小，而爲量甚多，故肉眼觀察，往往易認爲粗面岩或安山岩。

沿永安溪西上，至近白水洋處，北岸東山麓有紫色塊集岩出露，傾向北西西，傾角六十度，被覆於凝灰岩之下，礫石直徑自數公厘至數公寸不等。再西至仙居縣城，道上，地質情形大率類是，河流兩岸低山坡，均爲塊集岩夾紫色及綠色凝灰角礫岩，兩旁高山則爲凝灰岩，山高處有流紋岩及石英斑岩。仙居城東北一片低山，均係赭色礫岩，向西北傾斜，被於石英斑岩之下，石英斑岩造成主要山脊，質堅多節理，故仙居北山，狹谷瀑布甚多。仙居城南一帶，則均爲凝灰岩及凝灰角礫岩，與紹興一帶開石坑者完全相同，分佈甚廣，周圍數十里二三百公尺高之山坡皆是。仙居城西北爲出東陽大道，越北香嶺，再越長岡嶺，所見均係流

紋岩及石英斑岩。再西北至后閘，則見流紋岩下之凝灰岩系，漸次出露，層次甚平緩，分佈甚廣，除間有結晶甚細深灰色中性流紋塊，岩石性質均無大變更。直至東陽城東南五十餘里之老鷹山，龍珠山，山頂有流紋岩，較諸附近凝灰岩所成之山為高。

自此西北出山口，則見一片第三紀紅色細砂岩及頁岩，均成低緩邱陵，僅苦竹嶺官清嶺一支東西向山脈較高。橫店市（東陽城東南四十里）東北約五里，有一矗孤山曰八面山，蓋取其八面玲瓏也，山高距山脚四百四十公尺，山麓為紅色岩層，山頂有玄武岩平鋪其上，並有輝長岩露頭，輝長岩結晶甚粗，橄欖石結晶多而巨，當為侵入岩體。此種岩石情形與夫地形觀之，甚似一玄武岩噴發時之一火山頭。

官清嶺以北，仍為大批紅色岩層，以砂岩為主，頁岩次之，中夾多層礫岩及薄層凝灰砂岩，層面尚平緩，普通傾角自五度至二十餘度，岩性鬆輭。東陽城南十里之牛塢嶺南坡，仍為紅色岩層所掩蓋，嶺上則有凝灰角礫岩及角礫流紋岩，北坡有硬質黃色凝灰岩。

東陽至諸暨段（東陽—義烏—諸暨）

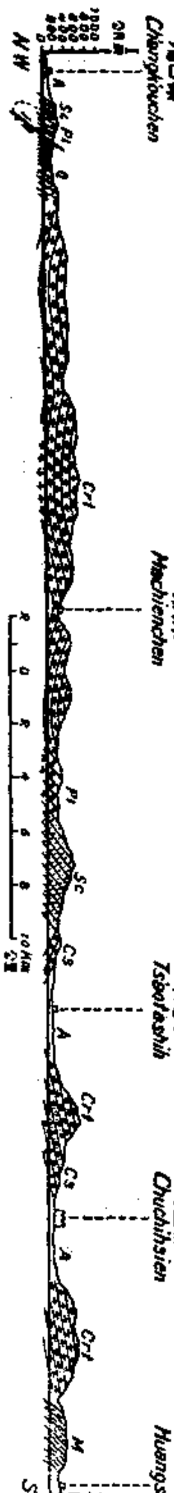
自東陽至義烏，係沿流紋岩所成高山北坡而行，故四十里內除流紋岩及第三紀紅色砂岩層所成之低邱陵外，無其他地層可見義烏縣城附近，在第三紀紅色岩層中所夾之黃色薄層砂岩內，覓得植物化石甚多，惟岩石鬆軟，保存不佳，未識能否檢定。

自義烏北行三十里至蘇溪鎮，兩旁僅第三紀紅色岩層所成之低邱陵，再沿杭江鐵路北行，兩旁露頭因經人工開掘，甚為清楚。蘇溪鎮西北一帶，虎頭山礫岩出露成二三百公尺之山嶺，自此東北行，沿走向直至諸暨之虎頭山，杭江鐵路亦順此走向而築，虎頭山礫岩之上，則不整合覆以流紋斑岩，在虎頭山一帶之刻面甚顯。

諸暨東南鄉璜山一帶，有變質岩出露，其北鄉則古生代地層沿浦陽江兩旁，甚為發育，詳地層章中。

諸暨至富陽段

自諸暨西北行，經古生代地層出露之背斜層，復入於流紋岩掩蓋區域。（第五圖）四十里至五洩，該地杭江鐵路劃為風景區，



第五圖　富陽縣塲口鎮至諸暨縣璜山市附近地質剖面圖

Fig. 5. Section from Changkouchen, Fuyang district to Huangshanshih, Chuchi district.

為流紋岩所成之矗壁瀑布。五洩寺西南約五里，在流紋岩之下，有薄層凝灰砂岩及細砂岩出露，採得魚化石及植物化石不少。自此西此行至浦江縣之馬劍鎮，均為流紋斑岩，間有薄層凝灰岩。馬劍鎮附近，流紋岩呈六方柱狀結構，每一柱體，直徑約一公尺，高十餘公尺至數十公尺不等，甚為美觀。自馬劍鎮西北行，直至富陽縣塲口，均為流紋斑岩所成之高山。塲口附近，有古生代岩出露，為奧陶紀石灰岩及頁岩，千里岡砂岩，飛來峰石灰岩，惟三者層次，均不完全，且係斷層接觸，奧陶紀頁岩中，得下奧陶紀筆石化石甚多。

第二章　地形

（一）山脈

調查區域內，山脈主體均作東北西南向，似與地層之走向相吻合，茲分述如下：

會稽山脈—位於紹興東南部，嵊縣西北部，諸暨東部，東陽北部，山脈大致作東北西南向，為錢塘江與曹娥江之分水脊。峰之高者，若嵊縣西南鄉之少白山，諸暨東南鄉之牛頭尖，及與東陽嵊縣交界一帶之太白尖，東白山，白鵝山等，均高出海面千餘公尺，餘均不過數百公尺，沿主脈向四周低落。造成山脈之主要岩石，為白堊紀之凝灰角礫岩，及流紋岩，山上樹木繁茂，泉流不息，紹興附近之柯岩東湖等，因以成為名勝。

四明山脈—位於嵊縣新昌之東北，鄞縣奉化之西北，曹娥江與甬江之分水嶺也，山峰之高出千公尺者，僅二三峰尖，普通以七八百公尺之高山爲多。山脈大致作北北東—南南西向，岩石組織大致與會稽山脈相同。

天台山脈—四明山脈自新昌之東部向西南行，即爲天台山脈，主脈位於天台縣之北，東南爲望海尖，銀山崗，東北延展至奉化縣，再東北爲鄞縣之五鶴山，自此東北入海，是爲舟山羣島，西南向延展即爲大盤山脈。天台山主脈華頂山一帶，爲一花崗岩侵入體，山之四周，多成峭壁深谷，而其頂則爲大片似平原，僅小山低崗起伏。天台山爲中國四大名勝之一，在昔佛教甚盛，廟宇林立，僧徒動以萬計，今雖衰落，而廟宇尚可以百計，僧徒尚可以千計，蓋山頂良田千頃，出產甚豐，頗足自給，自懸崖飛瀑，風景奇偉，又可以吸引遊客。山之最高峰曰華蓋峰，高出海面一一三五公尺。

大盤山脈—天台山脈越天台盆地向西南延展，是爲大盤山脈，爲錢塘江與靈江之分水脊，介於仙居，臨海，天台，東陽，永康，縉雲諸縣之間。山峰之高者，多在仙居縣之西北境及東北境 ，若大雷山爲天台臨海仙居三縣之交界，高出海面一三二三公尺。仙居北境諸山，若白錫山，青光山，仰天坪，大銀寥，孟溪山等峰，均在一千公尺以上。至大盤山主脈，位於東陽，永康，仙居三縣之交界，高一二七四公尺，其南一片山峰，高度均在一千公尺以上。自仙居至東陽或永康，越此大盤山，百餘里始出山口，故仙居縣除東行至臨海爲水陸大道外，均係山林叢雜，土匪出沒無常，交通至爲不便，故文化低落，民性強悍，爲浙省冠。大盤山脈大致均成自流紋岩及凝灰自礫岩。

括蒼山脈—位於臨海，仙居，縉雲，麗水，青田，永嘉，樂清，黃岩諸縣之間，爲靈江及甌江二水之分水嶺，浙省山嶺最叢雜區也。主脈曰括蒼山，高一四一六公尺，位於臨海西南五十里與仙居交界處，本地人名之曰蒼山，蓋遠望一片蒼色故名。至一千公尺以上之高山，所在皆是，臨海境內者，有卡人坑，仙人基，白岩山，天光尖等，其在仙居境者，有尤岫山，鷄籠山，芳草岩等，山脈方向大致爲東北—西南。

北雁蕩山爲括蒼東支脈，山脈方向幾爲東西向，爲凝灰角礫岩及粗面岩所造成，因傾斜極緩，幾成水平，故侵蝕作用，沿其

垂直節理進行，致成懸崖峭壁，奇突萬狀。峰之高者爲百岡尖，高一〇八〇公尺，其他山峰若雁湖等，高均在千公尺左右。

(二) 河流

錢塘江—錢塘江發源於仙霞嶺，一支自常山西北鄉來，曰常山港，一支來自江山南鄉來，曰江山港，至衢縣合流而爲衢江，蜿蜒曲折于紅砂岩中，合諸小溪至蘭溪，會東來之金華江，合流而爲蘭江。至建德，新安江自安徽來會，流經流紋岩所成之七里瀧狹谷中，兩岸峭壁夾峙，水流湍急。出谷口至桐廬，天目溪自於潛分水來會，合流而爲桐江。至富陽縣之塢口，壺源江自東南來，合流而爲富春江。東北流至蕭山縣之義橋，會自浦江諸暨北流之浦陽江，至此江流廣闊，是曰錢塘江，東北流入海。

錢塘江爲浙省第一大川，貫流南北，富舟揖之利，杭州至蘭谿一段，汽船暢行，浦陽江亦可通小汽船。至諸暨，蘭谿以上帆船可至常山江山，再上則僅能通竹筏耳。

曹娥江—介於會稽山脈及四明山脈之間，河流方向大致爲南北向，發源於天台山脈。富潤港，長樂港烏岩港自嵊縣西南境來至嵊縣合流而爲剡溪，與自新昌東南境來之黃澤港會於嵊縣北境之杉樹潭，合流而爲大舜江，北流至上浦鎮，會自西南來之小舜江，合流而爲曹娥江，北流入海，可暢通舟揖者凡一百二十公里。

靈江—靈江源分二支，一發源於天台山脈及大盤山脈間，至天台縣城，合諸小溪南流，是爲始豐溪。一發源於大盤山及括蒼山脈間，合諸小流而爲永安溪，東流經仙居臨海與南流之始豐溪匯爲靈江，曲折東南流，至三江口，與自黃岩來之永寧江合流，至海門入海。靈江口可通海輪，故海外交通，尙勝于錢江，小輪可通臨海，黃岩縣城，小船則可通天台，仙居縣城。

甌江—甌江發源於閩浙交界之武夷山脈，經龍泉東北流，是曰大溪，至雲和縣局村街，會自雲和來之浮雲溪，合流至麗水縣境之大港頭，會自遂昌松陽東南流之松陰溪，合流而北，至麗水縣城，再會自縉雲南流之好溪，乃曲東南流至青田，會自景寧來之小溪，於是匯爲巨川，是曰甌江。東流經永嘉，合自楓林鎮南流之南溪港而入海。甌江口巨輪進出，海外交通，爲浙省各江口冠，小汽輪可直達青田，青田以上，川流於流紋岩中，故兩岸峭壁，水流喘急，有七十二灘之險。

（三）湖泊

調查區域內，湖泊分佈於杭州，蕭山，紹興，諸暨一帶，亦卽錢塘江之下流也。舉其名者大者，若杭州之西湖，蕭山之湘湖，紹興之東湖，狹搽湖，瓜渚湖等，及諸暨北鄉之湖田，玆分述如下：

西湖—西湖位於杭縣之西，北西南三面環山，東隔杭縣平原，而與錢塘江相望，湖與江相隔最近處僅二公里半。環西湖一周，約三十華里，面積凡九七八，八七九方公尺。

錢江自富陽東北流，至蕭山縣西南，折向西北流，至杭縣之轉塘，爲五雲山所阻，又折向東北流。轉灣處江面較窄，故水流較速，迨一出山口，江面驟寬，水流亦緩，高速度時所夾之巨量泥沙，至此遂沉下停積，此杭州中積平原之所以造成也。西湖本爲一江灣，其灣口因杭州中積平原之造成，乃相隔絕而成湖泊。

湘湖—湘湖臨蕭山城西南，杭州東南二十餘里，大致成東北西南向之狹長形，長凡八公里，最寬處達三·六公里，面積幾倍於西湖。考其成因，乃由於錢塘江之改道，試觀地形圖。（第五版）錢塘江自富陽東北流，若經湘湖入海，係一直線，乃至湘湖西南端僅隔半公里。忽折而西北，至轉塘，又折向東北，而又經離湘湖東北端僅二公里而北流，錢塘江如經湘湖而過，較此多費兩番周折當近數十里。由地形上觀察，錢塘江必一度經湘湖直流，但何以後忽改道，其理亦至爲明顯，蓋湘湖兩旁有千里岡砂岩所成之石岩山及美女山夾峙，故當時每値水大時，必因兩旁山之阻峙而不得暢流，有若今日之七里瀧然。此種狀態，年深日久，於是江流每値水過大時，分一支向西北平地繞道而行，迨後其支流之河床，漸寬漸深，久之捨湘湖之道而行此曲折紆廻之道矣，湘湖乃隔離而成爲湖泊。

紹興縣北鄉一帶湖泊—紹興縣北鄉，除少數小山外，爲大片中積平原，近江邊數十里內，幾全爲沙土，蓋沉積未久也。湖泊甚域，舉其名者，若城東十里之東湖，舉其大者，若城北之狹搽湖，城西北之瓜渚湖，城東二十里之賀家池等，周圍均數十里，其他小湖，不勝枚舉　考其成因，據作者觀察，紹興及蕭山北鄉一帶，似均一度爲淺海所侵入，厥後海水後退，低窪之　，蓄水

而成湖泊，其後江流地海潮均向北侵襲，江南沙灘漸漲，故至今此類湖泊離江邊甚遠。此種情形，一部分且爲歷史所記載，如顧氏方輿紀要云：「海寧縣西南五十里有赭山，其對岸相峙者曰龕山，屬蕭山縣界，橫江截海，爲之海門，爲控要扼害。」而今赭龕二山，均在江南岸，非特海門已淤爲陸地，赭山且離江岸十餘里矣。此果由於江流之改道，而海水之後退歟，抑或陸地之上昇，亦不爲無因也。

諸暨縣北鄉之湖田—諸暨北鄉一帶，湖田甚多，湖田者，低窪之農田也，較普通平地有低至數十公尺者，肥沃異常，水量豐富，雖大旱亦不受災害。此種湖田，乃湖泊之晚年期也，湖田之大者，在縣城東北約五十里，楓橋鎮西北十里一帶，湖作方圓形，周圍約二十餘公里，現以人工作堤，劃分成數十區，曰周家湖，裏大湖，海家湖，孟家湖，西新湖等。湖田四周環山，僅東南及西北兩小口可以出入水流，東南地形漸高，且臨近會稽大山脈，西北漸低落，出西北即爲浦陽江。故此大湖田之成因，當爲昔日會稽山脈之水，聚而流經楓橋鎮進東南小口，蓄水於此，西北雖有出口通浦陽江，以其口小流，出量尚不及流進水量之多，於是湖泊成焉。迨後因東南流進之水，入口後水流驟緩，而所夾之泥沙，遂停積於此，逐漸增加，加以海準下降，浦陽江之水綫亦因之而下退，於是西北口流出量增加，湖泊遂逐漸淤塞，遂成今日之湖田。

(四) 海岸

浙省沿海均爲火山岩及花崗侵入體，海岸曲折，島嶼林立，此次足跡所經，除杭州灣外，曾一度至平湖縣之乍浦，並經過臨海縣之海門，及樂清溫嶺永嘉等縣海岸。

浙江沿海形勢曲折，島嶼林立，足示海岸下降之徵。但在最近時似陸地又有逐漸上昇之跡，各沿海之小山山坡上，尚劃有昔日之水線。(此事尚待再加考察)乍浦西北五里之雅山，爲二叠紀飛來峰石灰岩所成，離海面高一〇四公尺，山上之石灰岩露頭，石灰質大部已溶化，所剩一矽質多孔狀之物，粗視之，頗似火山岩中之浮石，但其下則石灰質漸多，此種狀態，當此久浸於海水中，石灰質爲海水衝擊溶解之結果，乍浦東南獨山，岩石爲粗面岩及安山粗面岩，面海山坡，成懸崖絕壁，其半坡尚有灰白色之

水綫遺跡，樂清縣大荊鎮東南爲一海灣，該地沿海數十里，均係懸崖峭壁，若百丈岩，棺材岩，均係當時海水衝擊之結果，而遺有痕跡焉。

第三章　地文

浙省中部之地文，大致與贛東相似，（詳拙作江西玉山廣豐二縣地質礦產）茲分爲四期：

（一）仙霞期—白堊紀以後之剝蝕平原。

（二）贛東期—寬廣河谷及盆地之造成，第三紀紅色砂岩之停積。

（三）嵊縣期—紅色砂岩停積後之剝蝕平原，玄武岩之掩蓋。

（四）衢江期—現代河谷所深切之幼年地形。

仙霞期—爲浙省遺留至今之最古地形，其高度距今海拔千公尺以上。調查區域內，天台山，括蒼山，雁蕩山之頂，皆有此類侵蝕平原之遺跡。天台山高千餘公尺，山坡陡峭，而登其頂，則又爲一片低坡起伏之似平原，田隴相望，置身其上，頓忘已離平地千公尺矣。雁蕩山頂，懸崖絕壁之上，村落農田相望，小溪緩流，且千餘公尺之山頂，尚有湖蕩在焉。諸此情形，似當爲一古代剝蝕平原之遺跡，較之贛東浙西一帶，尚爲顯著。考諸地質，此類高山，多成自白堊紀之火山岩流，蓋當白堊紀火山噴發告終之季，浙省幾盡爲所掩埋，迨後剝蝕繼之，而成一侵蝕平原，其時代當在白堊紀以後，第三紀紅色岩層停積之前也。

贛東期—作者曾於江西玉山廣豐二縣地質礦產篇中，論贛東期如次：「仙霞期剝蝕平原造成之後，繼以造山作用，（燕山運動後期）使大陸逐漸上升，當其上升之時，剝蝕隨之，於是一方使山之高度，日增靡已，成今日高出海拔千公尺諸高山，一方則剝蝕日劇，寬廣河谷及盆地之造成，衢江紅色岩層之停積，與夫古生代地層之重行出露，皆其侵蝕之結果也。」浙省東部，代表贛東期之地形，更爲明顯，若嵊新盆地及天台盆地之造成，錢塘江兩岸寬廣河谷之產生，與夫東陽義烏一帶紅色岩層之停積，皆代表本期地形也。贛東期之時代，自當後於白堊紀，而隨第三紀紅色岩層停積之告終而完成。

嵊縣期—第三紀紅色岩層停積之後，地面又略起拗曲作用，侵蝕繼之，於是寬廣河谷中，又略呈一似平原。迫後玄武岩噴發而出，盡掩覆於此似平原之上，義烏東陽一帶，第三紀紅色岩層拗曲甚烈，而與其上玄武岩之接觸面，幾成水平，此接觸面，當代表另一侵蝕平原之遺跡，是曰嵊縣期。他若嵊縣新昌天台一帶，玄武岩掩蓋前之地面，亦即第三紀南嶺運動以後所成之侵蝕平原，無不屬之。

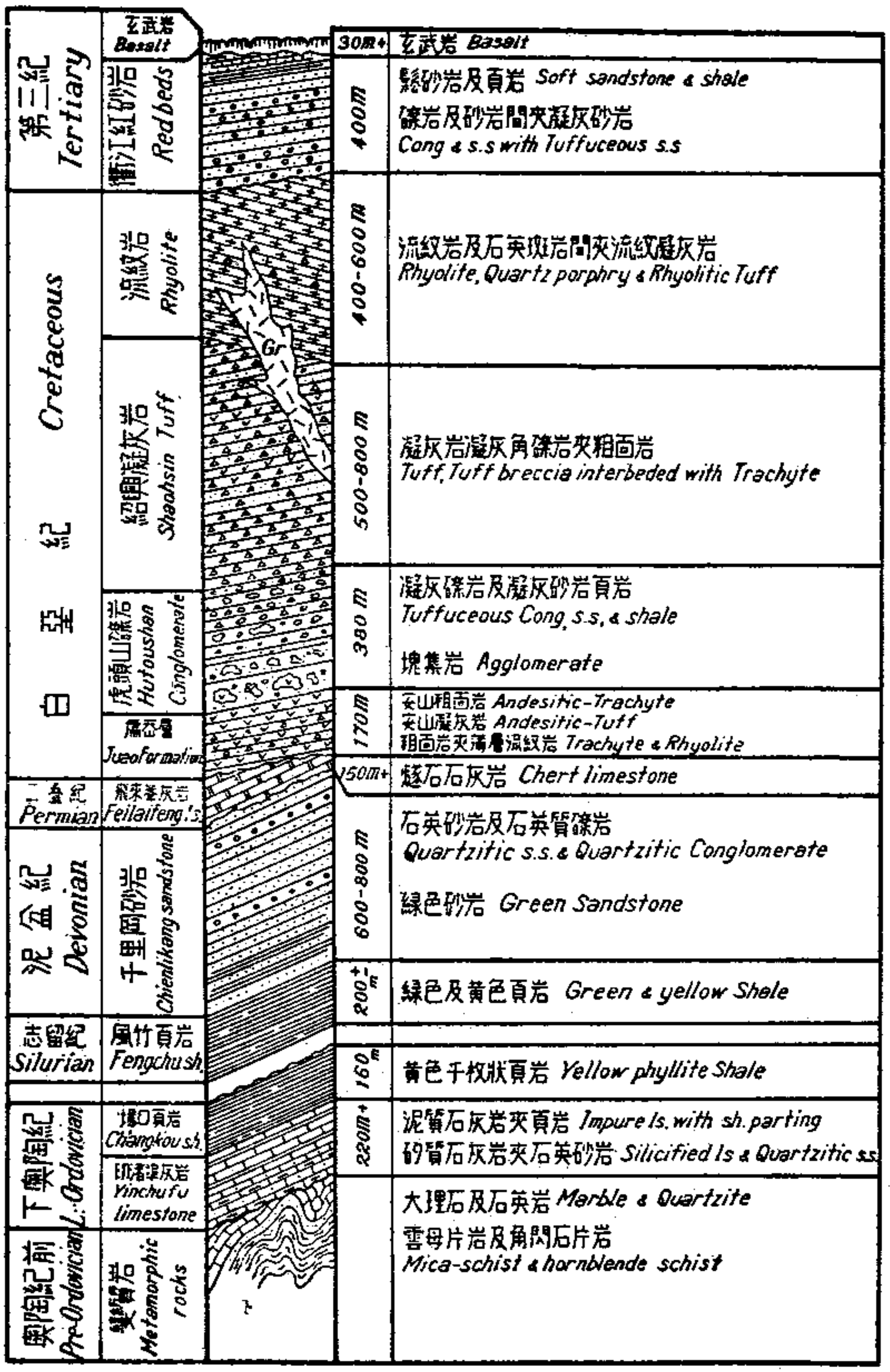
衢江期—本期地形，皆切於嵊縣期之上，組成狹谷深溝，凡現代河流切成之幼年期溝谷，無不屬之，至今猶繼續進行也。調查區域內，曹娥江靈江甌江及其支流所經之溝谷，均甚明顯。

第四章 地層

調查區域內，大部爲白堊紀火山岩流，僅諸暨至紹興一帶，有古生代岩層露出。又嵊縣東北及諸暨西南一帶，有變質岩出露。玆將所見地層，自下而上，依次分列如下：

第六圖浙江東部地層柱形圖

變質岩	奧陶紀前
石灰岩及頁岩	奧陶紀
風竹頁岩	志留紀
千里岡砂岩	泥盆紀
飛來峰石灰岩	二疊紀
儒嶴層中性噴出岩	
虎頭山礫岩	
紹興凝灰岩	白堊紀



第六圖 浙江省東部地層柱狀圖

Fig. 6. Columnar section of Eastern Chekiang.

衢江紅色岩層
玄武岩 ｝第三紀
冲積層　近代

變質岩—嵊縣及諸暨二處所見之變質岩，有石英雲母片岩，角閃片岩，正長石片麻岩，石英岩，大理石。其層次似以片麻岩作底，其上爲片岩，再上爲石英岩及大理石，石英岩脈甚多。變質岩分佈于嵊縣北七十里王城市迤東一帶，及諸暨東南鄉陳蔡市璜山市一帶，後者已詳見孟憲民君報告。王城市迤東之變質岩，分佈於銀沙袁香一帶，岩石爲石英雲母斑岩，雲母片岩，角閃石片岩，被覆於凝灰岩及凝灰礫岩之下。

作者曾於浙省西部新登縣三溪口附近，奧陶紀石灰岩之下，見有石英岩及石英雲母片岩，似可與浙東之變質岩相比較，據此則浙省變質岩之時代，至少當在奧陶紀以前。但因浙省寒武及震旦紀地層尚未明確發現，故變質岩亦僅能謂爲奧陶紀前而不能確指屬於何層也。

奧陶紀石灰岩及頁岩—調查區域內，於富陽縣場口鎮西南山露出尚較完全，其下部爲厚層石灰岩夾矽質砂岩，其上爲薄層石灰岩夾黃色頁岩，再上則爲黃色頁岩，時夾薄層細砂岩，含下奧陶紀筆石化石甚爲豐富，粗經檢定，有下列數種：

Phyllogratus anna Hall

Tetragraptus bigsbi Hall

Didymograptus nitidus Hall

惟其上部爲一斷層所隔，而與千里岡砂岩及飛來峰石灰岩接觸。

諸暨東北約二十里之盛兆塢，直至紹興西南約三十里之漓渚市及灰皂頭，亦爲本系露頭，岩石大致下部亦爲厚層不純石灰岩夾矽質砂岩，漸上漸變爲薄層石灰岩夾黃色頁岩，露頭延長凡二十餘里，走向爲東北西南。其東南西北兩面均被覆於凝灰岩之下

或埋入平地，僅濟渚市東北石灰岩隔一河濤，與千里岡砂岩相望，關係不明。

「附」浙省奧陶紀地層，朱庭祜君首在浙江北部分爲上下兩層：下部曰印渚埠系，以石灰岩爲主，中夾多層板岩，砂岩，石英岩，及千枚岩。上部曰荆山層，爲板岩，千枚岩，含泥質石灰岩，扁桃狀石灰岩及泥質砂岩，其後劉趙二君調查浙江西部地質，亦分爲上下兩層：下部仍名之爲印渚埠系，係上下兩層各三百公尺之泥質薄層石灰岩夾一厚三百餘公尺之頁岩及砂岩所組成，頁岩中得下奧陶紀化石甚多。上層曰硯瓦山層，以綠色灰質頁岩及含灰質結核之頁岩爲主，間夾有不純石灰岩薄層。作者曾在江西東部，所見奧陶紀地層有三層：下層曰交塘系，以泥質石灰岩及細砂岩夾石煤爲主，中層曰玉山頁岩，得(Lower Arenig)筆石化石甚多，上層爲大南嶺石灰岩，爲薄層石灰岩夾頁岩，得(Upper Arenig)化石甚多。此三層似與劉趙二君之印渚埠系相當。其上岩層，在贛東因受大斷層所隔而不顯。此次作者與盛君莘夫在浙江西北部所見奧陶紀地層，似覺該地之交塘系，(卽印渚埠系下部）與贛東及浙江西南部均可比較，僅岩性上稍有出入，玉山頁岩，則岩性與層位完全相當，所得化石亦相同。惟大南嶺系在浙江西北部陸相沉積增多，石灰岩中之泥質大增，於所夾之頁岩內，尙覺得與大南嶺頁岩中相似之化石羣。至其上之硯瓦山層，岩性上仍可與浙江西南部相比較，惟層厚大減。又江蘇南部奧陶紀地層，下奧陶紀崙山石灰岩之上，僅二十公尺之中奧陶紀湯山灰岩，其上卽爲志留紀之高家邊頁岩，由此觀之，奧陶紀地層，似有愈往南愈發育之勢，往北則厚度漸減，層數漸缺，長江以北，則下奧陶紀石灰岩之上，卽爲石炭紀地層，中奧陶紀之地層竟缺而不露矣，茲將各地所作之柱狀剖面圖，比較如附圖所示。（第四版中國東南部奧陶紀地層比較圖）

志留紀頁岩——諸暨縣城西北，臨千里岡砂岩所成之高山麓，有若干小山坡，成自黃綠色頁岩，與江山附近之風竹頁岩頗相似，惟露頭不完全，亦未覓得化石。

志留紀頁岩，在浙江西北部尙稱發達，其上部由頁岩而漸變爲砂岩，卽千里岡砂岩，兩者完全整合，其下與奧陶紀地層爲不連續，交接處爲一層含灰質結核之紫色頁岩，產寶塔石甚多。浙省之志留紀頁岩中，化石頗不易尋覓，作者僅在於潛縣東九里

橋，得不完善之（Monograptus）數塊，僅能代表志留紀而已。

千里岡砂岩—浙省中部千里岡砂岩，除諸暨西北鄉自成一東北西南向山脊外，餘均不過零星露頭。蕭山湘湖兩旁，紹興西南漓渚市東北有峰山雄山，亦爲本系岩層組成，成一東東北—西西南方向之小山脊。又富陽塲口鎮西南，本系岩石亦有一部分露出，與奧陶紀岩層成斷層接觸。所見本系岩層，其走向大致均爲東北西南，諸暨西北本系岩層整合覆于志留紀頁岩之上，而二叠紀飛來峰石灰岩假整合覆於本層之上，本系岩石，下部以綠色及紫色砂岩爲主，間夾砂質頁岩，上部則以石英砂岩爲主兩者之間，常見有石英質礫岩爲之分界，故調查浙省地質者，有將其分爲兩系，下部名爲界嶺砂岩，上部謂爲西湖石英岩。實則兩者岩性上雖甚易分爲兩條，而兩者均未覓得可代表地質時代之化石，故地層系統上尙無分爲兩層之必要也。

二叠紀飛來峰石灰岩—本系石灰岩僅見於諸暨西北鄉大橋市附近，假整合覆於千里岡砂岩之上，其上則爲流紋岩不整合掩覆。岩石爲砂質薄層石灰岩，其底部時露灑靑質頁岩。

儒岙層中性噴出岩—紹興南部及新昌天台間，火山岩系底部有粗面安山岩，粗面岩，及安山凝灰岩，粗面凝灰岩及薄層流紋岩出露，其上則爲虎頭山礫岩。紹興縣城西南凝灰岩系之下，亦有此類中性噴出岩露出。天台城西北黃裏岙一帶，中性噴出岩與虎頭山礫岩接觸處甚清晰，礫岩傾角四十餘度。接觸處礫岩中卵石有大塊粗面安山岩等，故此項噴出岩，當爲浙省初次火山爆發之產物也。

虎頭山系紫色塊集岩礫岩砂岩—本層沿用孟憲民君舊名，彼在諸暨縣虎頭山所見如下：「上部爲一礫岩層，至下部則漸侵入一砂岩層，與流紋岩接觸處，露紫色與灰色頁岩，其下卽爲礫岩，大致爲石英與長石之礫石，含於一細密潛晶質之石膠中。」此次調查區域內，首見於紹興之香爐峯，爲紫色塊集狀礫岩，卵石以黯紫色硬砂岩爲主，直徑自數公厘至數十公分不等，膠合物則爲紫色凝灰砂岩，整合被覆于凝灰岩系之下。次見於嵊縣新昌一帶，嵊縣之烏岩，此紫色礫岩層亦被覆於凝灰岩層之下，新昌西南之究山，則傾斜二三十度之礫岩層上，覆有傾斜甚緩之流紋岩層，不整合之現象，極爲顯著。天台西北鄉黃裏岙一帶，礫岩之

下，有中性噴出岩露出，可知礫岩停積以前，火山即已活動，故礫岩中常有噴出岩卵石。天台東南之白岩嶺頭，亦有一層安山岩，似夾於礫岩層中者。本系岩層，常夾有凝灰角礫岩，凝灰岩及流紋岩薄層。樂淸縣大荆鎭東百丈岩一帶，凝灰岩系整合覆於礫岩層之上，前者抵抗風化力較強，後者較鬆輭，故成百丈削壁。礫岩層又露出於仙居縣城附近及諸暨縣城附近一帶，流紋岩均直接覆於礫岩層之上，接觸處甚不規則。

紹興凝灰岩層—本層在浙省分佈至廣，其岩石爲全省主要建築材料，以灰綠色凝灰角礫岩爲主，角礫之大小多寡，隨層隨地而異，常夾以潛晶質之熔岩。調查區城內，首見於紹興西南鄉及東南鄉一帶，層次尙整齊，每層厚約一公寸，傾斜甚緩，故開採頗易，以其成本低廉，取用不竭，且抵抗風化力尙強，故舖石板大道及各項建築石料，多取材於是，石坑林立。新昌嵊縣南鄉及天台西南鄉，露頭面積亦至廣，北雁蕩山脈盡爲此項岩石造成。環視各地，本系岩層與虎頭山礫岩層均係整合接觸，兩者具爲漸次遞變，其接觸處固無明顯之界限也，惟與其上之流紋斑岩層，則爲不整合接觸。北雁蕩山東北麓，流紋斑岩同時覆於凝灰岩層及礫岩層之上，而凝灰岩層固整合覆於礫岩層之上也。又新昌之壳山及諸暨之虎頭山，流紋岩及流紋斑岩直接覆於礫岩層之上，兩者之間，無凝灰岩層之遺跡，蓋當流紋岩流溢之前，該地之凝灰岩層已侵蝕無餘矣。本層岩石，橫斷裂縫甚多，故傾斜平緩之處，侵蝕作用常依此裂縫而進行，致成懸崖絕壁，如樂淸縣之雁蕩山，溫嶺縣之方岩，黃岩縣之童山，皆造成奇突風景。本層之厚度，在雁蕩山所量得爲八百餘公尺，紹興附近露出者亦達六百公尺。

本層岩石大致以灰綠色潛晶質酸性居多之熔岩及火山灰爲甚，而以各種角礫塊參雜其間，角礫之紫色者，以砂岩爲主，似來自其下之虎頭山礫石層，角礫之灰綠色者，多成自本層自身之凝灰岩等。本層內常夾有酸性岩流，惟多少仍含有凝灰及角礫也。

流紋岩—流紋岩爲造成浙省主要山脈之岩層，當其流溢之時，浙江全省本皆覆沒於岩流之下，其後屢經侵蝕，其下之岩層，始得重行出露。

流紋岩凝結至厚，但甚不易測得其精確厚度，蓋其層面，常不淸晰，而傾斜甚緩，故即依傾斜方向行數十里盡爲流紋岩，而

實際上厚度並不甚大。調查區域內，流紋岩最發育處，首推諸暨之五洩至富陽之塲口一帶，露頭沿傾斜方向延展達五十里，計其厚度，亦不過五六百公尺。

全層岩石之成分，大致無甚變化，惟結晶粗細及斑晶多寡，相差殊遠，故岩石包括流紋岩，流紋斑岩或石英斑岩。岩石之顏色，有兩種：卽紫色與灰綠色，前者似屬上部，後者爲下部，惟風化後概成紫紅色。結晶之粗細，隨層隨地而異，蓋本層之造成，乃由於無數次熔岩噴發，其流溢之範圍，熔岩之多寡，與夫冷却之遲速，均無一定。近底部處，往往含黑雲母六方體甚多，浦江縣馬劍鎮附近，流紋斑岩成柱狀結構，(Columnar Structure) 均爲六方柱狀，甚爲美觀，此種現象由於熔岩凝結時驟冷而縮所致。

花崗岩侵入體—調查區域內，各花崗岩侵入體之顏色及組織，雖時有變更，而其侵入之時代，卽與各岩層間之關係則一也。花崗岩露頭範圍之大者，首推天台山，成一岩盤 (Lacolith) 圍岩向四周緩斜，其他均爲小範圍露頭，分佈於天台南鄉及臨海縣北鄉一帶。

岩石在天台山者爲微紅色，結晶甚勻之花崗岩，以石英結晶爲最多，正長石及透長石次之，黑色礦物以黑雲母及角閃石較多榍石及磁鐵礦亦時見於薄片中。

天台南鄉前岸一帶之花崗岩中，有閃長岩岩脈，岩石作灰白色，以斜長石爲主，雜以黑色細長條針狀之角閃石，縱橫錯列，甚爲美觀。與花崗岩接觸處，似屬漸次遞變，故或爲岩漿之分離作用而造成也。河頭鎮附近，花崗岩露頭範圍較小，與圍岩接觸處，多成文像花崗岩，卽石英與正長石相互包含之結晶也

調查區域內之花崗岩，大致均屬同時代之侵入體。與流紋岩之關係，在臨海河頭鎮附近，所見甚爲淸晰，接觸處花崗岩本身含黃鐵礦甚多，且流紋岩局部受接觸而稍變質。至與第三紀紅色岩層之關係，雖未見其接觸，但由於停積情形觀之，紅色岩層停積之季，花崗岩似已早崛起而爲高山矣，故花崗岩侵入時代，大致爲白堊紀之末期，正値燕山運動後期發作之季也

第三紀衢江紅色岩層——調查區域內僅分佈於東陽義烏一帶。所見岩石，以紅色砂岩爲主，夾礫岩層甚多，（並夾有凝灰質砂岩），全層不整合覆於白堊紀火山岩流之上。

本層岩石，大體均極鬆軟，顏色均爲鮮赭紅色，砂岩中時有白色石灰質包含物，其底部爲一厚層之礫岩，其卵石卽以其下之岩層作材料，而以粗鬆之砂石混和而膠合之。本層岩石，所見尚不完全，惟在東陽南鄉牛岑下一帶，其厚度已達四百公尺以上。義烏附近，本層所夾之黃綠色砂岩中，得植物化石數塊。

玄武岩——浙省玄武岩流噴出之時代甚新，所見均成水平層，不整合掩蓋於第三紀紅色岩層及白堊紀火山岩系之上。岩石作深黑色，氣孔甚多，含橄欖石甚多，輝石亦不少，長石僅少數鈣長石及鈣鈉長石、磁鐵礦多成小顆粒，滿佈其間，岩基大多爲黯色玻璃質。

調查區域內玄武岩分佈於嵊縣新昌附近及天台西北鄉及東南鄉一帶。東陽義烏一帶，第三紀紅色岩層所成之侵蝕平原上，時見有侵蝕剩餘風化甚深之玄武岩薄層。又東陽東南鄉之八面山，峭壁矗立，八面玲瓏，山頂則爲玄武岩所成之似平原，並有結晶甚粗之輝長岩侵入，含橄欖石巨粒結晶甚多，成分與玄武岩相似，故八面山或爲玄武岩噴發時代之一火山口。

第五章　地質構造及地殼運動史

浙省中部古生代地層走向，以東北西南最爲普遍顯著，中生代火山岩，雖大部傾斜甚緩，但其走向仍不失爲東南北西向，故由此類岩石造成之主要山脊，若括蒼，若會稽，亦莫不作東北西南向。調查區域內河谷及盆地大致均順背斜軸進行，山脈常依向斜軸而存留，故浙省地形，已趨於壯年期狀態，玆分述如下：

諸暨背斜層——諸暨縣城至紹興縣城一帶，爲一東北西南軸向之背斜層構造，背斜層中心，古生代岩層出露，火山岩均向兩旁緩斜，惟古生代地層一致向西北緩斜。此背斜層東北至紹興附近入於平原，西南至諸暨西南覆沒於流紋岩下。（第一圖）

嵊新背斜盆地——嵊縣新昌一帶爲一依背斜軸而成之帶狀盆地，近背斜軸一帶凝灰礫岩及凝灰砂岩（虎頭山層）露出，而兩旁

則爲流紋岩及凝灰岩所成之高山。盆地大致爲東東北—西西南向，東北至嵊縣與奉化交界處，西南至嵊縣之長樂鎮，盆地長凡百里，寬約二十餘里。

天台背斜盆地—構造大體與嵊新盆地相同，爲一東東北—西西南向盆地，其中段向北展寬，東至橫頭戴，西南至街頭鎮，北至白鶴殿，南至天台縣城附近，盆地延長凡九十餘里，最寬處達四十里。

璜山背斜層—諸暨東南璜山市一帶，爲一背斜層構造，背斜軸大致作北北東—南南西向。近背斜軸一帶變質岩出露，其兩翼則爲白堊紀火山岩流。

袁番背斜軸—嵊縣北鄉與紹興交界之王城市迤東袁番一帶，亦爲一背斜層構造，背斜中心，變質岩出露，兩旁則有白堊紀之岩層掩覆，與璜山背斜層情形大致相似。

地殼運動史

浙省在古生代尙未發現顯著之造山運動，而造陸運動則上奧陶紀及石炭紀均甚顯著。本區域內，古生代地層遠不如浙西完整，而中生代及新生代地層，則較發育，故僅將中生代以後之地殼運動，列表比較如下：

地質年代	運動情形	比較
侏羅紀末期	造山運動、褶曲、斷層、	燕山運動第一期
白堊紀	中性熔岩漿及凝灰礫岩之噴發與停積 拗曲及侵蝕	燕山運動第二期
上白堊紀	流紋岩流溢	
白堊紀末期	花崗岩之侵入拗曲及侵蝕	燕山運動第三期
第三紀初期	衢江紅砂岩之停積	
第三紀中期	拗曲及侵蝕	南嶺運動

第三紀末期　玄武岩流溢

一、虎頭山礫岩層及紹興凝灰岩與古生代地層之不整合，沿錢塘江及浦陽江兩岸多處均可見及。義烏縣城西北，約二十五里之烏灶煤田，煤系傾斜甚陡，而其上之凝灰礫岩，則傾斜甚緩，兩者似亦為不整合接觸。至烏灶煤系，據李陶君所採植物化石，經本所潘鍾祥君檢定結果，謂確屬侏羅紀，故造山運動似在侏羅紀之後期也，而與北方最普遍之燕山運動第一期相當。

二、當凝灰礫岩等停積之季，地殼仍不穩固，拗曲作用與侵蝕作用，同時進行，迨後主體熔岩流溢，兩者遂時呈不整合接觸，是可謂為燕山運動第二期。

三、流紋岩與其上之衢江紅色岩層之不整合—浙省當流及岩流普遍掩蓋之後，拗曲作用，更有加無已，加以花崗岩漿湧起，故造成若干以東北西南向為軸之背斜層及向斜層。背斜軸以抵抗風化力薄弱，年深日久，遂夷為盆地及河谷，向斜軸則高峙成今日之高山。於盆地及寬廣河谷中，有紅砂岩停積於是與流紋岩遂成顯著之不整合。此項運動時期，似屬於白堊紀之末期，可謂為燕山運動第三期。

四、衢江紅砂岩與玄武岩間之不整合—當衢江砂岩停積之後，拗曲作用仍繼續不怠，使衢江紅砂岩向盆地或河床中心傾斜，傾面普通為一二十度，但局部亦有大至三四十度者。而水平層之玄武岩掩覆其上，成不整合接觸。在義烏附近所見甚為清晰，李陶君在江山縣西鄉亦見有同樣情形，是則南嶺運動，亦波及於浙省矣。

第六章　礦產述略

調查區域內，可謂無具有大價值之礦。義烏新昌嵊縣諸暨之氟石，諸暨小東鄉之鉛鋅礦，樂清西鄉之錳礦，及諸暨西北鄉之黃鐵礦，尚能供小規模之開採，茲分述如下：

氟石—調查區域內氟石，均成脈狀，生於流紋岩中。此種氟石脈多與流紋岩之層面垂直，蓋流紋岩因凝結時之冷縮及褶皺關係，發生與走向平行之裂縫甚多，氟石脈遂起而充填其中，礦脈來源或與花崗岩岩漿之侵入有關。所見之氟石質尚純，除少量之

石英外，未見其他礦物共生。氟石顏色有二種，一爲綠色，一爲紫色，質之純者，顏色極爲鮮明可愛，故浙省氟石之用途，除製氟酸作煉鐵熔劑等外，其用以雕刻各項精雅器皿者甚多，北平市上，充作古玩珍品。在杭州市價，普通氟石每噸自八元至二三十元不等，全視其含氟化鈣成分之多寡而定，此等皆運往外埠，作製造氟酸等用。其大塊質純顏色鮮明裂縫稀少者，價值甚高，每噸有售至一百五六十元者。氟石礦之開採，普通均爲露天開採，蓋氟石礦脈，往往垂直流紋岩圍岩之層面，亦即常與地面成垂直，故一般開採，均沿山坡自上而下，逐步往下採掘，既不必抽水，又不必支柱，故成本甚廉，僅工人之工價至巳。礦主多採包工制，即每噸礦石，石匠得若干，地主得若干，運費若干，礦主不費分文，坐享其利。義烏南鄉鐘村所開之氟石，據浙江建設廳礦產事務所分析結果，其成分如下：

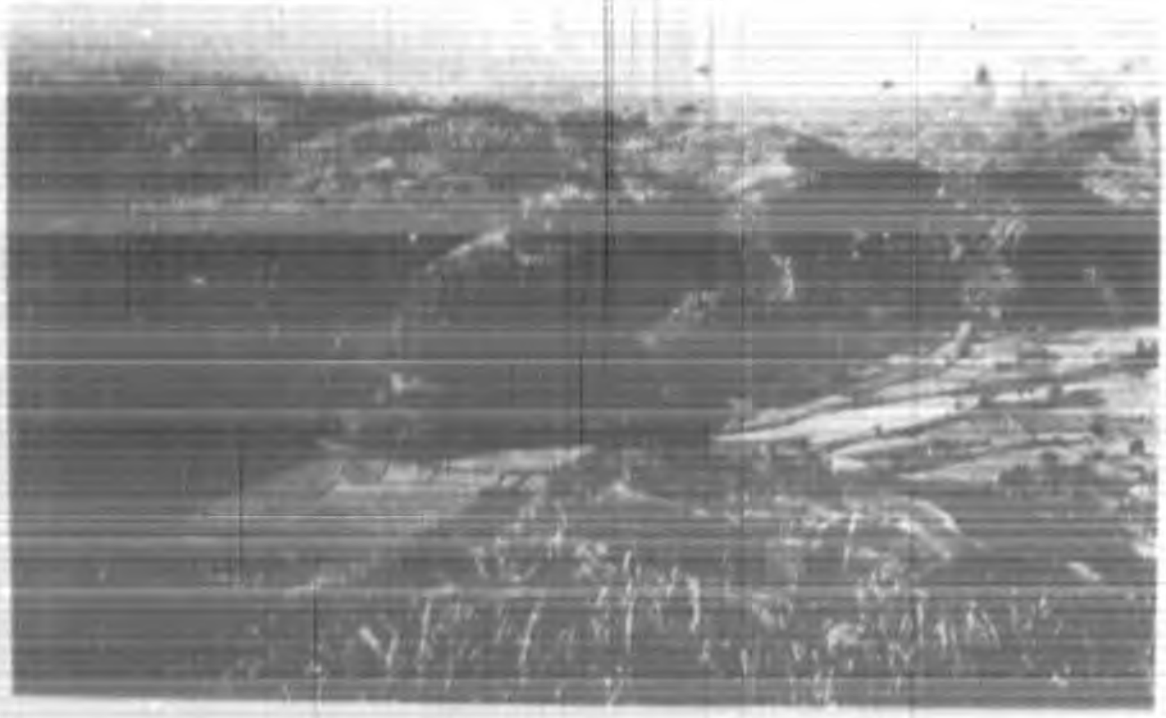
鈣氟$_2$	百分之九五・四九
鐵$_2$氧$_3$及鋁$_2$氧$_3$	百分之一
矽氧$_2$	百分之〇・六五
硫酸鈣	百分之一・三〇
燃燒損失	百分之〇・六〇

錳礦——樂清西鄉潭頭村南山半坡，有一硬錳鑛脈，圍岩爲粗面凝灰岩，脈向與圍岩之走向平行，爲一順裂縫所生之礦脈，脈長約六十餘公尺，最厚處達五公尺，深度不明。該地爲土法開採，掘有五洞，其一已深至二十餘公尺，開採之成本雖輕，惟全視銷路而定價值，據云常因銷路停滯而歇工。運輸尚便利，僅自礦洞至船埠二十里，須人工肩挑，小船行六十里至館頭鎮，即易大輪載滬。與鑛共生者，尚有黃鐵礦及鉛鋅礦。

鉛鋅礦——諸暨小東鄉璜山一帶，爲變質岩出露之區，變質岩中，閃鋅礦及方鉛鑛黃鐵礦之礦脈甚多，大致由於後起造成璜山背斜層之大岩基侵入。此侵入岩除出岩枝外，其主體尚未出露，岩基侵入時，上與變質石灰岩起接觸作用，而生接觸礦床物。岩

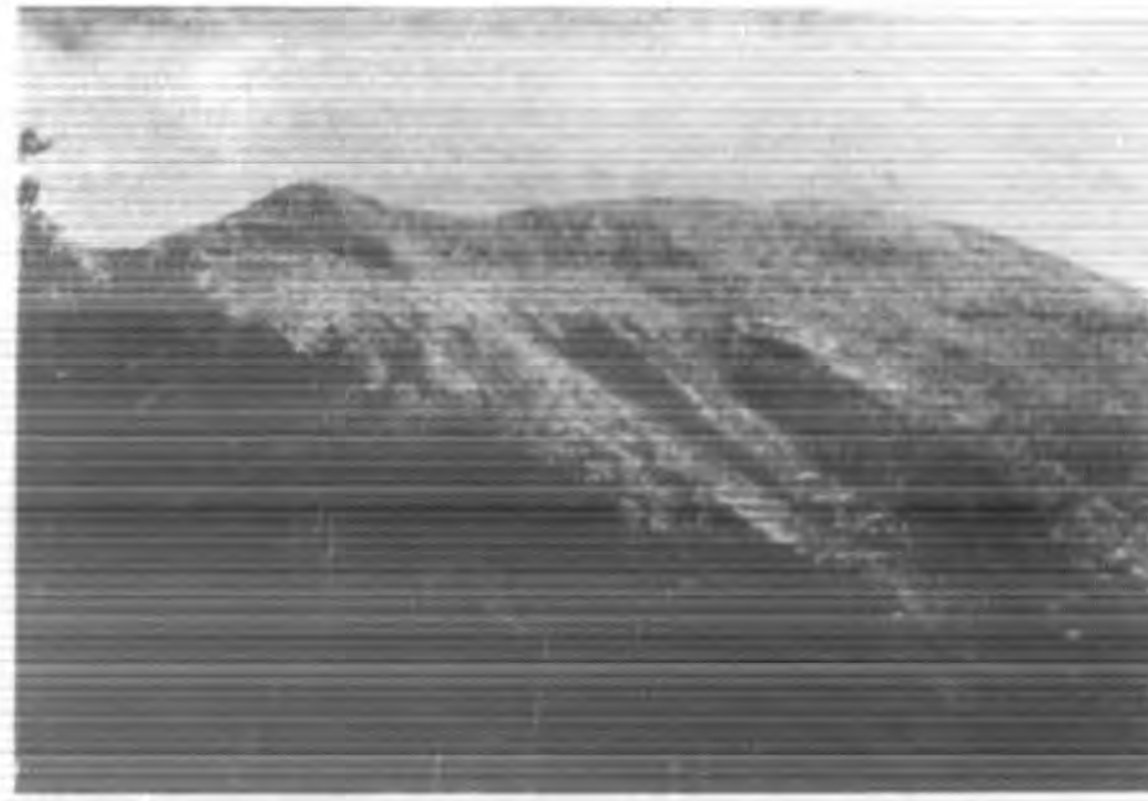
漿冷凝而分離之時，各種氣體隨其縮隙而出，接觸帶間即起交代作用，繼之則爲較低溫度之礦脈，石英脈之沈澱。就中以洞岩山之鉛鋅礦，比較稍有價值，前曾由大豐公司開採，現已停工，該處離鐵路僅二十公里，交通尚便利。

黃鐵礦—諸暨西北鄉堰頭村附近，二叠紀飛來峯石灰岩中，黃鐵礦成球狀礦床，現所發現處，據云礦量尚富。礦質成分頗佳，由勵乃驥等集資開採，惟此種球狀礦床，其礦量極難估計，葢變化莫測。惟交通甚便，距鐵路僅五六公里。天台北鄉與新昌交界之大同山，花崗岩與流紋岩接觸處帶上，有黃鐵礦產生，本地人亦正在用土法開採，惟交通頗不便，黃鐵礦之價值又甚低，實無利可圖也。



新昌縣附近虎頭山礫岩所成之似平原
(嵊縣期地面)及衢江期河谷

Fig. 1. View showing the peneplain of Chenhsien formed by Hutoushan conglomerate and deep valley of Chukiang stage, near Sinchang.



天台縣黃裡畬玄武岩與虎頭山礫岩之不整合

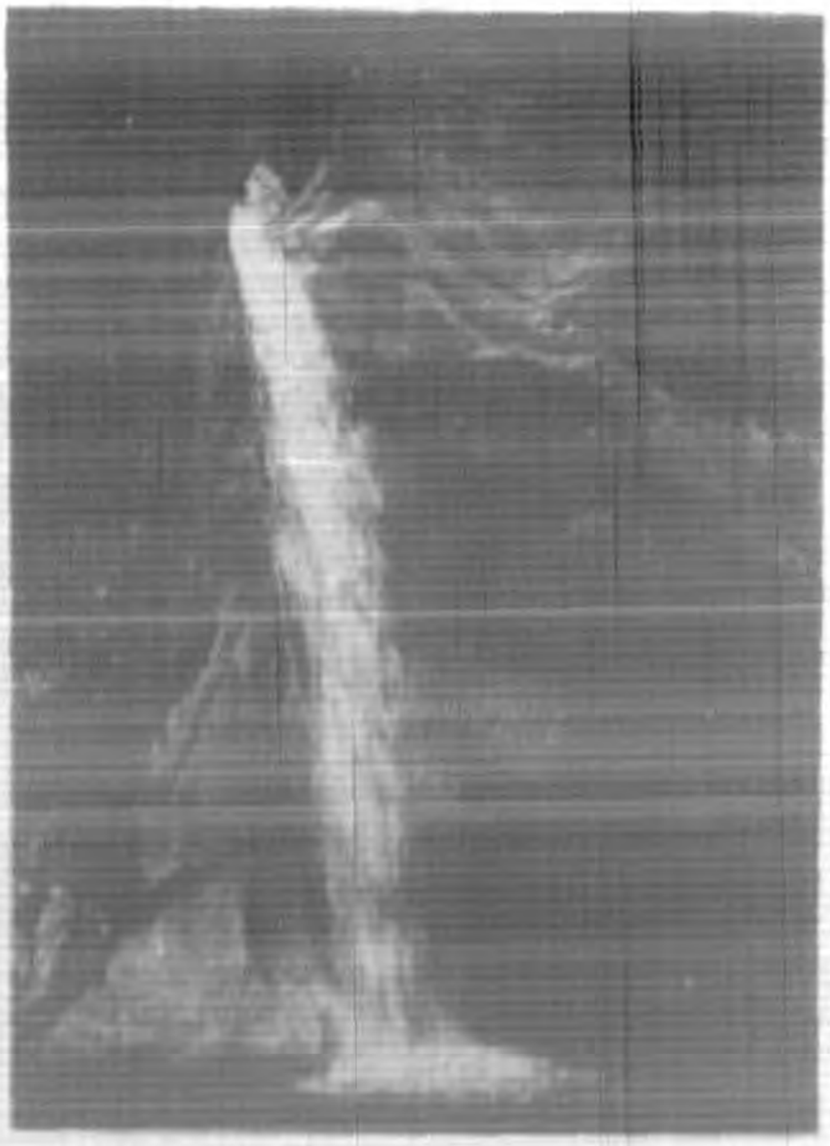
Fig. 2. View showing the basalt resting unconformably upon the Hutoushan conglomerate, Huangliao, Tientai district.

紹興縣柯岩及七星岩爲凝灰岩所成之峭壁

Fig. 3. The cliffs of tuff, Koyen and Tsisingyen, Shaohsing district.

天台山花崗岩石樑瀑布

Fig. 4. The natural bridge of granite and waterfall, Tientaishan.

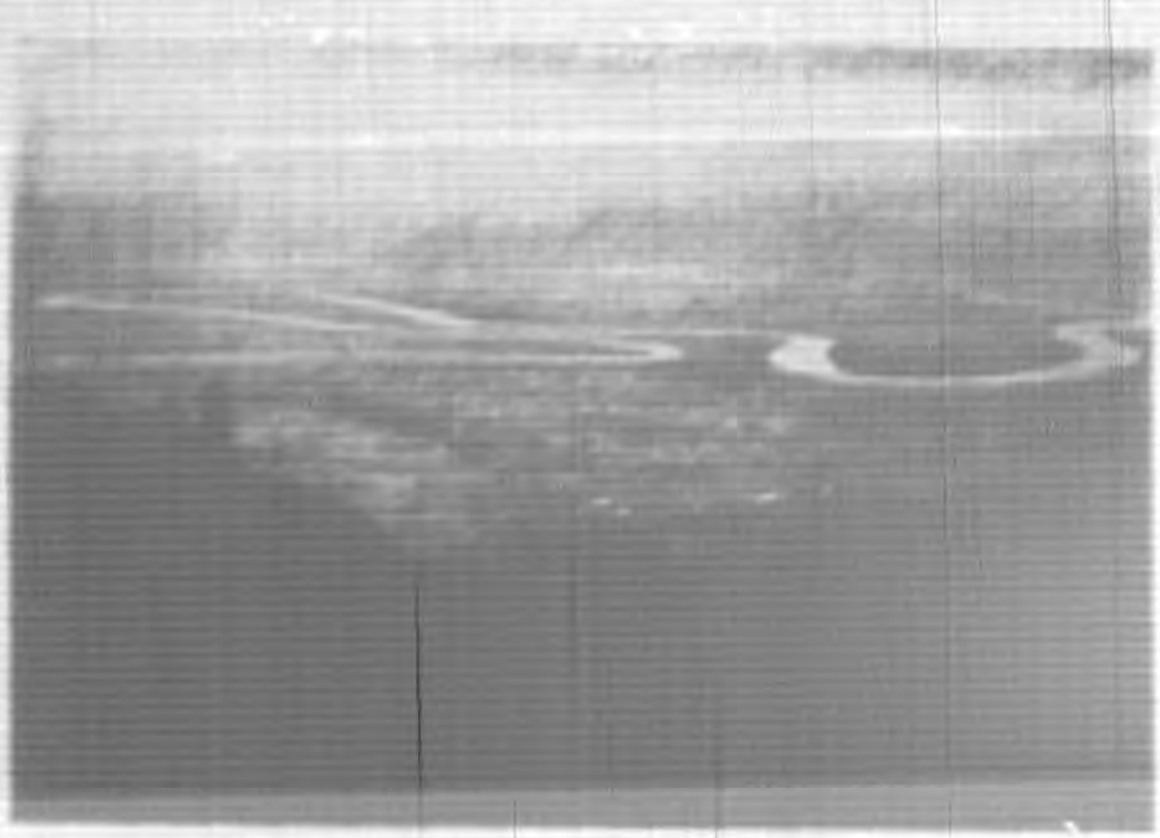


天台山'銅壺滴漏'瀑布示沿花崗岩節理侵蝕之結果

Fig. 1. The "Tunghutilou" or a small waterfall resulted from the erosion along the joints in granite, Tientaishan.

天台山'水珠簾'瀑布並示花崗岩三種節理

Fig. 2. The "Shuichulien", a waterfall in granite which is cut by three sets of joints, Tientaishan.



黃巖縣東山下望永寧江之蜿曲

Fig. 3. View showing the meadering of Yungningkiang, Huangyenhsien. Looking N. E. from Tungshan.

溫嶺縣方岩流紋凝灰岩所成之峭壁

Fig. 4. View of Fangyen, Wenling district showing the cliffs of rhyolitic tuff.

樂清縣雁蕩山之"接客僧"絕壁為凝灰岩與粗面岩所成

Fig. 1. View of the "Tsiehkeseng", a cliff formed in tuff and trachyte. Yentangshan, Loching district.

樂清縣雁蕩山之"合掌峰"示水平層之粗面凝灰岩沿垂直節理侵蝕之現象

Fig. 2. View of the "Hochangfeng", a cliff showing the horizontal bedding of trachyte tuff and erosion along its vertical joints. Yentangshan. Loching district.

樂清縣雁蕩山之絕壁"老僧披衣"

Fig. 3. View of the "Laohoupi", a cliff, Yentangshan, Loching district.

諸暨縣青口街附近薄層流紋岩之層理

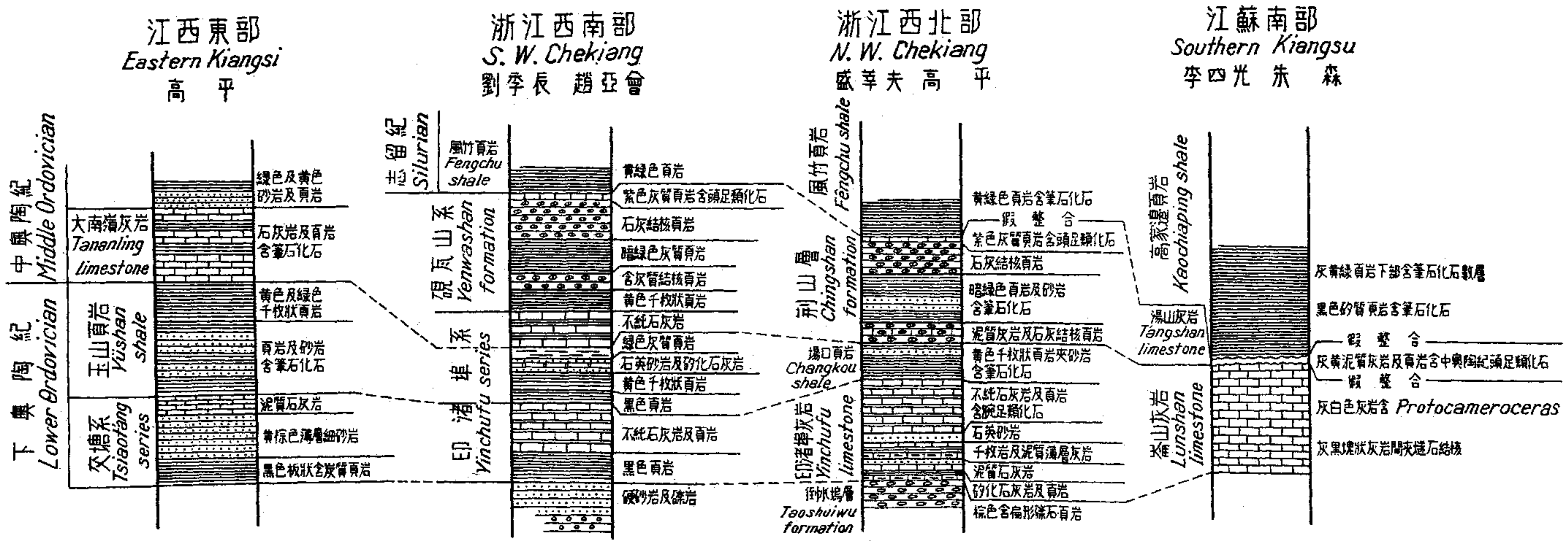
Fig. 4. Rhyolite showing the thin bedding near Chingkouchieh, Chuchi district.

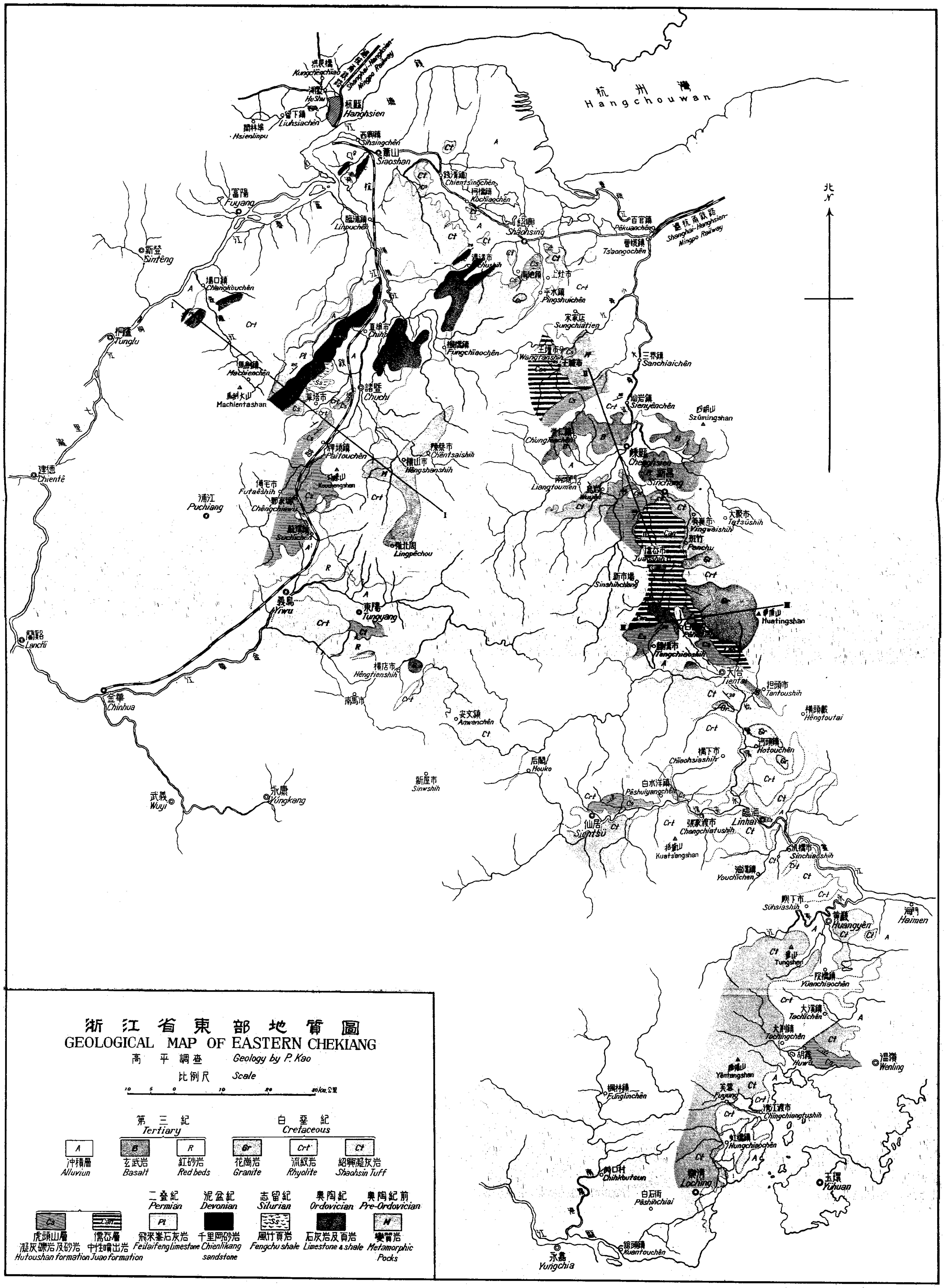
中國東南部奧陶紀地層柱狀剖面比較圖

COLUMNAR SECTIONS SHOWING THE CORRELATION OF THE ORDOVICIAN FORMATIONS OF SOUTHEASTERN CHINA

比 例　二萬分之一

SCALE 1: 20,000





浙江省東部地質圖
GEOLOGICAL MAP OF EASTERN CHEKIANG
高平調查 Geology by P. Kao
比例尺 Scale
第三紀 Tertiary
白堊紀 Cretaceous
A 沖積層 Alluvium
B 玄武岩 Basalt
R 紅砂岩 Red beds
Gr 花崗岩 Granite
Crt 流紋岩 Rhyolite
Ct 紹興凝灰岩 Shaohsin Tuff
二疊紀 Permian
泥盆紀 Devonian
志留紀 Silurian
奧陶紀 Ordovician
奧陶紀前 Pre-Ordovician
Cs 虎頭山層 凝灰礫岩及砂岩 Hutoushan formation
Can 儒岙層 中性噴出岩 Juao formation
Pl 飛來峯石灰岩 Feilaifeng limestone
千里岡砂岩 Chienlikang sandstone
風竹頁岩 Fengchu shale
石灰岩及頁岩 Limestone & shale
M 變質岩 Metamorphic Rocks
杭州灣 Hangchouwan
北 N

山東鋁土礦之顯微鏡研究

謝家榮

山東淄川博山煤田內於石炭二叠紀煤系之頂部，產呈鮞狀構造之鋁土礦一層，厚自二公尺至四公尺不等，其地質情形，已詳王竹泉先生所著之報告中，(見本所地質彙報第十四號)茲不復贅。本文所論者，係鋁土礦在顯微鏡下所現之結構及其礦物成分，最後對於礦床成因，及實用問題，亦略爲申論焉。

據王竹泉先生之顯微鏡研究，謂鋁土礦 (Bauxite) 含於鮞狀或豆子狀之圓粒中，係白色至棕色之透明針狀結晶，在交斜聶氏鏡下現顯著之非均性。據此次研究，則似鋁土礦係棕色至黃紅色之非結晶體，在交斜聶氏鏡下完全消光者，至於王氏之白色透明結晶礦物，恐係高嶺石之微晶結合體。此外尚有折光率及重屈折率俱甚高之小粒礦物，經鑑定爲水鋁石。(Dore) 鋁土礦呈顯著之鮞狀或豆子狀結構，每個圓粒，由同心環狀之棕色不結晶體(卽鋁土)所組成，此項棕色體常爲白色之高嶺石及水鋁石所交換。在顯微鏡下可見各種階段之交換，有完全不變者，有交換方在初期者，亦有二者密切共生，顯示交換作用已屆成熟者，更有已至交換末期，整個圓粒已全變爲高嶺石者，以上各現象可參閱所附顯微鏡下照像圖。至論水鋁石則常成微粒分出，論其生成次第似更在高嶺石之後。各圓粒間之粘質，有卽爲棕色之鋁土者，亦有爲高嶺石所充塡者。此外尚有一種不呈鮞狀或豆子狀構造之鋁土礦，在顯微鏡下觀察，除棕色之不結晶體外，亦有高嶺石及微粒結晶甚多。高嶺石亦有成細脈穿越全體者。

山東鋁土礦業經黃海化學試驗所及地質調查所化驗室分析，其所含鋁氧約在百分之五〇至五十九之間，故成分尚不算低，所欠缺者矽氧二過高可達百分之二〇，因之於選煉上稍感困難耳。(最近黃海化學試驗所已覓得一法可減少矽氧二而得純粹之氧化鋁)惟有一事，最足注意者，卽倘將圓粒揀出而加以分析，則其中所含之鋁氧並不較礦層全體爲高，由此可見鋁土礦並不限於圓粒構造，而因圓粒中含高嶺石較多之故，其所含鋁分或反將減少矣。

上述顯微鏡研究之結果，對於鋁礦之實際利用上，有二點應加以注意：

(一)據王竹泉先生研究之結果，謂鯿狀或豆狀構造明顯之部，亦卽鋁分豐富之部，而此項構造不及全層三分之一，故王氏特就全部礦量減去約三分之二，其餘下之三分之一始認爲堪採之鋁礦。據此次顯微鏡研究，並佐以化學分析之結果，當可知此項假定之非是。究竟全礦層是否俱含有百分五十左右之鋁氧，固須俟詳細化驗後始知，但鋁氧豐富之部決不限於鯿狀構造明顯之部，則已彰彰明矣。

(二)山東鋁土礦之缺點，在矽分之過多，而就此次研究含多量高嶺石之事實觀之，頗若矽分俱由此礦物而來，故我人倘能思得一法，將礦石中之高嶺石析出，則鋁分卽可因之而增加矣。又據顯微鏡下觀察，高嶺石與鋁土礦之共生，並不甚密，故倘能將礦石研至相當細度，此二種礦物之分離或可無甚問題，但用何種方法選分，則須詳加試驗後，始能知之。

最後對於山東鋁土礦層之成因，略供意見；鋁土礦層之成，與紅土化 (Lateritization) 有密切關係，已成爲世界學者公認之理論，山東鋁礦似亦不能例外。故作者之意，以爲山東鋁礦之成，純係特殊氣候下之產物，觀於鋁礦層產於一紅色地層（三疊紀）及二疊紀煤系灰綠色地層之間，可知其氣候係代表乾熱與濕溫二者之過渡時間，其時地面岩石，風化甚烈，紅土化作用不難進行，因而造成鋁土礦；至於是否曾經一度遷運，而重行沉積，如王氏之所設想，固難論定，但就事實觀之，此項擬議似亦可以不必也。

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GEOLOGICAL RECONNAISSANCE BETWEEN LUNGYEN (龍巖) AND AMOY (廈門), FUKIEN

(SUMMARY)

BY T. F. HOU, Y. L. WANG, AND C. C. CHANG

INTRODUCTION

In the autumn of 1933 we were appointed by the Geological Survey of China to undertake a geological reconnaissance in the region between Amoy and Lungyen of Fukien province along the projected railway line. This work was intrusted to the Survey by the commission of preparation of the Changchow-Lungyen railway which gave us many facilities and assistance. The Head Commissioner Mr. Hwang (黃奕住) and his sons and the Commissioner Mr. Lin (林鼎禮) have specially given the authors favorable helps. To the above institute and gentlemen we acknowledge herewith our obligation.

Our maps were thus made by route sketching with the aluminium sketching board and in some districts when it was necessary the planetable was also utilized. At the same time an air surveying party of the General Staff made a map along the projected railway line on the scale of one to five thousand.

STRATIGRAPHY

The stratigraphical column in the investigated area is not complete, as Algonkian strata as well as the Lower Palæozoic and even part of the Mesozoic are wanting. Moreover the sediments were disturbed and metamorphosed by the Mesozoic orogenic movement. Most deposits are continental except a part of the Permo-Triassic strata and the lower Permian limestone attaining a small thickness from a few to 150 meters. The order of the formations which we recognized in the field may be shown as the columnar section (Pl. V) below:

Modern	Alluvium
Pleistocene	Sand and gravel beds........................20 m
Younger Tertiary	Red clay and conglomerate.................50 m
Older Tertiary	Liuhuisheh Basalt...........................200 m
Upper Cretaceous	Touling volcanics...........................200 m
Lower Cretaceous	Paisha red sandstone and conglomerate...300 m
Triassic	Yanping shale................................180 m

Permian	Upper Part	Ts'uipingshan sandstone & shale	250 m
	Middle Part	Gigantopteris coal series	250 m
	Lower Part	Chihsia limestone	150 m
Carboniferous		Nanching quartzite	700 m
Archæan		Gneiss	unknown

Gneiss: The gneiss is distributed in two areas; one on the seashore, south of Amoy island, in the vicinity of Taomei (島美) and Liuhuisheh (柳會社), which marks a general strike towards NE with the tendency to connect the gneisses of several small islands of Wusu (吳嶼), Maosu (帽嶼), Liehsu (烈嶼) and the big island of Chinmen (金門); another area of gneiss between the villages of Panwei (板尾) and Shihchin (石勤), west of Hsungsu (嵩嶼) peninsula (Pl. III). The gneisses are granitic with good banded structure and in some parts have been intruded by granite, quartz porphyry, diabase and quartz veins.

Nanching quartzite: It is widely distributed in the investigated area and can be simply classified into three parts: (1) the lower part is about 300 meters thick and mostly represented by massive quartzite with a few intercalations of shale, generally in flesh colour and hard character; (2) the middle part consists of interbedded layers of shale, quartzite, slate and claystone (Fig. 1) with a thickness of about 200 meters and (3) the upper part is mostly grey and black sandy shales interbedded with quartzose sandstones and a layer of conglomerate with pure white quartz pebbles of variable size at the base. The thickness of this part is also about 200 meters. Although the Nanching quartzite series is quite thick and widely distributed, no fossils have been found, so that its age is quite uncertain. At several places it is actually overlain by the Chihsia limestone. According to its rock characters and stratigrafic position it can be fairly correlated to the Chinhsian formation (進賢層)[1] of Kiangsi, Ch'ianlikang sandstone (千里崗沙岩)[2] of Chekiang and Wutung series[3] of Nanking.

Chihsia limestone: It is a greyish blue limestone with flint nodules or bands, calcite veins and some graphite scales scattered in the layers. The limestone is completely wanting in southeastern Fukien that is to say in the area near seashore, yet it appears on the west of the country and specially well developed in the vicinity of

1 Geological Reconnaissance along the projected railway line from Nanking to Fuchow. H. C. Tan and S. W. Wang. Bull. Geol. Surv. China. No. 14.

2 Geology of Western Chekiang, C. C. Liu & Y.T. Chao; Bull. Geol. Surv. China. No. 9.

3 A Geological guide to the Lungt'an district, Nanking. J. S. Lee & S. Chu.

Lungyen (Fig. 2, Fig. 3). Unfortunately this limestone has been metamorphosed in not a small scale, so that the fossils were mostly destroyed. From this formation we only got some undeterminable fusulinidæ, crinoid stems and one gastropod (*Straparallus*) (Fig. 4).

Gigantopteris coal series: It disconformably overlies the Chihsia limestone or in some case directly the Nanching quartzite series when the latter limestone is wanting. Its components are sandstone and shale with an anthracite seam from 0.5-1.6 m. thick in the middle part (Fig. 5). Some plant fossils were collected from the black shale zone just above the coal seam (Fig. 6, Fig. 7) and have been determined by Dr. H. C. Sze as:

Gigantopteris nicotianæfolia Schenk

Sphenophyllum thoni Mahr

This coal series is also widely distributed in the vicinity of Lungyen, but the rock characters and the thickness of the coal seam are often variable.

The great hiatus before the deposition of Gigantopteris coal series and the facies change of lower Permian deposits:—The outcrops of the Chihsia limestone are very irregular in this region; and its thickness is also quite variable. This condition was probably due to two causes; 1) the change of facies of the lower Permian deposit (Fig. 8) and 2) the erosion took place before the coal series, so that a larger part of the limestone had been eroded away (Fig. 9).

Tsuipingshan shale: This series conformably overlies the above mentioned coal series with the main components of shales and intercalating sandstones. It is well developed in Tsuipingshan, east of Lungyen city. Fossils are more or less accumulated in the lower part of the series, marine and continental ones often occur in the alternative layers. The fauna as determined by Dr. T. H. Yin and flora by Dr. H. C. Sze, indicate that this series still belongs to the Permian age as shown in the following list:

Tsuipingshan (翠屏山), Lungyen

F65 flora: *Labatanularia lingulacus* Halle, and other indeterminable plants
fauna: *Gastrioceras* sp.
Athracomya cff. *lævis* Dawson
Fish spines
Ganoid scale

South of Paisha (白沙)

F59.	*Gastrioceras* 2 sp. *Productus gratiosus* Waagen *Arcidæ*

Lungmenhsu (龍門墟), W. of Lungyen

F72	*Pelecypod* resembling *Solenomorpha* *Brachiopod* resembling *orthotetes* *Nautiloid* gen. et sp. ind.

Hsiaochi (小池), W. of Lungyen

F80	*Agathiceras* *Gastrioceras* sp. *Ammonoid* gen. et sp. ind. *Brachiopod* resembling *orthotetes*. and other indeterminable Pelecypods and Gastropods.

Maolingchia 12 km E. of Lungyen.

Fc16	*Schizodus* *Pectinidæ* gen. et sp. ind.

The fossils as shown above were collected from the sheared shales with bad preservation.

Yangping shale: This is a series of red, yellow and green shales with a few intercalations of thin sandstones. The shales in some part are calcareous from which we collected at Yangping (洋坪) a large amount of marine pelecypod, probably *Anoplaphora* of Triassic age. 2.5 km west of Hsungsu (嵩嶼) of the sea-shore, there are grey shales intruded by quartz porphyry and containing badly preserved Mesozoic plant fossils such as *Pterophyllum*, *Ctenis*, etc.

Paisha red sandstone: The main components are thick beds of red sandstone with intercalation of shales (Fig. 10), the basal part is characterized in some places by the conglomeratic bed with large pebbles of quartz and quartzite (Fig. 11). A thin seam of lignitic bituminous coal has once been found in the shale of this series. The contact of the basal conglomerate with the Palæozoic sediments below is a plane of unconformity as is shown by Fig. 7.

Touling volcanics: They are usually found to be rhyolite, tuff, andesite and quartz porphyry. They may rest upon Paisha red sandstone or in other case directly on Palæozoic rocks or granite in distinctively unconformable manner. Sometimes rhyolite and quartz porphyry are intrusive rocks in the Palæozoic rocks and granite.

Liuhuisheh basalt: This kind of rock was met with in two places, one is Liuhuisheh near the coast of Haich'eng district (海澄縣), S. of Amoy, while the other is in Tienmashan (天馬山), S. of Lungyen. In the former place the basalt is unconformably resting upon the gneiss (Fig. 12) and in the latter place it is underlain by a bed of agglomerate and overlain by some tuff sandstone.

Tertiary red clay and gravel: It is commonly found near the coast (Fig. 13), on the border of Lungchi (Changchow) (龍溪) plain and in the valley of Paichi (北溪) (Fig. 14). About 10 kilometers on the west of Hsungsu, the reddish clay and sand rest about 20 meters above the sea level (Pl. III, E). The rocks are subclastic including red clay, sand and gravel from which *Oystrea* shells were collected that testifying the retreat of the sea or the rising up of the sea shore.

Pleistocene gravel: It is another kind of gravel usually combined with loose sand and clay to form heaps or cliffs, sometimes more than 10 meters high, standing on the river banks or on the coast. It differs from the above mentioned Tertiary beds as clearly of another stage. Just on the coast of Liuhuisheh (柳會社) this series unconformably rests upon the basalt (Fig. 12) and a seam of peat locally occurs in the sand and gravel.

Alluvium: It is not different from that seen in the other provinces containing loose sand, clay and gravel, generally not thicker than 10 meters.

INTRUSIONS

Granite: Granite occurs in the region surveyed as laccoliths, stockes, dykes and sheets, they may be distinguished by two main types. One is *normal granite*, flesh coloured, medium grained with chief constituents of quartz and orthoclase. Locally it grades into porphyritic texture especially near to the edge of the granite body. The other type is *hornblende granite*, whitish grey coloured, coarse grained and chiefly composed of quartz, plagioclase and hornblende. The intrusive bodies of the latter type are smaller than the former.

Quartz porphyry: It is light grey and flesh coloured with phenocrysts of quartz and less feldspar. It often intrudes the granite as well as Palæozoic and Mesozoic sediments.

Diabase: In the surveyed region it is often met with in dykes, veins or sills intruded into the Mesozoic and Palæozoic rocks. It is greyish black coloured and fine textured with chief constituents of augite, plagioclase, hornblende and biotite.

STRUCTURE

The orogenic movements of Mesozoic age produced a series of parallel foldings of the Palæozoic sediments, which are intimately connected with the granite intrusions. The Cretaceous strata, Paisha red sandstone and Touling volcanics, are however, not so much disturbed. They are not in concordance with the Palæozoic ones, although they are also inclined and gently folded. The structure from Amoy to Lungyen may be simplified as follows (Pl. VI):

1. *Granite laccolith near the sea shore*:—From Amoy to the east of Nanching (南靖) there is a great laccolith of granite which intrudes in the gneiss, quartzite and early Mesozoic shales (Pl. VI).

2. *Syncline between Nanching (南靖) and Lungshan (龍山)*:—It is formed by the Nanching quartzite series, about 12-19 kilometers broad and trending in NE direction to unknown distance.

3. *The great laccolith of granite in the area between Linglou (嶺兜), Kuite (歸德), Shuichao (水潮) and Yungfu (永福)*:—This granite body occupies a large area as shown by the map (Pl. I), and forms the highest mountainous country to divide several water systems of southern Fukien province. The intruded rocks are the Palæozoic sediments which lie sometimes upon the high part of the granite hills.

4. *Huaan syncline*:—One syncline is made by Permian and Carboniferous sediments and is much disturbed by the intruded granite.

5. *Changp'ing syncline*:—This syncline trends in NE-SW direction, starting from the far northeast of Changping city extending to Tsint'ou (津頭) NE of Lungyen, in a distance of more than 120 km. The northeast part is broad and the southwest end is narrow. The two limbs are made up by Palæozoic strata of which the eastern one is disturbed by granite while the western one is rather flat and regular. Its central part, in the vicinity of Changping, is covered by the Cretaceous sandstone.

6. *Yichiapang-Hsialao anticline*:—One gentle anticline is in continuation with the above syncline, it trends in NE-SW direction and dies out north of Lungyen with a fault (Pl. I and Fig. 15).

7. *Ch'ihmeishan syncline*:—It also strikes NE-SW with the broad central part near Ch'ihmeishan (赤眉山) and gradually narrows towards southwest. This syncline is in similar cases with the Changping syncline mentioned before.

8. *The Tungshan syncline of Lungyen*:—The high hills east of the Lungyen city are however changing their ridge direction to N-S from its original one of NE-

SW. The axial zone, in the vicinity of Maolingchia (毛嶺峽), is made up by Triassic shales and the eastern limb constituted by Permian and Carboniferous strata which are disturbed by the granite, and this can be seen in Langcheh (朗車) and Shuiwei (水尾), west of Yungfu (永福). The western limb is made up by Permian sandstone and limestone which produces a series of local foldings as (a) Tungpaoshan anticline (Fig. 2), (b) T'suip'ingshan syncline (Fig. 3), (c) T'ashan (塔山) syncline and anticline (Pls. IV & VI) and (d) Lungyentung anticline (Fig. 3).

9. *Lungyen anticline*:—The axis of this anticline is constituted by the Nanching quartzite cropping out in the low hills in the surrounding of Lungyen city. The east limb is cut by a fault which produced the unusual feature with all the eastern hills of Lungyen. The west limb can be met with at about 1 km west of the city with the Permian limestone and sandstone dipping about 20° to the west.

10. *Lungmenhsu syncline*:—It is a sharp syncline at the eastern hill ridge of Lungmenhsu (龍門墟) village, 6 km west of Lungyen city (Pl. IV). The syncline runs in the direction N-S with two limbs of coal series sharply inclined about 30-40° towards the axial zone.

11. *The Shihchung and Yangping synclines*:—As shown by Fig. 4, there are two synclines in the two named villages which are connected by a thrust: the Chihsia limestone of the limb of the former syncline was thrusted upon the center of the latter.

Faults: Faults are not very common in the region surveyed. Only two were met with; one on the east of Lungyen city and the other is the thrust fault at Shihchung as above mentioned.

MINERAL RESOURCES

The significant mineral resources in the surveyed region are only *Coal* and *Iron* which may be summarized as follows:

I. *Coal fields*: Coal is not very rich in southern Fukien province and mostly occurs in the hilly countries of Lungyen. As already mentioned in the chapter of stratigraphy, the only workable seam is the anthracite 0.5-1.6 m. thick embedded in the *Gigantopteris series*. The distribution of the coal fields and the coal reserves as described in greater detail in the Chinese text may be briefly mentioned as follows:

Coal Reserve:

1.	Lungyen coal field (Pl. IV)	
	a. East of T'ashan (塔山)	5,948,800 tons
	b. W. slope of Hiakungshan (蝦公山)	2,733,600 "
	c. Tungpaoshan (東寶山) anticline,	
	E. limb	3,536,000 "
	W. limb	1,560,000 "
2.	Lungmen coal field	1,892,800 "
		1,456,000 "
3.	Hsialao coal fields — Northern hill	1,624,000 "
	Hsialao coal fields — Southern hill	3,040,000 "
4.	Tachi and Kotengyu coal field	3,640,000 "
5.	Supang coal field	2,704,000 "
6.	Paisha coal field	5,800,000 "
7.	Waiyang and Supan coal field	3,040,000 "
	Total	36,975,200 tons

II. *Iron ores*: In the surveyed region, three localities of iron deposits have been found.

1. West of Loyang village (洛陽村), 53 km north of Huaan city, there is a hematite ore in the form of a broad vein in the quartzite (Fig. 16). It is the high temperature contact ores originated from the granite as indicated by the associated minerals of garnet and magnetite and other minerals of pyrite and jarosite. The ore contains more than 45 percent of iron and the ore reserve has been roughly estimated at about 12,800,000 tons.

2. At Ts'aoyang (草陽) about 70 km northeast of Changp'ing (漳平), a magnetite ore occurs in the Permian sandstone and limestone, which is also originated from contact metamorphism due to the granite intrusion (Fig. 17). The magnetite ores are found in massive, kidney, and crystal forms in association with garnet, apatite, zircon, and rutile. One broad quartz vein intrudes into the sandstone. The iron ore occurs at the contact zone in the forms of lode and lenses. The reserve is not very large and may not exceed 400,000 tons.

3. Another notable iron ore occurs in Tanlin (丹林), 9 km east of Changchow or Lungchi (龍溪), which is the specular iron ore probably originated from the hornblende granite. One pegmatite vein about 50 meters wide exists in the granite and the iron ores are scattered among the crystals of feldspar and quartz of the pegmatite. At some places it can accumulate in larger amount as veins.

A GEOLOGICAL RECONNAISSANCE ACROSS THE EASTERN TSINLING*

(BETWEEN LOYANG AND HSICHUAN, HONAN)

By P. Teilhard de Chardin, G. B. Barbour and M. N. Bien[1]

(Geological Survey of China, Cenozoic Laboratory)

INTRODUCTION

The Tsinling Range has long been recognized as a natural geological boundary between North and South China. While this generalization is accepted by all, there exists only a few sections across the range[2] and they were all taken west of Sian in Shensi and Kansu. The eastern part of this mountain range in Honan (along the 111 degree of E. longitude) where it approaches its end was obviously deserving a special study. Here the mass of the folds is more concentrated and, as a consequence, the geology of the North comes almost in contact with the geology of the South.

It was therefore with eagerness that the authors of this present memoir took the opportunity of crossing such a critical area between Loyang and Hsichuan in July 1934. The primary aim of this minor expedition was in accordance with a general plan, started under the late Dr. Davidson Black by the Cenozoic Research Laboratory, of elucidating the relationships and contrasts which exist between the Cenozoic formations of the Huangho and Yangtze basins respectively. At the same time the study of the older floor was also considered and it was never forgotten during the course of the journey.

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* In the present paper, the name *Tsinling* is used in its broad and geological sense, for designating the whole E.-W. mountainous system separating from each other the Yangtze and the Huangho basins east of Lanchow. Our section is taken at the very end of the Tsinling proper. Immediately eastward, the mountain splits into three secondary ranges; the Hsiungerhshan, running in a NE. direction between the Loho and the Iho valleys; the Waifangshan, striking East; and the Funiushan, bordered along its southern foot by the Nanyang basin.

1 Dr. Barbour having left China immediately after the journey, the redaction has been chiefly made by P. Teilhard. Most of the sketches and the major sections are due to Mr. Bien.

2 By Richthofen, Loczy, Willis, Obrutchev, and more recently by Chao and Huang. We shall chiefly refer to the Chao and Huang's memoir (1931), in which all the previous works are found, summarized and completed. In 1920, Dr. Nystrom has made a geological crossing of the Tsinling between Loyang and Nanyang, along a route passing east of our own sections. But the results have not yet been published.

The results of our observations are mostly embodied in the itinerary map on the scale of 1:300,000 which is presented below. A detailed explanation of the route divided into its most natural sections is given in the text and at the end a few general conclusions are ventured.

It is to our regret for not having met Mr. S. L. Tsao of the Geological Survey of Honan in the field, who, for the last two years, has been working on the geology of Honan and has published several reports on the subject (see especially Tsao, 1933). We have no doubt that as a result of his more detailed work in that province, Mr. Tsao will soon correct and complete the present publication.

As a base for the geology, we have used the maps on a 1:100,000 scale made by the Military Surveying Bureau.

A short Bibliography will be found on p. 37.

I. THE CENOZOIC COMPLEX OF THE LOHO, BETWEEN LOYANG AND CHANGSHUI

Between Loyang and Changshui, the Loho runs along a broad flat valley, bordered on the right bank of the river by a series of mountainous cliffs representing probably a succession of faults "en échelons", and, on the left bank by an endless area of rolling and partly dissected hills.

1. *Right bank*. With the exception of Iyang, we did not visit any locality on the right bank of the Loho. At Iyang, the base of the mountain consists of a typical oolitic limestone (Cambrian), probably followed by Ordovician limestone and Carboniferous sandstone (coal mines are reported a few lis only from Iyang, in the mountain): the typical Paleozoic series of the Shansi, apparently (cf. Y. Wang, 1932).

Further upward, that is SW. of Iyang, the Loho cuts, along its right side, several well shaped high fans, evidently related to the pre-Malan gravel-systems so extensively spread over the hills of the left bank (see below). Then, at the latitude of Changshui, a high serrated range appears on the eastern skyline, running in a NE. direction between the Loho and the Iho valleys. Judging by its contours and by the reported presence of smoky quartz crystal, this mountain is likely to represent a huge dyke of Mesozoic pegmatite-granite, such as found so frequently along the eastern Shansi border, in the Western Hills of Peking, in Eastern Mongolia and in Jehol.

2. *Left bank.* As observed from the upper part of the Loho basin (for instance above Changshui) the rolling hills forming the country NW. of the lower Loho fit, by their summits, into a remarkable topographical surface, about 300 meters high over the valley (*Loho surface* or *erosional plane* of Barbour[1], see Pl. I, fig. 1). We did not reach the highest points of this ancient terrace. But several sections studied in the cliffs along the road prove that it consists (at least along its marginal parts) of an older Cenozoic sedimentary series (*Lower zone*), levelled and dissected by several types of gravels and loams (*Upper zone*). To this intricate system we give the name of "Cenozoic Loho Complex".

a). *The Lower zone.* In common, the deposits forming the Lower zone have this character of being separated from the over-formations by conspicuous layers of rounded gravels. In many cases (see fig. 1, section at Yenchiu), they are strongly tilted. But, in other places (figs. 2 and 4), they look horizontal. Lithologically, the sediments are mostly red and strongly detrital, the pebbles consisting almost exclusively of *imperfectly rounded* fragments or blocks of weathered andesite. The coarseness of the elements is however diminishing from the SW. to the NE., a

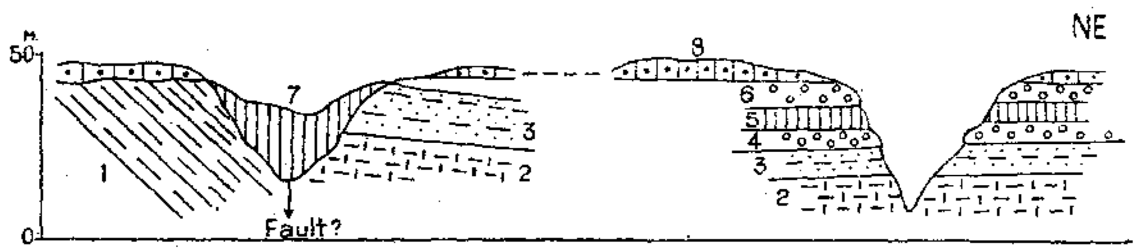

Fig. 1.—Longitudinal section in the cliff of the Loho, at Yenchiu. 1, strongly tilted red clays and consolidated white sands. 2, thick mottled green marls. 3, very coarse sands, half consolidated. 4, first series of gravels (4-5 meters). 5, red sandy clay (7-8 meters). 6, second series of gravels (3-4 meters). 7, red clays. 8, rewashed superficial gravels. 1-3, Lower zone. 4-7, Upper Zone. Loess omitted.

maximum being observed at Changshui (where the blocks reach 1,50 meters in diameter), and a minimum at Yenchiu (where the tilted beds are simply sandy). A good intermediate case was observed near Kaomei (fig. 2), where the sediments show a regular alternation of pebble beds (30 cm. thick) and dark sandy clays (80 cm. thick).

A doubt remains concerning the nature of the thick mottled green marls and coarse white sands designated as "series B" (2,3) on the fig. 1. The reference of those beds to the Lower zone is made probable by their position *under* the gravels of the

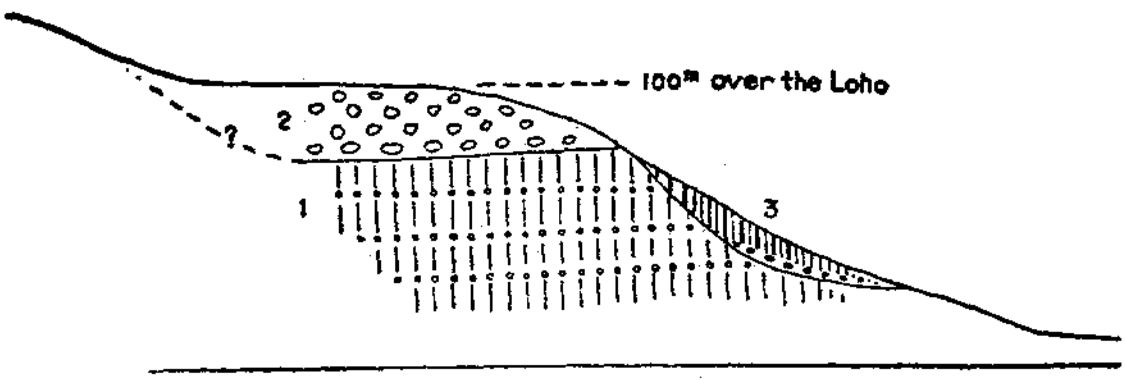

Fig. 2.—Transversal section in the cliff of the Loho near Kaomei. 1, thick detrital series of regularly alternating red-violaceous sandy clays and layers of subangular andesitic pebbles (Early Tertiary?). The beds look horizontal. 2, thick gravel formed of well rounded pebbles and boulders of andesite: 12 meters thick in the preserved part (Pliocene). 3, Red concretionary loam, with cemented basal conglomerate Lower Pleistocene. 1, Lower Zone. 2-3, Upper Zone.

"series C" (4,5 and 6), by a possible faulting and even tilting, and also by the fact that, lithologically, they are similar to the white beds observed in the Lower zone near Loning (fig. 4). Still they might represent some intermediate formation, between the Upper and the Lower zones.

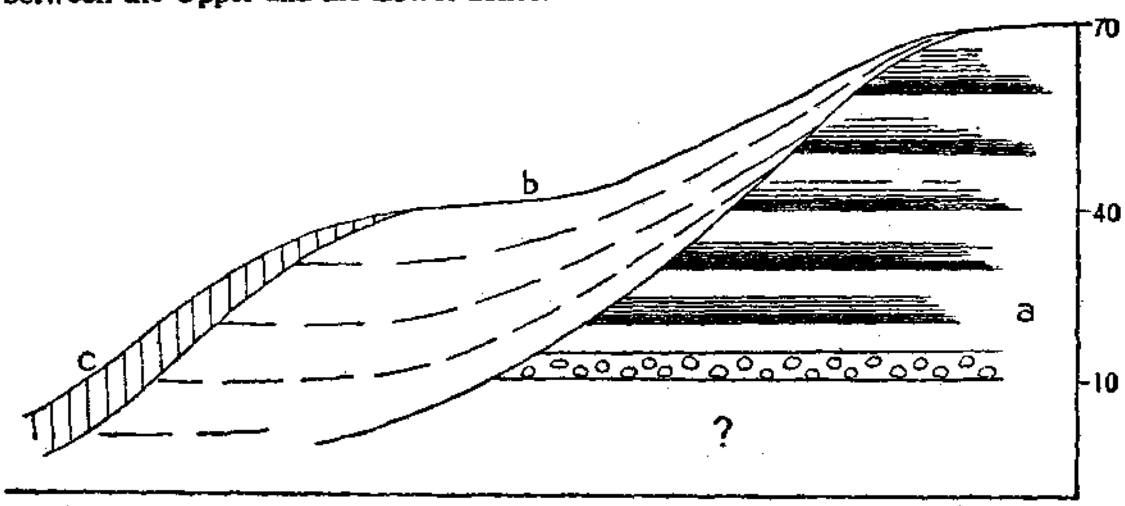

Fig. 3.—Transversal section of the cliff at the confluence of the Kanho and the Loho, near Peipo (S. E. of Kaomei), eastern bank of the Kanho. *a*, Red banded concretionary loam (Lower Pleistocene). *b*, faintly reddish, slightly banded "loess". *c*, Malan loess?.

No fossils have been found in the Lower zone. But, on account of its disturbed and weathered conditions, we regard it as Early Tertiary, and presumably identical with the Eocene Yuanchü beds of South Shansi (see Andersson, 1923).

b). *The Upper zone.* As told above, the Upper zone of the Loho hills consists of a succession of thick gravels (chiefly andesitic *well rounded* pebbles and boulders) and red loams, capping and dissecting the sediments of the Lower zone. Those beds may eventually have an original dip of deposition, but they are never clearly tilted.

In the absence of any observed fossil, the stratigraphical analysis of this upper complex is only possible on a physiographic base. And even so the distinction of the successive gravels is made difficult by the uneven ground on which they have been deposited.

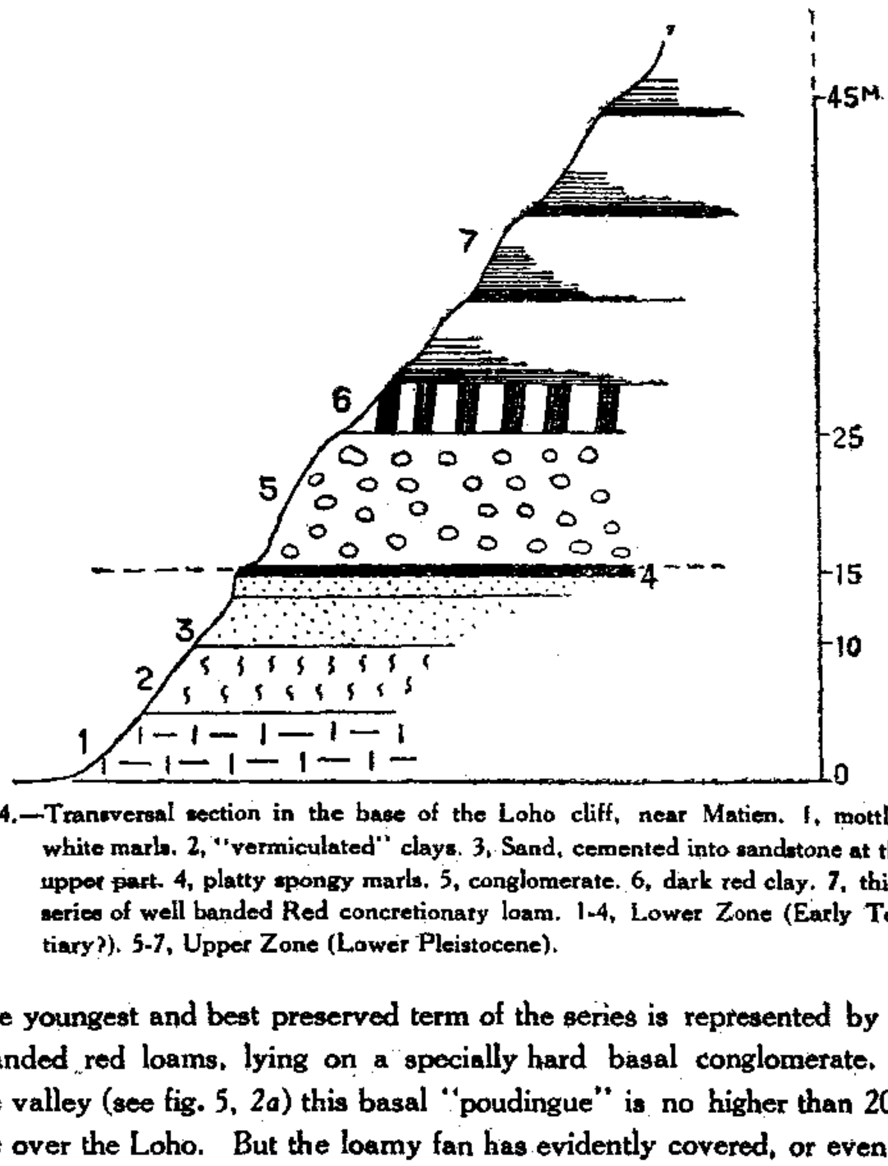

Fig. 4.—Transversal section in the base of the Loho cliff, near Matien. 1, mottled white marls. 2, "vermiculated" clays. 3, Sand, cemented into sandstone at the upper part. 4, platty spongy marls. 5, conglomerate. 6, dark red clay. 7, thick series of well banded Red concretionary loam. 1-4, Lower Zone (Early Tertiary?). 5-7, Upper Zone (Lower Pleistocene).

The youngest and best preserved term of the series is represented by concretionary banded red loams, lying on a specially hard basal conglomerate. In the axis of the valley (see fig. 5, *2a*) this basal "poudingue" is no higher than 20 meters in average over the Loho. But the loamy fan has evidently covered, or even largely buried, the most part of the present hills. The red bands of the loam (marking a succession of old soils) are extremely regular and distinct. For instance, between Kaomei and Loning (figs. 3 and 4), the cliff shows seven red bands, regularly spaced at 10 meters each from the other. The concretions, generally small and rounded, are swarming, mostly disseminated in the mass of the sediments. Although, by lack of time, we could not search for fossils, there is practically no doubt that, for all its physiographic and lithological characters, this important loamy formation is identical with the "*Siphneus tingi* beds" (Lower Pleistocene[1]) of Shansi.

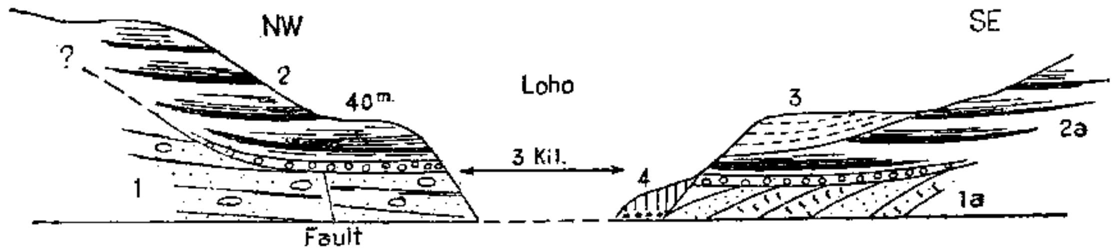

Fig. 5.—Section of the Loho valley at Changshui. 1, coarse detrital red series (slightly dipping), with andesitic blocks. Early Tertiary. 1*a*, strongly tilted red vermiculated clays and small gravels (Early Tertiary). 2-2*a*, Red banded concretionary loam with thick basal conglomerate (Lower Pleistocene). 3, banded loam (40 meter terrace) 4, Malan loess?

Evidently earlier than the banded loam, but of a doubtful age, are such high gravels (associated or not with red clays) as represented in figs. 1 and 2. In absence of any palæontological evidence, we will assume that those gravels correspond to the various sedimentary *Pliocene* cycles recognised in North China. The *Loho surface* has been referred by Barbour (Barbour, 1934) to the Tanghsien stage. Traces of

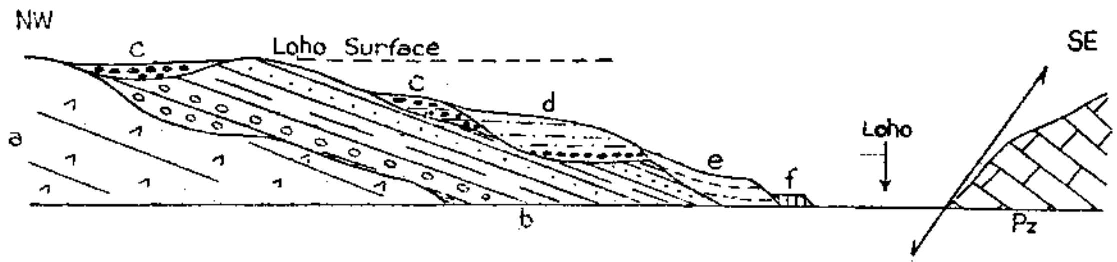

Fig. 6—Transversal generalised section across the Cenozoic complex of the lower Loho (*Lohò Complex*). *Pz*, Palæozoic. *a*, andesites (Sinian? or Jurassic?). *b*, Early Tertiary detrital formations. *c*, Upper gravels (Pliocene). *d*, Red concretionary loam (Lower Pleistocene). *e*, older loess (Middle Pleistocene?). *f*, Malan loess.

1 Concerning the last correlation of the *S. tingi* beds, see Teilhard and Pei, 1934.

Pontian and Sanmenian (= Villafranchian) fans are most probably present over this platform. The solution of the problem would be given by a section connecting the Loho valley and the Mienchihhsien basin, this latter one being an area in which the Pontian and younger red loams are richly fossiliferous.

c). *Later formations.* Posterior to the Red concretionary loam, we have noted in several places, between Loyang and Changshui (see figs. 3 and 5), the presence of a rather thick, loess-looking, formation, building a 40 meter terrace along the present river. The sediments dissect deeply the Red loam; and they differ from an ordinary Malan loess by the recurrence of several reddish zones (which however do not contain an appreciable amount of concretions). Lithologically, as well as physiographically, this formatian resembles closely the 40-50 meters sandy-loamy terraces of the Lower Fenho referred by Teilhard and Young (see T. and Y., 1930-1933) to a *pre-Malan* (Choukoutien?) stage. If so, the true Malan deposits would be only indicated, between Iyang and Changshui, by a thin veneer of loess, and low gravel fans, such as represented in figs. 3 and 5.

II. THE FAULTED TERTIARY BASINS, BETWEEN CHANGSHUI AND LUSHIH

Immediately above Changshui, the older rocks so far concealed under the detrital Cenozoic formations of the Lower Loho basin come to the light. And the river enters a series of deep gorges only interrupted by the Lushih plain.

Three main formations have to be described for this segment of our road, namely: the andesites, the faulted Tertiary beds, and the cap of the younger Red loams.

1. *The andesites.* As already mentioned, andesitic rocks (generally characterised by large feldspar crystals) form the most part of the gravels filling the Lower Loho basin. Although of a more massive texture (vacuolar, but without large phenocrysts) there is no doubt that the effusive rocks cut by the Loho gorges belong to the same formation. Between Changshui and Lushih, they occur as two extensive bars, in which the beds strike dominantly NE., with a SE. dip of 30° in average. They look distinctly hardened by metamorphism. And the vicinity of some intrusive granite is positively demonstrated by a number of quartz seams cutting irregularly the entire mass of the lavas.

On the whole, the Loho andesites belong clearly to a single and powerful sheet, —first intensively dissected by the Lower Tertiary erosion;—then dismembered by the faults limiting the present Tertiary basins (see below);—then, finally, levelled by the Loho erosional plane.

Their geological age is still uncertain. In a single place (see fig. 10, section at the Shihpapan[1]), we found their flows associated with partly metamorphosed sediments: sandstone, slates and white clays. From the lithological appearance of those interbedded deposits, and from the petrographical characters of the andesite itself, a Jurassic age would seem probable. Yet, similar andesites, occurring along the faulted Yüanchü Eocene basin, in South Shansi, have been reported by Andersson (see Andersson, 1923)[2] as forming *flows* in the Sinian quartzite. If Dr. Andersson has not been deceived by *sills*, then a similar Precambrian age would be more likely than a Mesozoic one for the Loho lavas.[3] In any case, either Sinian or Jurassic, the North Honan and South Shansi andesites, on account of their enormous extension, have to be regarded henceforth as representing one of the most important eruptive centers of North China. No traces of similar rocks have been observed by us on the southern side of the Tsinling.

2. *The faulted Tertiary basins.* (Fig. 8) As shown by our Map, two extensive Cenozoic basins, separated from each other by faulted blocks of andesite, run, in a NE.-SW. direction, between Changshui and Lushih: the Tsungyang basin, and the Lushih basin.

In the Tsungyang basin, the sediments, extremely thick (at least 3000 meters along a cross-section passing by Tsungyang), are mostly torrential. Several horizons of dark red clay (containing white concretions) occur however in their mass,—and also a median zone of white marls. Now, an interesting fact is that, near the top of the formation, a sharp break is observable in the deposit (see figs. 7 and 9). Following a thick basal poudingue, a massive "moraine-like" series begins: uncompletely rounded boulders and blocks, embedded disorderly in a yellowish sandy matrix. Although no unconformity was recognised between this huge fan and the underlying red clays, white marls and gravels, some important orogenic or climatic event has to be advocated for explaining such a change in the sedimentation.

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1 The Shihpapan is the name given to the steep cliff climbed by the Lushih road at the place where it crosses the Loho gorges, between Kuhsien and Yinghsienchen.

2 The same rock is cut by the Longhai railway, East of Shanchow (N. Honan), and, judging by the composition of the river gravels, is extensively represented in the northern side of the Fenghuangshan, in the Ichang area (South Shansi) (see Teilhard and Young, 1933).—Sinian andesites have been found in West Shansi by Dr. North (Norin, 1924) and have been reported more recently in several sections of North Hopei (see Kao and Hsiung, 1934).

3 A Sinian age would be definitely established by an observation made by Dr. Nystrom near Lushanhsien, Honan (quoted by Kao and Hsiung, 1934).

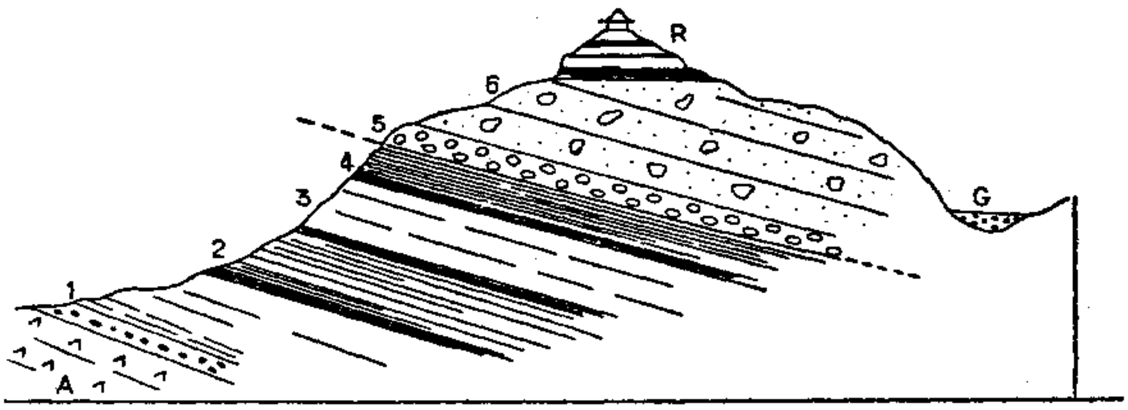

Fig. 7.—Partly diagramatic section in the Early Tertiary beds near Tungssu. 1 gravels and sandy marl. 2, dark red clays, with white concretions. 3, white sands and marls. 4, dark red concretionary clays. 5, hard and thick conglomerate. 6, "morainiform" accumulation of sands, pebbles and blocks. *A*, andesite. *R*, Red concretionary loam (Lower Pleistocene). *G*, patch of high gravels (Pliocene?). 1-4, lower formatiom. 5-6, upper formation. Each of both formations is several hundred meters thick.

From a tectonic point of view, the entire series is strongly tilted, striking NE., dipping SW., the dip reaching 80 degrees along the NW. border of the basin. On account of the marginal faults, no natural basal contact was noted. Yet, the fact that the deposits overlie directly an andesitic floor is suggested by the presence of andesite pebbles in the lowest beds observable in the formation. Most probably

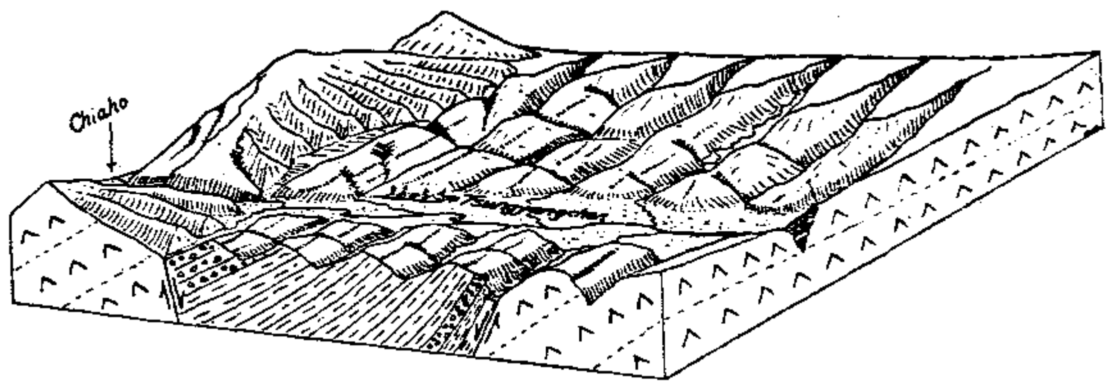

Fig. 8.—Block-diagram of the Tsungyang Basin, showing the structural relationships of the Early Tertiary deposits and the bedrock (Andesite).

fossils are to be found, chiefly in the middle white horizons of the basin. But we did not see any. We rely therefore on tectonic and lithological characters only for referring the series to an Early (ante-Miocene) Tertiary age. The possibility however of a Pliocene age for the uppermost ("morainiforme") erosional fan will be faced below in the general Conclusions.

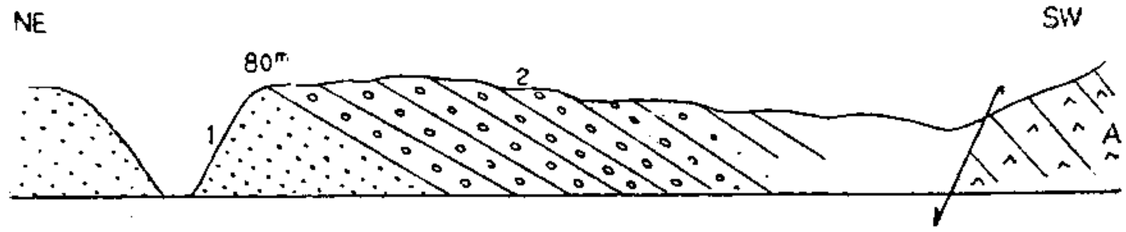

Fig. 9.—Section in the Early Tertiary beds, along the right bank of the Loho, at Kuhsien. 1, red clays, alternating with gravel layers (more than thirty alternations). 2, thick detrital series. *A*, andesite. Length of the section: about 2 kilometers.

In the Lushih basin, the tectonic and sedimentary characters of the deposits are essentially the same as in the Tsungyang basin. Several thick conglomerates, interbedded with red clays, are observed in the lower zones of the basin, near Yinghsienchen (see fig. 11). Further SW., between Yinghsienchen and Lushih, the beds, more gently dipping, seem lighter in colour, less coarse, and admit thick concretionary layers. Further on, along the southern limit of the basin, a huge detrital overformation marks (just as in the Tsungyang basin) the end of the sedimentation (see the next paragraph).

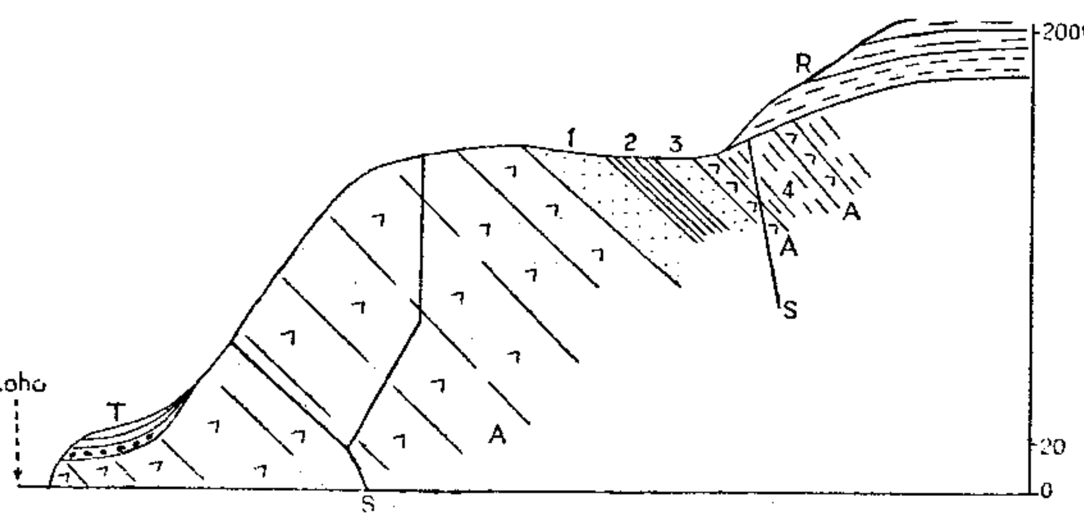

Fig. 10.—Section of the Loho cliff at the Shihpapan. *A*, andesite cut by quartz veins (*s*). 1, quartzitic sandstone (30 meters). 2, hardened slates (20 m.). 3, quartzitic sandstone (10 m.). 4, white marls (over 20 m.). *R*, Red concretionary loam, with hard basal pan, conformable to the slope. *T*, twenty meter terrace and gravel, corresponding to the Red loam.

3. *The younger Red loams.* More or less extensive patches of Red banded concretionary loams, capping everywhere the andesites and the tilted Tertiary beds, prove that the red Pleistocene clays, so much developed in the Lower Loho basin,

have formerly covered the entire area between Changshui and Lushih. That the formation of this red fan has occurred after a sharp previous dissection of the "Loho erosional plane" is made clear by the fact that the red cap extends very low down in the gorges cutting the andesitic platform. The basal hard pans or concretionary layers of the loam dip strongly in conformity with the slopes (see fig. 10), and seem to be in connection with an abrasional terrace (locally covered by cemented gravels) running at some 20 meters over the Loho (see fig. 10). At the entrance of the Lushih plain (see fig. 11, Yinghsienchen) the same basal conglomerate of the Pleistocene red loam hangs at some 50 meters in the cliffs. A lower jaw of *Siphneus* (*tingi*?) was collected in a concretion near Kuhsien. Unfortunately the teeth are missing on the specimen.[1]

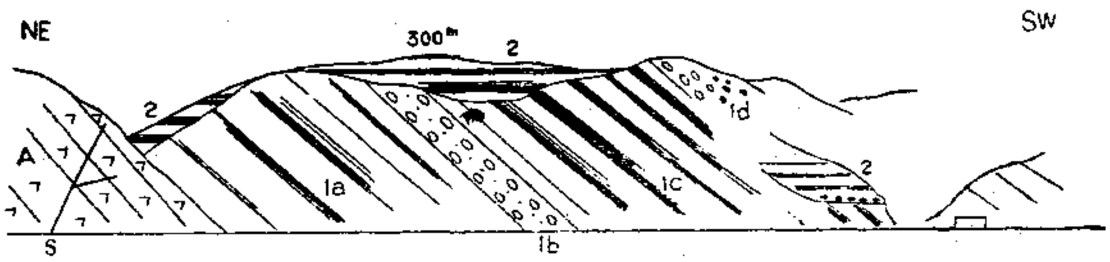

Fig. 11.—Section along the right bank of the Loho near Yinghsienchen. *A*, andesite, cut by quartz veins (*s*). 1*a*, banded red clays. 1*b*, thick sandstone and conglomerate. 1*c*, banded red clays and gravels. 1*d*, "morainiform" conglomerate. 2, Red concretionary loam (with basal conglomerate at some 60 meters above the Loho). 1*a*-1*d*, Early Tertiary. 2, Lower Pleistocene. Loess omitted. Length of the section, about 5 kilometers.

Traces of the "Loessic cycle" (Chingshui-Malan stages) are clearly expressed everywhere, chiefly in the Lushih basin, West of the Shihpapan. But the deposits are not important enough for being reported on the Map and in the sections.

III. The Main Branch of the Tsinling (Huangho-Yangtze Divide), between Lushih and Yutangkou (See the General Section, A and Pl. I, Fig. 2)

Leaving Lushih, our road has first crossed the southern border of the Lushih Tertiary basin, and then, at Lingkeng, entered the first formations belonging to the Tsinling proper (Tsinling axial zone). — Those two sections of our itinerary have to be described separately.

1 An exceptionally high seated conglomerate, probably referable to an earlier stage of the dissection of the Loho surface was observed in the Tsungyang basin, near Tungssu (see fig. 7).

1. *The southern border of the Lushih basin* (between Lushih and Lingkeng).

Exactly as in the Tsungyang Tertiary basin, the southern border of the Lushih basin is marked by the sudden apparition of thick conglomeratic formations, probably disconformable, but not evidently unconformable, with the underlying tilted marls and clays. Here however the conglomerates are no more andesitic, but chiefly consist of limestone elements, loosely cemented, — the blocks reaching several cubic meters in the highest conglomeratic zones. *No granitic elements observed.* In the less conglomeratic horizons, the formation turns into a coarse massive sandstone, curiously similar to the Ichang sandstone (as observed near Ichang, at the entrance of the Yangtze gorges). From the granitic Tsinling range, the conglomeratic series is clearly separated by a fault. But, across the Loho, the under-conglomeratic Tertiary clays overlie, in an apparently quiet way, a non-metamorphosed dark limestone (Sinian?) which (in spite of the absence of any basal gravel) represents possibly a natural floor.

In the whole area, the "Loho erosional plane" is remarkably distinct, at some 300 meters over the valley; and a veneer of Malan loess is well developed along the slopes. Near Lingkeng, at the very entrance of the gorges, remains of a remarkable 60 meters terrace is represented by several "shoulders" and a thick conglomerate mainly composed of highly weathered granitic boulders. This is most probably the terrace corresponding to the Lower Pleistocene Red concretionary loams. The loams themselves are not specially well represented in the area.

Then, most abruptly, begin the calcschists and the granitic rocks of the Tsinling axial zone.

2. *The northern axial zone of the Tsinling* (between Lingkeng and Yutangkou).

a. *Characters of the rocks.* Between Lingkeng and Yutangkou, the axial zone of the Tsinling consists of a thick metamorphosed series, in which several units can be distinguished, from North to South, running parallely in an East-West direction.

1). North of the Laochienling pass, the granitisation is dominant. Most of the rocks are formed by a confused mixture of gneissic and amphibolitic rocks, amongst which, from place to place, true granite is individualized: a bluish biotite granite, penetrated by a redder granite corresponding to later phase. The metamorphism however is not complete. And, in two places, an original limestone is perfectly recognisable, namely near Lingkeng and near the Laochienling pass.[1]

1 Amongst the granitic rock a large enclave was very suggestive of a metamorphosed andesitic block.

Near Lingkeng, the limestone (over 100 meters thick), although mostly transformed into white marmorised calc-schists and amphibolitic rocks, still preserves by patches its former blue colour. Approaching the pass, this feature becomes clearer. Although forming very thin patches (scarcely 1 meter thick) in the granitised sediments, the rock, of a dark blue colour, is so little marmorised that it does not differ appreciably from an ordinary Paleozoic limestone.

2). *South of the pass*, the road enters immediately a thick slaty series in which the granitisation becomes gradually slighter. First, the foliated sediments (including a few layers of marmorized limestone and of perfectly distinct conglomerates) are intensively injected with quartz, strongly sericitized, and sometimes cut by E-W. granitic dykes. But, after some 10 kilometers, the metamorphism decreases. And, for miles, the valley crosses transversally a monotonous series of strongly dipping greenish slates, so well preserved that we were at every minute expecting to find in it some Graptolite or Trilobite. Then, succeeding to some 10 meters of a very hard basal poudingue (in which well rounded pebbles of quartz, quartzite and sandstone occur, but *no limestone*) begins a huge massif of limestone (probably over 1000 meters thick), dipping strongly southward, conformably with the underlying slates. The rock is first white and marmorized. But further south, along the Wutaoho valley, it passes into a bluish rock, of an ordinary Paleozoic type. Most probably fossils could be discovered in this formation, which, by its position along the Wutaoho basin, parallelize most curiously the metamorphosed limestone of the Kuanho valley (see below).

b. *Age of the rocks*. Since we did not find any fossil in the above mentioned slates and limestones, their stratigraphical position cannot be positively established. Basing however on the characters of the rocks, a Paleozoic age will be suggested. In no pre-Sinian formations of China do we know so little metamorphosed blue limestones, nor so well preserved and so massive sedimentary sequences.[1]

More distinctly, it may be noted that, approximately at the same latitude, Chao and Huang (1931, p. 136) report in the central Tsinling an E-W. Paleozoic zone consisting of Cambro-Ordovician slates and Silurian limestone *separated by a basal conglomerate* from a thick Devonian limestone. Those being essentially the conditions observed along our section, we have tentatively adopted in our Map the

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As suggested by Dr. Grabau, we consider the Sinian (Precambrian) as an inferior term of the Paleozoic.—At Kouyang (north of Paotou, Suiyuan) a well preserved series (quartzite, blue limestone, micaceous slates) has been recently referred by C. C. Sun (Geological Memoirs, Ser. A, n. 12) to the Wutai. But so far we could judge by personal observations, this series represents a metamorphosed Paleozoic syncline.

same denominations (including however conventionally the entire underconglomeratic series under the same name of Silurian).[1]

If this hypothesis proves to be correct, the "Tsinling system" (Wutaian) of Chao and Huang would not be found (at least as forming a distinct zone) in the Eastern Tsinling, or even the validity of this system might be questioned. We shall come back to this point in our Conclusions.

IV. THE WUTAOHO BASIN (Between Yutangkou and Huangsha)

Immediately south of the limestone range above described, the Lushih-Hsichuan road joins the first large river descending towards the Han and the Yangtze. The valley runs along a faulted basin in which thick tilted Tertiary conglomerates lie in close contact with a granitic floor.

The conglomerates, over 200 meters thick, form a very homogeneous and extensive brown mass, in which a few red and white clayish intercalations only occur, in the lower zones. Basal beds of red arkose indicate a natural sedimentary contact with the granite. Granitic pebbles and boulders were *exclusively* observed in the formation, even at the points where the conglomerate is at present in immediate contact with the limestone. The strata dip, from both sides, towards the center of the valley, more strongly along the fault lines which mark the northern and the southern boundaries of the basin.

The granite is much weathered, and we could not determine the nature of its relations with the adjoining limestone. But a fault contact would explain the fact that the limestone is not metamorphosed in the very place in which we could observe it at the closest distance (some 300 meters) from the granite.

Everywhere in the basin the conglomerates are mostly barren from any superficial deposits, nor do they show marked physiographic features. Their Early Tertiary age is supported by any possible analogy with similar formations observed along both sides of the Tsinling range.

V. THE MIDDLE AXIAL ZONE OF THE TSINLING (Between Huangsha and Peiyu) (See General Section, B)

Between the Wutaoho and the Kuanho extends a monotonous and deeply dissected area (ancient warped peneplain?) consisting entirely of granite and various crystalline schists.

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1 This would be, in the E. Tsinling, the trace of the Caledonian movements, recognised by Chao and Huang in the Central Tsinling and the Tapashan, and recently emphasized by the geologists of the Hunan.

The granite is never observed as important massifs, but forms a series of elongated strips in the schists: a finely grained biotite-granite, or a white muscovite pegmatite rich in tourmaline and garnets. The mass of the mountains consists mostly of grey banded amphibolites and corneans, in which beds of metamorphosed limestone (pure or impure marble containing diopside and diallage crystals) are recognisable in several places. At the very entrance of the Kuanho basin, such a limestone, dipping NE., grows into a conspicuous ridge from which apparently are quarried slabs of marble extensively used all over the country. If, as we thought (and as indicated, it seems, by the map of Tsao, 1933), this marmorized zone is connected, in a SE. direction, with the Nanyang marble (see below), a Sinian age would be indicated.

In this whole system, the strike shows a distinct shifting from the E.-W. direction (as observed in the Tsinling near Lushih) to a NW.-SE. orientation.

Along the meandering gorges followed by our road just before reaching Peiyu, in the Kuanho valley, runs a perfectly distinct 20 meter terrace, still lined with old, partly cemented, gravels. This, as we shall see later, represents the cycle of the Red concretionary loams (Lower Pleistocene).

VI. The Kuanho Basin (Between Peiyu and Hsihsiakou)

With some minor differences in the characters of the sediments, and with more distinctly impressed physiographic features, the Kuanho basin is an exact duplication of the Wutaoho basin: in a SE. direction, the river follows the axis of a "graben", filled with a great thickness of tilted Tertiary deposits.

The sediments, much less conglomeratic than along the Wutaoho, are still very coarse, and of an exclusively crystalline origin. They consist generally of a moderately consolidated sandstone, mixed with small gravels. To this torrential and siliceous nature of the deposits is probably due the absence of fossils in perfectly promising exposures. Here again, as along the Wutaoho, the beds dip from both sides towards the axis of the valley, very strongly along the marginal faults, more gently in the central parts of the basin.

In the Wutaoho basin, we could not recognise any clear physiographic surface. Here, on the contrary, two (or even three) terraces are beautifully expressed by the topography, namely:

a) An upper 100 meter terrace, not restricted to the present river, but *planing* in a conspicuous way *the whole extension* of the Tertiary sediments (see fig. 12). No gravels preserved.

b) A middle 20 meter terrace, *limited* to the borders of the present river. This terrace planes the micaschists near Tinghochen, and is still covered by a partly cemented gravel. But the corresponding red loams, observed further south, have disappeared here.

c) A low terrace (less than 10 meters), scarcely emerging from the flood plain: gravels and grey loam.

Fig. 12.—Rock-cut terraces of the Kuanho Basin. (View looking southeastwards from above the village Peiyu).

The middle terrace is evidently the same as the one above mentioned along the gorges, N. of Peiyu. As made clearer in the two next paragraphs, and in the Conclusions, it belongs to the cycle of the Red concretionary clays (Lower Pleistocene). We regard the upper terrace as representing an undetermined Pliocene stage.

VII. The Southern Axial Zone of the Tsinling and Its Margin

(Between Hsihsiakou and Hsichuan)

(See General Section, C)

South of Hsihsiakou, the Hsichuan river cuts transversally, in moderately deep gorges, the eastern end of a rather high range, and, further on, a rocky karstic platform. In this area two dominant facts were observed by us: first, the southern contact of the Tsinling axial rocks with the big non-metamorphic Paleozoic formations of Central China; and secondly the first re-appearance of the Red concretionary clays.

1. *The end of the Tsinling axial zone.* So far as the vicinity of Shangchi, no sign would indicate an approaching termination of the Tsinling regime. The gorges run across an almost vertical series of foliated micaschists, injected with quartz, and containing numerous thin seams of pure graphite; an evident continuation of the series forming the mountains north of the Kuanho.

Some four kilometers however before Shangchi, a sudden and complete change occurs in the landscape. Along a sharp NW.-SE. line, the yellow smooth surface of the crystalline hills is replaced abruptly by a dark karstic surface; and further vast exposures of regularly bedded limestones appear, rolling endlessly toward the South.

Here the axial zone of the Tsinling has come to its end. And here begins the massive Paleozoic series of Central and South China.

So far we could judge under unfavourable conditions of time and light, this first-class break represents clearly an abnormal contact line along a sub-vertical fault. No evidence of overthrust whatever. And no traces of injected eruptive rocks either. Yet the dynamometamorphism is intense. On a thickness of several hundred meters along the contact, the limestone (originally blue, as proved by small splinters preserved in the rock) has been completely crushed and transformed into a pink brecciated, obscurely crystallised, rock. This hardly breakable substance, stained externally in black, has been forced locally by pressure in the softer "Tsinling formation", and forms a series of small isolated patches in the mass of the crystalline schists, in front of the main contact-line. A few kilometers on the left of our road, the frontal area of the limestone is marked by a rather sharp, eroded, fold, containing (in a syncline?) a horizon of characteristic platty lithographic limestone. This zone has been indicated on the map as possibly Silurian, a suggestion supported by the observation of Tsao (1933) for the same area, and also by the presence of a similar facies under the Devonian, west of Neihsiang (see below).

South of Shangchi, the formations become apparently quiet. And, up to Hsichuan, the high rocky plateau crossed by the river is entirely made of a thick, well bedded, limestone, gently undulating, with a dominant dip northward. The rock, hard and dark, very slightly crystalline, contains a few siliceous aggregations, and no fossils. In accordance with the observations of Tsao and C. Li (see Li and Chu, 1930), we shall refer it to the Sinian.

2. *The re-appearance of the Red concretionary loams.* Along the gorges, between Hsihsiakou and Shangchi the same physiographic features are observed as in the Kuanho basin. The high 100 meters terrace is represented by a clear platform planing the strongly weathered and deeply dissected crystalline schists on the right bank of the Hsichuan river. The lowest (Malan?) grey sands and gravels were noticed in several places. The middle (20 meters) gravels are easily traceable (they form a specially thick accumulation at the north entrance of the gorges, near Hsihsiakou). But something new happens. Overlying this "middle terrace", a typical Red concretionary loam appears, and gradually increases,—for the first time along our road since we had left the northern slopes of the Tsinling.

At the north entrance of the gorges (near Hsihsiakou) the red formation is already distinct. But, approaching Shangchi, it takes its normal development. Not exceeding a few (10-20) meters in thickness, the banded loam, crowded with small rounded concretions, and distinctly ending along the 20 meter gravel-terrace, extends upwards and caps the higher hills along the valley. In spite of the fact that no fossils were collected, we had no doubt, at that minute, that we were confronted with an exact equivalent of the "*Siphneus tingi* beds" of North China. And this feeling was henceforth strengthened by further observations.

A more enigmatic formation met by us along the same section is a remain of old terrace preserved in the valley, near the village of Wangchuan, at the place where the Shangchi-Hsichuan road, after crossing the river, climbs the limestone plateau of the right bank. As shown by the figure 13, the formation consists of some 12 meters of white sands and sandstone, lying on a basal conglomerate, and not apparently tilted. Above extend the gravels of the middle (20 meters) terrace corresponding to the Red loam. We suspect that this isolated patch belongs to the Pliocene "Nanyang formation" (see below).[1]

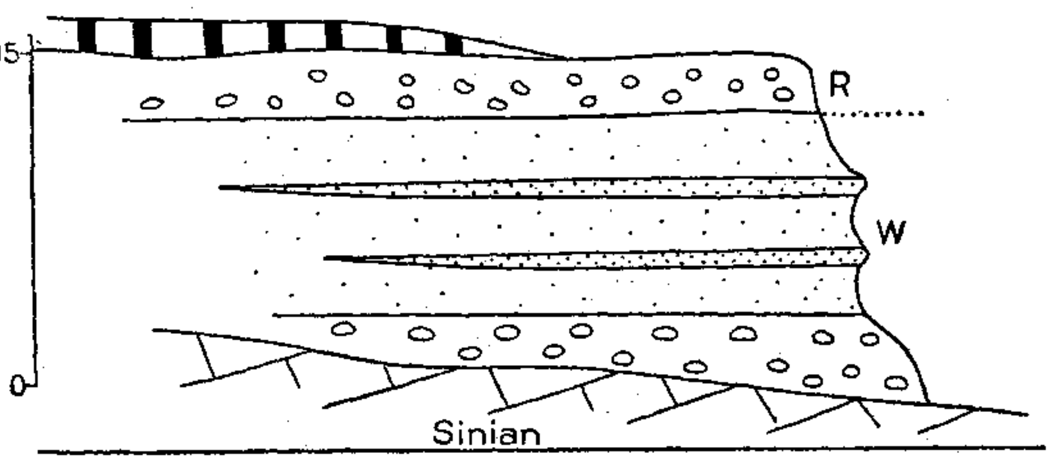

Fig. 13.—Section across a remain of old terrace, near Wangchuan, south of Shangchi. *W*. white formation (sands, sandstone layers and basal conglomerate). *R*, Red concretionary loam, and its basal gravel (Lower Pleistocene).

VIII. The Hsichuan Basin

The Tertiary beds of NE. Hupeh and SW. Honan have been first described by C. Li (Li, 1930), who has also discovered the only fossils dating palæontologically the formation: remains of a small Eocene Perissodactyle (*Lophialetes*, see Teilhard, 1930). More recently, the Hsichuan area itself has been mapped by Tsao (Tsao, 1933). We have therefore only to observe here that the Hsichuan basin is, lithologically and tectonically, the natural extension and the close equivalent of the Wutaoho and Kuanho basins above described.

1 This latter one being possibly the same as the "Post-Hsichuan formation" of C. Li (see Li, 1930).

In its NW. branch, crossed by our road, the basin is rather tightly pinched between two masses of Sinian limestone. Along the northern cliff, the Tertiary series, formed by a number of hard conglomeratic layers alternating with red clays, is bent in a sharp syncline. Further the sediments become less coarse (reddish, pink and white sands or marlish clays). Typical Red concretionary clays cap the higher slopes, and come in connection, along the Tanchiang river, with a perfectly clear gravel, representing the ordinary Middle (20 meters) terrace (s. fig. 14).

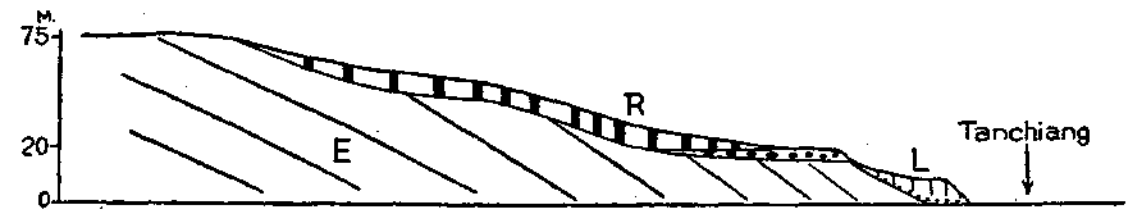

Fig. 14.—Cenozoic formations along the Tanchiang (right bank) near Hsichuan. *E*, Eocene gravels and clays. *R*, Lower Pleistocene Red concretionary loam, and 20 meter gravel terrace. *L*, Malan terrace?

On the opposite, left, bank of the river, the same conditions are prevailing, with a still larger development.

IX. From Hsichuan to Neihsiang. The Devonian Limestone and the Beginning of the Nanyang Formation

Between Hsichuan and Neihsiang we travelled by motocar, a condition unfavorable for observations. Still, along this section, three interesting points were noted.

1) Just after crossing the Hsichuan river, the road passes a small hilly basin in which the Red concretionary loam (indicated on the Map) caps and conceals largely an older (horizontal?) series, in which white beds and concretionary limestone seem predominant. If these beds do not belong (as we rather think) to the Eocene beds of the Hsichuan basin, they might be referred, on account of their colour and of their horizontality, to the same "Nanyang formation" as the white beds filling the Nanyang plain (see below).

2) For a long time, we did not notice any appreciable change in the composition of the Paleozoic limestone building the barren hills on both sides of the road. But, near the pass leading to the Neihsiang plain (close to Hsinshuyen) a block of stone proved to be fossiliferous, containing well preserved Devonian Brachiopods:

Cyrtiopsis sp., and *Sinospirifer sinensis* (determinations of Dr. Grabau). At this place the Devonian limestone overlies a thick series of dark red slates and platty limestone (Silurian?[1]). We had no time for tracing the boundaries of this Paleozoic syncline. But there is at least the evidence that, along the southern foot of the Tsinling, the Devonian extends more eastwards than formerly supposed, the most oriental locality so far recorded (see Chao and Huang, 1931) being roughly at the longitude of Sian.[2]

3) Coming to the Neihsiang plain, our attention was attracted by thick massifs of a white concretionary lacustrine (?) limestone sticking along the feet of the Paleozoic hills, at the level of the plain. In spite of the fact that the typical Nanyang beds (as described below) are characteristically barren originally of limy formations, we have tentatively referred, on our Map, those white beds to the "Nanyang formation", assuming that their chemical nature could be a local feature due to the vicinity of the Paleozoic limestone. Typical "Nanyang beds" are observed in the hills crossed by the road immediately SE. of Neihsiang.

X. From Neihsiang to Nanyang and Hsuchang

Our geological itinerary stops at Neihsiang. From this place, our party went on eastwards, following the southerd foot of the Tsinling, by Nanyang, Yehhsien, Hsianghsien, and finally reached Hsuchang, on the Peiping-Hankow railway. For this section a reduced and generalised map only is given (see fig. 15) expressing the few points which have a possible bearing on the problems dealt with in the present paper.

1) *The metamorphosed area of Nanyang.* Close to Nanyang, a series of isolated hills emerge from the plain, one of them (the Tushan) consisting of a beautiful pyroxene-diorite,[3] whilst the others contain a marmorized banded limestone containing a few *Collenia*-like concretionary masses (Sinian?). As already suggested (and as positively indicated, it seems, by the Tsao's map, 1933) this marble represents the SE. continuation of the northern range of the Kuanho basin, where the

1 Not reported on the Map. Some kilometers in the North, Mr. Tsao, who has followed another road, reports a large extension of Silurian beds (see Tsao, 1933).

2 Lately more Devonian Brachiopods (*Atrypa*) have been brought by Mr. J. T. Fang, reported to be collected some 50 lis NW. of Haichuan, apparently along the same zone.

3 The diorite of the Tushan is intensively searched for a jade-like substance it contains, and the marble is widely used for slabs. The so-called jade represents crushed veins of an almost entirely feldspathic rock (anorthosite, containing a few pyroxene, amphibole, zoisite, and sphene), associated with the main pyroxene-diorite. (Determination by Prof. Lacroix).

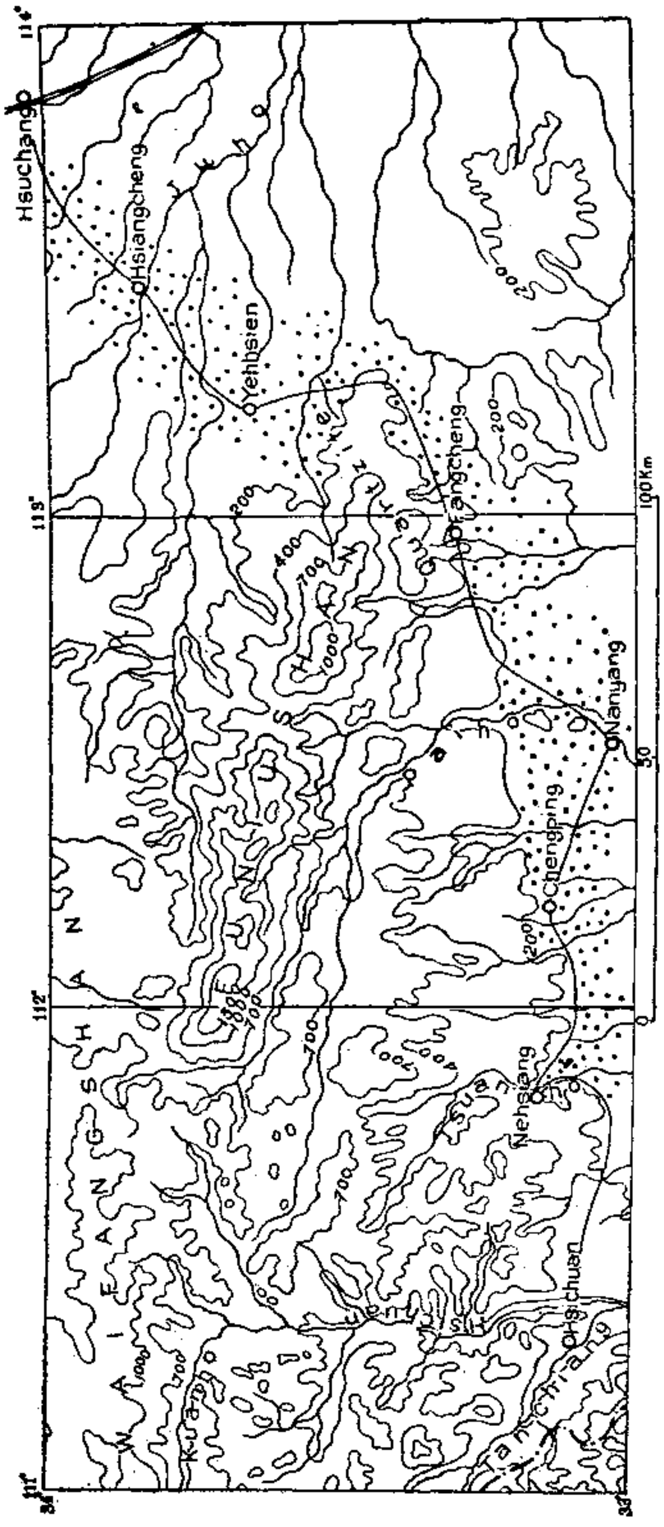

Fig. 15.—Sketch map of the Hsichuan-Hsuchang area. Dotted area, Nanyang formation.

characters of the rocks is exactly the same. Anyhow, caught as it is between the great limestone-plateau of Hsichuan-Neihsiang westward, and the big quartzitic formations of Yehhsien-Hsianghsien eastward, the Nanyang metamorphosed area represents probably a true prolongation of the Tsinling axial zone, bent in a SE. direction.

2) *The quartzitic massifs of the SE. Tsinling.* Immediately east of Nanyang, the Tsinling range is formed, along the plain, by a large development of grey and red Sinian quartzites. And the same rock builds the whole of the mountains between Yehhsien and Hsianghsien. This sharp opposition between equally extensive limestone and quartzite formations, west and east of the metamorphosed Nanyang zone respectively, has evidently a meaning which a more complete mapping of the Eastern Tsinling will help to discover. On the whole, it would seem that, whilst the West Nanyang limestones have a decided "southern facies" (presence of the Devonian, etc.), the East Nanyang quartzites on the contrary show rather northern characters. In the rivers near Yehhsien we have noticed pebbles of a curious Sinian(?) shale (chocolate in colour, with circular green spots) perfectly identical with a rock extensively used at Lushih for burial stones.

3) *The Nanyang formation.* All along the incurved footline of the Tsinling, from Neihsiang to Hsuchang, the low undulations emerging from the alluvial plain show a surprisingly constant structure, expressed by our figure 16.

a) The core of the hill consists invariably of a white or green sandy clayish deposit (decidedly sandy, and even containing pebbles in the Nanyang area itself), striped with vertical vermiculations of a more clayish nature and of a generally lighter coloration. To those fundamental sediments, of a probably fluvio-lacustrine origin, we give the name of *Nanyang formation*. The series *seems* undisturbed, and perfectly horizontal.[1]

b) Then, invariably also, appear the Red concretionary loams. Their banded beds, crowded with rounded concretions, dissect and cap the gently undulating hills, generally separated from the "Nanyang formation" by a hard pan or a strongly cemented gravel.

c) Now, two more points have to be noted. First, *before the deposition* of the Red loam, the Nanyang formation has been exposed and weathered for a long time. Its upper zone is frequently reddened; and most constantly it contains a number of limonitic pisolites or larger ferrugineous concretions.[2] Secondly, *after the beginning* of

1 See however the additional note, at the end of this paper.

2 Those ferrugineous formations are abundantly found, in a rewashed condition, in the basal pan of the Red loam, west of Hsuchang.

the deposition of the Red loam, an intensive calcification of the contact surface has happened. The limy deposits, so characteristic of the period of the Red loams, invade the vermiculated under-formation,—either along fissure-like pockets, either along horizontal superficial zones. Sometimes the concretions (formed in this secondary way) are irregularily spread in the white Nanyang clay, embedding the undisturbed pisolites. More generally they fill, in a selective way, the vermiculations only.

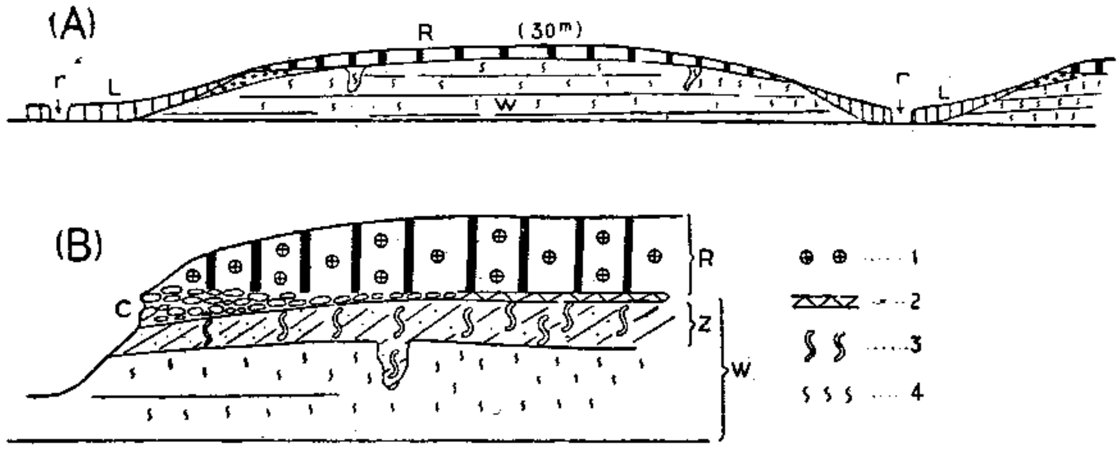

Fig. 16.—(A). Generalised structure of the superficial sediments in the Nanyang Basin. *W*, white vermiculated sands and clays. *R*, (Nanyang formation, Pliocene?). *R*, Red concretionary loam (Lower Pleistocene). *L*, grey loam and sand (Late Pleistocene). *r*, river.

(B). Enlarged section, for illustrating the relations between the sediments of the Nanyang Basin. *W* and *R* as above. *c* basal conglomerate of *R*. *Z*. zone of subaerial weathering and subsequent calcification of *W*. *p*, pocket of calcification. 1, concretions. 2, hard pan. 3. calcified vermiculations and iron pisolites. 4, original vermiculations.

On the whole, the general history of the basin can be traced by the following steps:

1. Deposition of the Nanyang white beds in an extensive fluvio-lacustrine basin.
2. Emersion and weathering of the Nanyang beds, under climatic conditions allowing the complete dissolution of the lime and the formation of a ferruginеous crust.
3. Further erosion of the formation, and subsequent deposition of the Red loam, under condition favourable to an intensive accumulation of carbonate of lime.
4. Late erosion, and deposition of the grey sands or loams of the Malan stage.

Now, if we assume, as elsewhere in this paper, that the Red loams are Lower Pleistocene, then the Nanyang beds, and their phase of weathering, would fall in the Pliocene (between the Pontian and the Sanmenian inclusively). From another side, the same Nanyang formation shows a series of striking analogies with the "lateritic clays" so characteristic of the Yangtze basin (Yuhuatai terrace, see Barbour, 1934): those Yangtze clays also are vermiculated; they are barren of limy concretions; and they are surmounted by a clear ferruginous crust capping their weathered surface

Put together, those facts point to the conclusion that the "vermiculated clays" of the Yangtze valley, identical with the Nanyang formation, should be held as Pliocene,—the Red concretionary loams being decidedly absent in this meridional area, or represented by the Siashu loam of Nanking (see Barbour, 1933). Those views have been accepted by Barbour in his latest contribution of the physiography of the Yangtze valley (see Barbour, 1934).[1]

SUMMARY AND CONCLUSIONS

From the precedent observations made in the East Tsinling area, a series of dominant facts seem to come to a better light, and can be summarized as follows.

1. The Axial Zone of the East Tsinling. Nature and Structure

An *axial zone*, consisting of granite and granitized sediments, is clearly marked in the Tsinling along our itinerary. And this zone is limited, both on the North (Lushih) and on the South (Shangchi), by fault lines, without any clear evidences of overthrust. Near Shangchi, the limit is especially sharp, being marked by a complete change in the nature of the rocks and a strong dynamometamorphism. Near Lushih, the contrast is less striking, the blue metamorphosed limestone of the axial zone being in contact with a non-metamorphosed rock of the same type (Sinian?), and traces of granitisation being noticeable in the andesites, outside of the main range.

Now, so far as the original nature of the axial zone is concerned, we believe that it represents largely (if not only) a metamorphosed Palæozoic series.[2] Between Lushih and the Wutaoho, patches of a blue limestone are preserved even in the most

1 Immediately north of Hankow, in the first hills cut by the Peiping railway, the vermiculated clays are capped by a peculiar formation consisting of irregular quartz fragments disorderly embedded in a red sandy clay. This might be the southern equivalent of the Lower Pleistocene Red concretionary loams of the North.

2 As told above, we include the Sinian in the Paleozoic.

granitised parts of the section; and a half of the range consists of a scarcely metamorphosed succession of slates and limestone, of a decided Paleozoic appearance (?Silurian and ?Devonian, on the Map). Further on southward, the rocks become more crystalline. Yet a continuous recurrence of marmorised limestones is observed, linking the Wutaoho ?Devonian with the Kuanho Sinian marbles. In such an homogeneous series, it seems impossible to draw a line between younger and older crystalline rocks. If therefore a pre-Sinian metamorphic series is present ("primitive axis", "Tsinling system" of Huang and Chao, 1931, cf. Huang 1931), this series has been so tightly amalgamated with the Paleozoic as to become a single metamorphosed unit.

Along our itinerary we did not observe, in the axial zone, any noticeable development of quartzites, nor any intrusion of porphyritic rocks. The first absence seems to corroborate our assumption that the Paleozoic series does not come here in sedimentary contact with any older crystalline floor. The second one indicates a deep seated area for the last metamorphism of the range.

The trend of the metamorphosed rocks, first approximately E.-W. (south of Lushih), deflects gradually toward a SE. direction. The importance of the branch passing by Nanyang is marked by the differences observable in the sedimentary series on both sides of the metamorphosed zone: Sinian, Silurian and Devonian limestones (South Tsinling Paleozoic facies) in the SW.;—Sinian quartzite (North Tsinling facies) in the NE.

2. The Early Tertiary Cover of the Tsinling

Early Tertiary formations have been already observed several times on both sides of the Tsinling (see Young, 1934). But in no recorded section is the shelf of the "Eocene" deposits so continuous and so impressive as between Lushih and Hsichuan. Judging by the several hundred, or even thousand, meters of faulted conglomerates, sands and clays filling every valley North and South of the main range, the Tsinling must have been half buried under their own erosional products during the Early Cenozoic (=pre-Miocene) times.

Of course, outside of the two only fossiliferous areas so far discovered (Yuanchü, along the Huangho, and Hsichuan), the Eocene age of those huge fans is somewhat hypothetical. Just as near Ichang and in the Szechuan, Cretaceous beds may be suspected at the base of the series; and a post-Eocene age is possible for the uppermost tilted gravels of the Changshui-Lushih area. Yet since no unconformity is recognisable within the whole mass of the sediments, and because of so many tectonic and physiographic analogies observable everywhere in the deposits, it seems wiser to refer provisionally the entire formation to a single (Eocene-Oligocene) geological period.

As observed again further below, the great development of Early Cenozoic gravels in the Tsinling is so much the more striking that (as a difference for instance with the Tienshan) *no older, nor later important piedmont formations* seem to exist along the range.

3. The Question of the Pliocene

A puzzling point in our observations across the East Tsinling is that, since the beginning of our journey, we lost any clear contact with the Pliocene (Pontian and Sanmenian) formations so typically represented along the Huangho near Loyang, —for instance in the Sanmen and Mienchih areas. With a serious probablity, we have referred to the Pontian the planing of the Eocene beds along the Loho, and to the Sanmenian the depositions of the last *upper* gravls over this "Loho surface". But even this idea remains partly hypothetical.

South of Changshui the facts become still more obscure. With the exception of isolated patches (such as indicated in fig. 7), no high gravels were observed over the Loho surface along the northern foot of the Tsinling. We had to cross the range and to approach Hsichuan for coming again in touch with the Pliocene, as represented probably by the 100 meters erosional plane of the Kuanho, possibly by the lacustrine "Nanyang formation".

Nothing is found, along the section given by our Map, for representing the huge Pliocene fans, and eventually the "Himalayan" faultings, so characteristic or the Kuenlun, the Tienshan, the Mongolian Altai, the Shansi mountains, etc., nothing, *unless*, in spite of an apparent angular conformity, *we should have someday to refer to the Pliocene the tilted upper gravels* ("morainiform fans") of the upper Loho valley.

4. The Extension of the Red Concretionary Loams

In opposition with the obscure conditions of the Pliocene, the Lower Pleistocene, as represented by the Red banded concretionary loams,[1] is remarkably clear over the area covered by our journey. In fact, this formation represents by far the clearest Late Cenozoic deposits observed by us North and South of the Tsinling. On both

1 For the reference of the Red loams (Reddish clays) to the Lower Pleistocene, see Teilhard and Pei, 1934.

sides of the range, the same type of sediments extends, thicker on the northern slopes, much thinner in the southern basins, but always bearing the same lithologic and physiographic characters: red loams, crowded with rounded concretions, capping the hills and connected with a perfectly distinct 20 meter gravel-terrace.

In absence of any fossils in the Southern Tsinling, the common reference of all those red slope-deposits to a same Lower Pleistocene age is not absolutely demonstrated,—but hardly questionable. Similar loams have been observed by Chao and Huang, and by C. Li in the Han valley (Hanchung loams, see C. Li, 1930). But, as told above, they seem to disappear along the Yangtze, where they are possibly replaced by the Siashu loam of Barbour.

As expressed in their very name, the dominant character of the Lower Pleistocene loams is, in addition to their color, the abundance of lime they retain. In strong opposition with the underlying vermiculated clays of the South, they are *the most intensively concretioned formation* we know in China. This also has evidently a climatic significance.

5. The Boundaries of the Loess

To trace the southern limit of the Malan loess was one of the aims of our journey. Nothing especially clear was noted along this line. Strongly reduced along the Loho valley (unless to the Malan stage should be referred the questionable 40 meter terrace of Changshui, see figs. 3 and 5), the Loess is unexisting, as such, along the Southern Tsinling. A "Loessic" cycle however (Chingshui and Malan stages) seems to be everywhere marked by a low terrace and gray sandy loams, for instance in the Kuanho and Nanyang basins. But no fossils are known for supporting this attribution. On the whole, the Late Pleistocene formations were too scarce for being expressed on our geological Map.

6. The Rising of the Tsinling

As a final Conclusion, we may say that the major facts recognised by us as interesting the general history of the Tsinling are the following ones:

a) An intense and deepseated granitisation of the Paleozoic beds along the axial zone.

b) An enormous accumulation of erosional products during the Early Tertiary (and Late Cretaceous?) times.

c) A sharp vertical movement of the range before the Pliocene.

d) A moderate Pliocene erosion, followed, during the Lower Pleistocene by the general deposition of the Red concretionary loams along the slopes and in the basins.

e) A slight Upper Pleistocene change.

The absence of any incorporated Late Paleozoic or Early Mesozoic gravels (or lavas[1]) along the axial zone, and the probable absence of large Pliocene piedmont formations, have both to be carefully noted. Whatever strange is the fact, no evidence seems to have been brought so far suggesting positively, neither the existence of a Carboniferous or Jurassic true range, nor the occurrence of decided Himalayan movements in the Central and Eastern Tsinling. The apparent orogeny belongs essentially to an Alpine phase.

ADDITIONAL NOTE

Later observations on the Nanyang formation. This paper was to be sent to the press when one of the authors (M. N. Bien), surveying the W. Shantung, observed that the Eocene beds of this latter area show, in their superficial layers, the same characters as the Nanyang formation: vermiculations, presence of iron pisolites, and cap of concretionary red loam.

In referring the Nanyang formation to the Pliocene, we have been chiefly directed by the fact that those beds *seem* to be horizontal. But, must we confess, none of the sections observed by us was sufficiently deep for making this horizontality *beyond doubt*. If further observations could prove that the Nanyang formation is tilted, then it should have to be regarded as Early Tertiary in age. And consequently: 1) a continuous Eocene basin could be traced between Shantung and Hupei; 2) the Pliocene would be missing even in the Nanyang basin (just as in the Shantung?), being only represented by a period of weathering and lateritisation of the older deposits.

1 With the exception (if they are decidedly not Sinian) of the Loho andesites.

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Figure 1.—Field sketch of 25-mile stretch of Loho terrace from above gorge, west of Changshui.

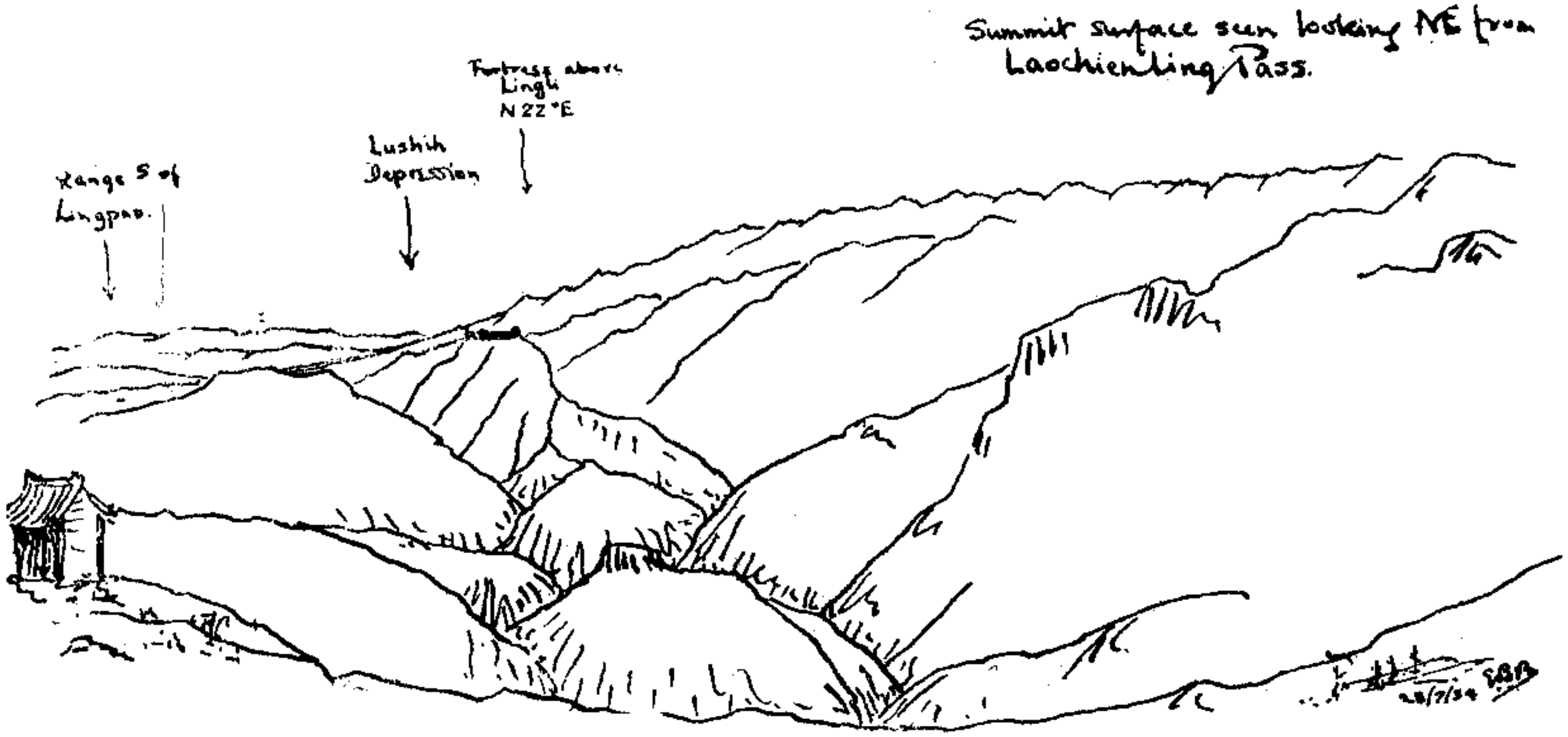
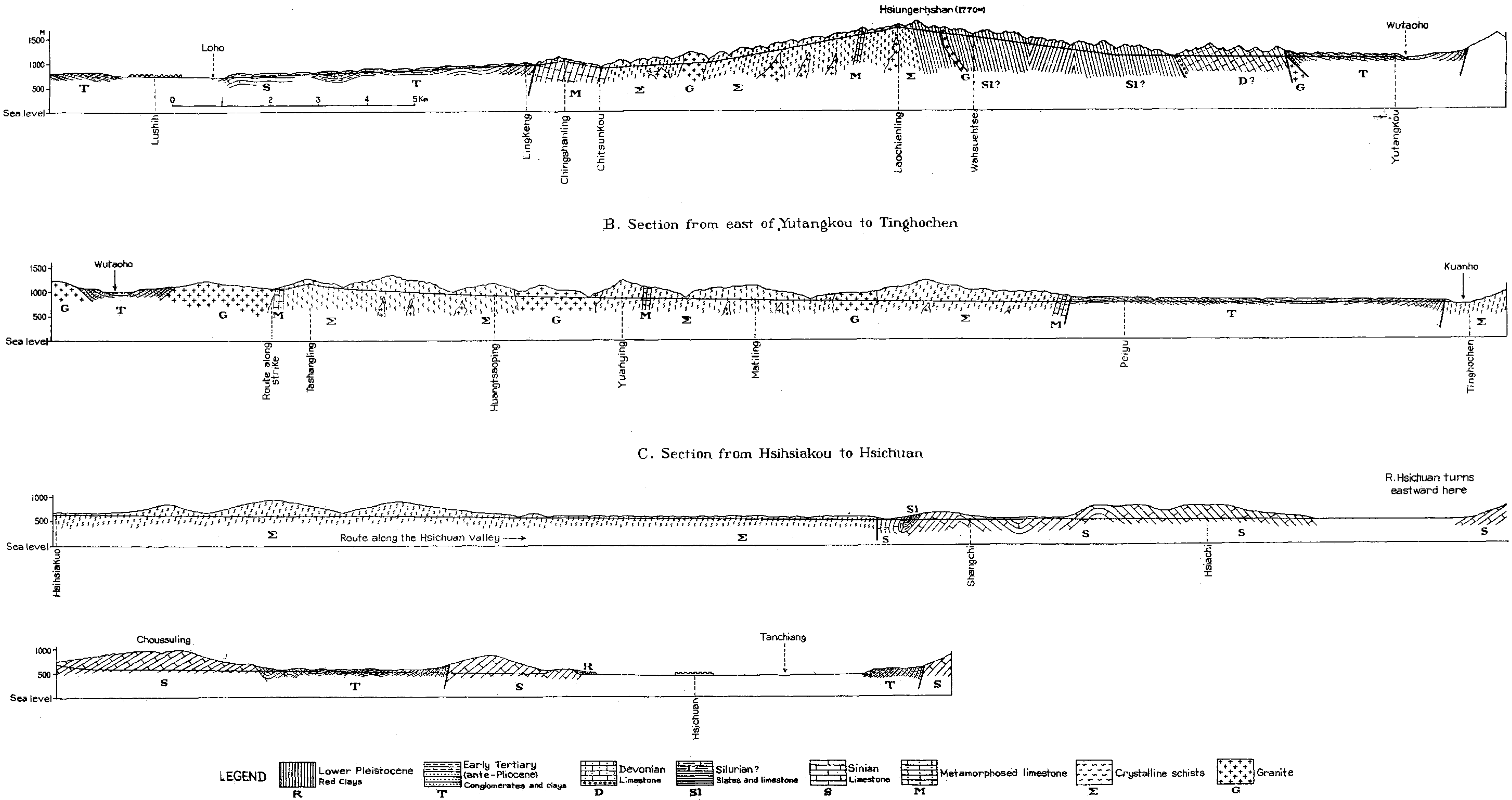
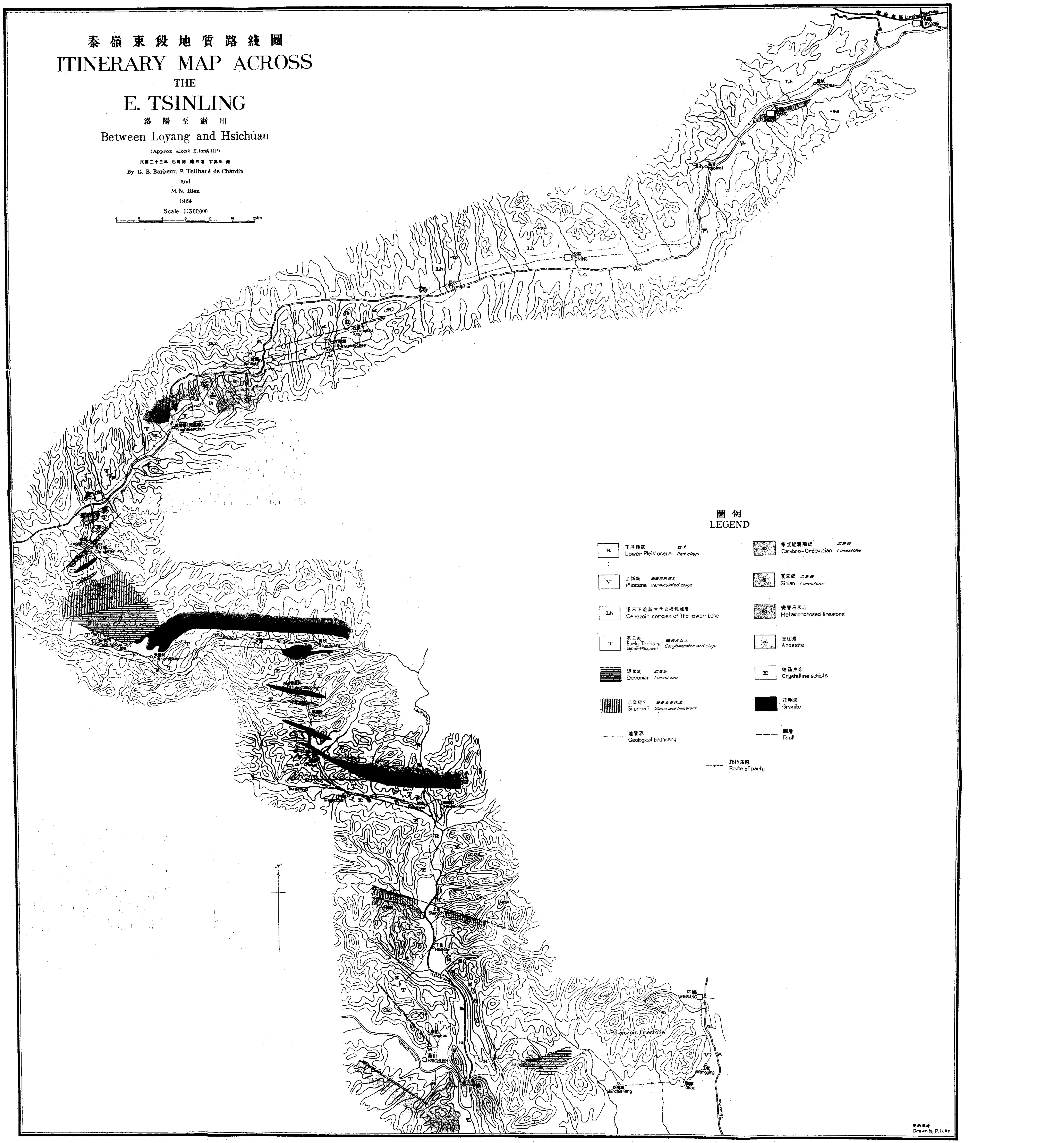


Figure 2.—View of summit surface from pass at Laochienling, showing warped profile of maximum crestlines.

SECTIONS ACROSS THE E. TSINLING FROM LUSHIH TO HSICHUAN

Horizontal and Vertical Scales 1:75,000





秦嶺東段地質路綫圖
ITINERARY MAP ACROSS
THE
E. TSINLING
洛陽至淅川
Between Loyang and Hsichúan
(Approx along E. long 111°)
By G. B. Barbour, P. Teilhard de Chardin
and
M. N. Bien
1934
Scale 1:300,000
4 0 4 8 12 16 20Km
圖例
LEGEND
R
Lower Pleistocene Red clays
V
Pliocene Vermiculated clays
Lh
洛河下遊新生代之複雜地層
Cenozoic complex of the lower Loho
T
第三紀 礫岩及粘土
Early Tertiary (ante-Pliocene) Conglomerates and clays
泥盆紀 石灰岩
Devonian Limestone
Silurian? Slates and limestone
Cambro-Ordovician Limestone
Sinian Limestone
Metamorphosed limestone
安山岩
Andesite
Σ
Crystalline schists
花崗岩
Granite
Geological boundary
Fault
旅行路綫
Route of party
LOYANG
LONING
Lo Ho
HSICHUAN
NEIHSIANG
Paleozoic limestone
Drawn by P.H.An

NOTES ON THE ASBESTOS DEPOSIT OF LAIYUAN DISTRICT, HOPEI PROVINCE

By T. F. Hou

1. *Localities:*—Asbestos has been mined at several localities in Laiyuan (淶源) and Yihsien (易縣) districts. Of these localities, the most important one is Yenmeitung (燕美洞) of Laiyuan, where the asbestos mines have been carried on continuously since the year 1914. The village "Yenmeitung" is situated on the left bank of Chumaho (拒馬河), about 30 km northeast of Laiyuan city and 106 km northwest of Yihsien (Map I). On the western hills of the village we found the asbestos deposits.

Other known localities of the asbestos deposits are: (1) at about 5 km north of Tzukingkuan (紫荊關) and (2) about 12 km south of Laiyuan city. But mining in these two localities was soon suspended on account of the poor quantity and quality of the deposits.

2. *Geology:*—The asbestos veins are found in the Sinian limestone near the contact with a big intrusive granite body. At Yenmeitung, the contact line of the limestone and granite runs in NNE and SSW direction. The Sinian limestone strikes from the north to south and dips toward the west at 28-46 degrees (Map II). Several belts of asbestos veins are parallelly (or nearly so) arranged in the metamorphosed siliceous limestone. The main belts trend from the north to south, distributed on the eastern slope of the mountain "Otiaoliang" (Map II).

As can be seen from the accompanied section at Yenmeitung (section, Map II), the basal part of the Sinian limestone is metamorphosed to form a banded structure, in which thin bedded gray crystalline limestone intercalated with thin layers of light yellow or yellowish green serpentine and white bands of talc and flint layers, but asbestos veins are not visible. This part of the beautifully laminated metamorphosed beds is about 150 meters thick. Above this, there is no less than one hundred meters of crystalline limestone intergrown with numerous veins of asbestos. Though the veins are rather irregularly distributed, the rich part of asbestos may be roughly located in three belts. The lowest belt lying on the bottom of the strata is about 3-5 meters thick. The middle belt lies about 40-60 meters above the lower one; it is about 5-7 meters thick. The upper belt is situated 20 meters above the middle one and is ten or more meters in thickness. The thickness and horizon of these belts are not regularly distributed in the whole area, but the middle and the upper belts have been worked at many places such as north to Tsingsuiho (清水河) and south to Suichuankou (水泉溝) with a total length of no less than 3 kilometers and the minimum combined thickness of 15 meters. In the upper part of the Sinian limestone, the asbestos and serpentine gradually disappear.

Veins of asbestos are in sheet-like shape of a few feet across and gradually thin out towards the margin. But numerous veins or sheets are always intergrowing nearly in parallel direction in the limestone. In the rich belt, the different veins are usually closely spaced, the interval between them rarely exceeds 10 centimeters. The asbestos are of the cross fiber type, i. e. with fibers perpendicular to the wall of the vein, the fibers are 3.5 centimeters in maximum length but usually only 1½ to 2 cm. The asbestos of the lower and middle belt is in golden color, brilliant silky luster and very fine fibers of considerable strong tensile strength; while the asbestos of the upper belt is almost pure white in color and comparatively brittle.

The asbestos of this area is a variety of serpentine-Chrysotile (a hydrous silicate of magnesia, hardness 3, specific gravity 2.2). The rich belts stretch continuously from the west of Tsingsuiho on the north to the west of Suichuankou on the south (Map II). Assuming that 50 meters as the workable width along the dip and 10-20 percent as the mineral content in the rock, we arrive at a total quantity of workable asbestos in the whole area as 400,000 tons. The detail figures are listed as follows:

	Length	Thickness	Width	Specific gravity	Content in rock	Loss by erosion	Probable reserves
Lower Belt	1,500 m	4 m	50 m	2.2	15%	2/3	49,500 (ton)
Middle Belt	3,000 m	6 m	50 m	2.2	20%	1/2	198,000 (ton)
Upper Belt	3,000 m	10 m	50 m	2.2	10%	1/2	165,000 (ton)
Total							412,500*(ton)

3. *Microscopical study*:—A number of the asbestos specimens were sent to Y. T. Nan for microscopical study. According to him the asbestos has a mean refractive index of about 1.512. It forms usually fine veinlet in a sheaf-like or massive serpentine. Small scales or sheets of calcite are often intimately mixed with the fibers of the asbestos. Besides, there occurs in the massive serpentine small grains of magnetite and hematite. Those serpentine containing an abundant amount of hematite shows a red color in handspecimen. Other colors such as green and yellow are also seen, the former color is due to the existence of antigorite and penninite, while the latter is due chiefly to kaolin, the weathering product. The contact metamorphic minerals such as amphibole, olivine, etc. are however not found either in serpentine or in marble.

* According to the record of the native mines 50% of the total output may be expected to be of high quality (thread).

It is doubtless that the asbestos of Laiyuan has been formed by recrystallization of the massive serpentine. Now the question is from what mineral has the serpentine been derived. Although we have not found in our specimens original silicate such as olivine or amphibole, it does not necessarily mean that they are really absent in our deposit. On the other hand, in the asbestos deposit of Hotzekien in Changping district, a deposit of similar nature as the present one, small grains of unalterd forsterite can still be seen in serpentine. It is therefore concluded that the original mineral from which serpentine was formed is probably also a variety of olivine, although it may have been entirely destroyed by alteration or it is not represented in our collection.

The occurrence of minute sheets of calcite in the chrysotile fibers has been already stated. This texture seems to show at first sight as if chrysotile was formed by the replacement of calcite. This derivation is however not possible. The more possible way of explanation is that the calcite has formed after the chrysotile, and that it has replaced the fibrous mineral almost entirely so that the calcite itself shows also a fibrous structure.

From the above microscopical study, it may be concluded that the formation of the Laiyuan asbestos deposit may be divided into following steps:

a) The intrusion of a granite into the highly magnesium and siliceous limestone of Sinian age has resulted in the formation of olivine and other contact metamorphic minerals; at the same time the limestone was recrystallized to form marble.

b) The residual solution of the granitic magma then came up and reacted with the original magnesium silicates such as olivine etc. to form the massive serpentine. The iron was separated as hematite or magnetite.

c) The massive serpentine was partly taken into solution and in its cracks and fissures was formed the recrystallized chrysotile. This change may also be considered as a kind of hydrothermal action.

d) The last stage of the history is the formation of fibrous calcite, a form pseudomorphic after chrysotile. It was probably deposited from the cold, ground water solution.

4. *Mining Condition*:—The asbestos has been mined in this area since the year 1914. There are three companies namely: the Yujung Co. (裕榮公司) at Suichuankou, the Pingyuan Co. (平源公司華北公司) at Tsingsuiho and the Chungta Co. (仲達公司) at Yenmeitung. The former two companies were closed in 1917 and 1932 respectively and only the last one—Chungta Co. remains now in

operation. The material is dug out by native farmers and the working period is three to five months every year. The mining method is simply by sinking small incline tunnels along a series of veins. These tunnels are one or more meters high and wide, with the maximum incline depth of about 30 meters. Mining tools are hammers, chisels, picks and shovels but no machinery nor explosives are used..

There are three to five hundred workmen engaged in mining operation. The daily output per man is 60-100 catties.

The materials carried out from the mine are divided into two classes; the first class consists of pure asbestos in lumps with fibers not shorter than 1½ centimeters and the second class includes the slabs and impure dust. The percentage of production of the first class is almost always 7% of the total.

The mining cost (the prices bought from the labourers by the company) is 240 coppers per picul for the first class and 80-150 coppers per picul for the second class.

The materials are again dressed, crushed and meshed to get the following products:—

Materials	1	2	3	4	5	Percentage in total	Cost of production per ton in dollars
	(After hand dressing.)	(After crushing and meshing)					
	50% pure lumps & needles.					3.5%	91.6
1st Class (Mining Cost $89.6 per ton)	(50% slabs)	70% Thread 1st class				2.3%	94.29
				20% Thread 3rd class		0.8%	(91.62)[1]
					10% Powder	0.4%	(89.6)[1]
2nd Class (Mining Cost $48.6 per ton)			20% Thread 2nd class			18.6%	52.8
				30% Thread 3rd class		27.9%	50.62
					50% Powder	46.5%	48.6
Dressing fee per ton	$2.00	$4.69	$4.2	$2.02			

1 Less important, being only 1.2% in quantity of total production.

The products of asbestos are transported on horse back from the mine to Yihsien (about 106 km) costing 23.52 dollars per ton. From Yihsien to Tientsin, it is transported by trains costing about $28 per ton and it may also be transported on small boat at Tinghsing (定興 35 km south-east of Yihsien) costing $22.4 per ton to Tientsin.

The prime-cost and market price at Tientsin as quoted from the mining company in March 1933 are given below:—

	Prime-cost per ton*	Market Prices per ton
1 Pure lumps and needles	137.32 (dollars)	365.00 (dollars)
2 Thread 1st class	140.21 "	224.00 "
3 Thread 2nd class	98.72 "	120.00 "
4 Thread 3rd class	96.54 "	75.00 "
5 Powder		(no market)

About 47% of the product belongs to the asbestos powder which can hardly be sold because it is very limited in usage. There is now little business in the Chinese market, but the company can produce more if there is more demand for this mineral.

* Tax of Production 5/100 not included.

NOTE ON THE GEOLOGY OF EASTERN CHEKIANG

A SUMMARY

BY P. KAO

1. INTRODUCTION

In the autumn of 1933 the writer was sent by the Geological Survey of China to make a geological reconnaissance in northeastern Chekiang. The route followed by the writer was from Hanghsien to Shaohsing, Sinchang, Linhai and Yungchia (Wenchow), from the last named place[1], the writer went to Haimen by boat and from there he went further eastward to Linhai, Sientsu, Tungyang, Chuchi, and finally got back to Hanghsien. Detailed description of observation along the route is given in the Chinese text. A route sketch showing geological formations on the scale of 1: 500,000 is herewith accompanied.

2. TOPOGRAPHY

The topographic feature of the surveyed area is remarkable in that it shows a regular distribution of mountain ranges trending all from northeast to southwest. This is the well known Sinian direction of Pumpelly; from north to south the following may be distinguished: (1) The Kweichishan range forming a watershed between Puyangkiang and Tsaongokiang. (2) The Szumingshan range, a watershed between Tsaongokiang and Yungkiang. (3) The Tientaishan range including the famous scenic point Tientaishan is located between the districts of Tientai and Fenghua. (4) The Tapanshan range, lying southwest of Tientai forms a watershed between Puyangkiang and Lingkiang. (5) Kuatsangshan range forms the watershed between Linkiang and Oukiang, being the most hilly region known in eastern Chekiang. Its southeast continuation forms the famous Yentangshan, also noted for beautiful scenery.

The principal rivers in the area surveyed are: Chientankiang, Tsaongokiang, Linkiang and Oukiang. These rivers are navigible in great part of their courses and form therefore important throughfare for communication and transportation. That part of the Puyangkiang (name for the upper part of Chientankiang) above Tunglu is noted for deep gorges and cliffs cut in rhyolite formation.

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1 It was originally planned that from Yungchia the writer should go northward across the Kuatsangshan range, but owing to the unsetted conditions there, this scheme was afterward changed.

Lakes are numerous especially in the lower part of the Chientankiang. Among the most noted and scenic lakes, the following are to be mentioned: (1) Hsihu or Western Lake of Hangchow comprising an area of about 980 sq. kilometers. It is surrounded on all sides except toward the east by hills of moderate elevation. In the east there is the plain of Hangchow. The present lake site formed most probably in former time a part of the Chientankiang from which it has been separated and to become a lake as a result of the silting of the Hangchow plain in the east. (2) Hsiang-hu located S. W. of the city Siaoshan is an elongated narrow lake trending from northeast to southwest. It is about eight kilometers long, with a maximum width of about 3.6 km. Its area is nearly doubled that of Hsihu. (3) Lakes in the north of Shaohsing are numerous, the most noted one is Tunghu 10 li east of the city. (4) A wide depressed area occurs north of Chuchi city; it is an important agricultural land on account of its fertile soil and abundant water supply. This area represents evidently a silted up lake, i. e. a lake in its old age.

Another important topographic feature is the coast line which in the province of Chekiang shows usually an irregular and zigzag outline and accompanied by numerous islands. The geology along the coast consists generally of volcanic rocks and intrusions. From the irregular and zigzag nature it appears at the first sight as if the Chekiang coast has been sinking during the recent geological time. On the other hand some observations made in the district of Chapu indicate in all cases a distinct rising of the coast. This is shown by the porous and cellular nature of limestone, the result of wave action, on hill top at 100 m or so above the sea level, Another evidence of the rising of the coast is shown by the existence of elevated sea cliff at many points along the coast. In order to explain the above controversy feature, it may be assumed that the coast of Chekiang has been sinking in former time (geologically also very recent) so that an irregular coast line was produced, but recently the tendency is more toward rising rather than sinking.

3. THE PHYSIOGRAPHIC STAGE

The physiographic stage of eastern Chekiang conforms in a general way to that of eastern Kiangsi[2] and may be divided as follows:

1. Hsianhsia stage:—This is an uplifted peneplain of post-Cretaceous age and represents so [illegible] ldest topography preserved. Its elevation reaches usually more than 1000 m above the sea level. The tops of such noted hills like Tientaishan, Kuatsangshan, Yentangshan all belong to this stage. Tientaishan

2 P. Kao: Geology of Yushan and Kuangfeng of Eastern Kiangsi, Bull. Geol. Surv. No. 23, 1933.

with an elevation of more than one thousand meters is characterized by precipitous cliffs and steep slope, yet when climbed over the top, one finds himself at once on a rolling hill of a fertile land, a typical view of peneplain topography. The same type of scenery may be seen on the top of Tientaishan, where besides a vast tract of cultivated land and sluggish streams, there exists also at thousand meters elevation, a lake basin, the famous lake of Yentang, from which the name of the hill is derived. From these features it can be seen that this uplifted peneplain or the Hsianhsia stage is even more developed in this part of eastern Chekiang than in western Chekiang or eastern Kiangsi. Nearly all these high tops are made up of Cretaceous volcanic rocks, and since no red beds existed the formation of this peneplain must be of pre-Tertiary and post-Cretaceous age.

2. Kantung stage:—This is characterized by wide valleys, basins or plains, a topography of advanced maturity. It involves two phases: an erosional phase by which basins, valley, etc. were excavated and in which the depositional phase has formed the wide spread red beds of Tertiary age. Its geological age started therefore from post-Cretaceous to the end of the Red Beds.

3. Chenhsien stage:—The red beds of early Tertiary age was again disturbed by the Nanling movement and on its tilted and eroded surface was laid down the basalt cap. As has been verified at several sections the contact between the basalt and its underlying red beds represents nearly a horizontal plain, in other words another peneplain of perhaps smaller extent existed prior to the extrusion of basalt; this erosion surface is herewith called the Chenhsien stage.

(4) Chukiang stage:—The formation of deep ravines and gorges cut in the basalt cap as well as older rocks is designated as the Chukiang stage. It is very probable that this vertical cutting is now still in progress.

4. STRATIGRAPHY

In the surveyed area, the Cretaceous volcanics constitutes by far the most abundant rock formation. Sedimentary rocks of Palæozoic age occurs only between Chuchi and Shaohsing. At northeast of Chenhsien and S. W. Chuchi a belt of metamorphic rock is exposed. The stratigraphical column in descending order may be given as follows:

Alluvium	Recent
Basalt Chukiang red beds	Tertiary

Granite intrusion Rhyolite Shaohsing tuff Hutoushan conglomerate Juao volcanics	Cretaceous
Feilaifeng limestone	Permian
Chienlikang sandstone	Devonian
Fengchu shale	Silurian
Limestone & shale	Ordovician
Metamorphic rocks	Pre-Ordovician

1. Metamorphic Series:—This series is composed of quartz-mica schist, hornblende schist, orthoclase gneiss, quartzite and marble. So far as can be seen from the field occurrence, the basal part of the series seems to be a gneiss then comes schist, quartzite and marble. The whole series is crossed by abundant quartz veins. The metamorphic series occurs only at two localities, namely, 30 km north of Chenhsien and 20 km southeast of Chuchi.

Near Sanchikou, Sintanghsien in western Chekiang the writer has found a series of quartzite and quartz-mica schist underlying an Ordovician limestone, so that the age of the metamorphic series is tentatively assumed to be pre-Ordovician.

2. Ordovician limestone and shale:—A complete section of the Ordovician rocks is exposed southwest of Ch'angk'ouchen, Fuyanghsien. From the top downwards, the section is roughly as follows:

1. Yellow shale with frequent intercalations of thin, fine sandstone containing Lower Ordovician graptolites: *Phyllograptus anna* Hall, *Tetragraptus bigsbi* Hall, *Didymograptus nitidus* Hall.
2. Thin bedded limestone with yellow shale.
3. Thick bedded limestone intercalated with siliceous sandstone.

A fault occurs above bed No. 3 so the latter is brought in direct contact with Chienlikang sandstone and Feilaifeng limestone.

Outcrops of Ordovician formation is also found between Shengshaowu 10 km N. E. of Chuchi and Lich'ushih and Huishatou 15 km S. W. of Shaohsing. The lower part is a thick bedded, impure limestone with siliceous sandstone, this grades upward into a thin bedded limestone and yellow shale, the succession being roughly comparable with the section southwest of Changkouchen just described.

3. Silurian shale:—This formation is represented in the surveyed area by only one locality i. e. northwest of Chuchi. It is composed of yellow and green shale forming low and gentle slope fringing the high hills of the Chienlikang sandstone.

In western Chekiang this same formation is more completely exposed and from which a number of graptolite fossils have been collected.

4. Chienlikang sandstone:—This formation is divisible of two parts, the lower part consists chiefly of green and purple sandstone with some sandy shale while the upper one is chiefly a quartzite. A layer of quartzitic conglomerate occurs sometimes at the contact of the two.

The principal outcroping area is at northwest of Chuchi forming there a hillock trending from northeast to southwest. Besides this, there are several scattered outcrops found for instance on both sides of Hsianghu lake in Siaoshan district and at Tzushan and Hsiungshan, southwest of Shaohsing.

The Chienlikang sandstone maintains both above and below a disconformable contact with other formations. At least a part of the formation is of Devonian age.

5. Feilaifeng limestone:—The only outcrop is seen near Tachiaoshih northwest of Chuchi, being unconformably overlain by the Cretaceous volcanic formations. It consists chiefly of a thin bedded siliceous limestone and with some bituminous shale in the bottom.

6. Juao volcanic series:—This marks the beginning epoch of the great Cretaceous volcanic formation in Chekiang and is represented by trachy-andesite, trachyte, andesitic, and trachytic tuff as well as thin flows of rhyolite. It is as a whole a volcanic formation of intermediate composition. It is overlain directly by the Hutoushan conglomerate, the latter showing a dip of about 40° and containing abundant pebbles of trachyte, trachy-andesite, etc. rocks evidently derived from its underlying formation.

The Juao volcanic series is distributed south of Shaohsing and between Sinch'ang and Tient'ai.

7. Hutoushan conglomerate:—This name was first proposed by Mr. H. M. Meng[3]. In the present investigation this same formation was found to be widely distributed in the districts Shaohsing, Chenhsien, Sinch'ang, Tient'ai, Chuchi etc. It is conformably overlain by the Shaohsing tuff and in some cases by the rhyolite beds which it maintains a distinct unconformable contact. Purple conglomerate

3 H. M. Meng: Geology of Shaohsin, Chuchi, Siaoshan and Chenhsien districts, Chekiang (in Chinese). Chikan, No. 10, Geological Institute, Academia Sinica, 1930, p. 64.

with pebbles of hard sandstone constitutes the chief rock, but agglomerate, tuff and thin beds of rhyolite are also frequently intercalated; at southeast of Tient'ai, a layer of andesite was seen to be interbedded in the conglomerate.

8. Shaohsing tuff:—This formation is widely distributed in Chekiang. Owing to its durability as well as regularity in bedding etc. the rock of this formation is now being extensively quarried for building stones and road material. Lithologically it is composed chiefly of light green tuffaceous agglomerate interbedded with felsitic lava flow. It is conformable with the underlying conglomerate formation but is distinctly unconformable with the overlying rhyolite.

The tuff shows usually a regular system of rectangular joint, this character combined with its rather gentle inclination will give after erosion a dissected rock column or pillar-like topography. The most remarkable scenery of this type may be seen at Yentangshan in Loching, Fengyen in Wenling and Tungshan in Huangyen. As to the thickness of the tuff formation it may be roughly estimated as 800 m at Yentangshan and 600 m at Shaohsing.

9. Rhyolite:—Unconformably overlying the tuff formation is the great rhyolite flow which has once covered the whole province of Chekiang and it was only after recent erosion that the older beds became exposed. The rhyolite maintains usually a very gentle dip, therefore it covers a wide area although its thickness may not be quite considerable; the maximum thickness may be only 500-600 meters in total.

Lithologically the rhyolite shows no important variation, except some slight change in texture; accordingly we may distinguish rhyolite, rhyolite porphyry and quartz porphyry. Two different colors i. e. a purple one and a light green one may be noted; the former belongs perhaps to the upper part while the latter to the lower part of the flow; on the weathered surface all rocks of the rhyolite group appears to be purple or purplish red. A beautiful columnar structure in the rhyolite was observed at Machienchen, Puchiang district.

10. The granite intrusion:—Although several varieties of granite may be distinguished, they represent nevertheless the product of the same intrusion. The largest body of intrusion is found at Tientaishan where it forms a typical laccolith; in other places as south of Tientai and north of Linhai the granite forms generally small intrusive body.

The granite is reddish in color, containing abundant quartz, orthoclase and some amount of biotite and hornblende. Small dikes of dioritic rocks are sometimes seen to cut across the main mass.

Some slight metamorphic effect may be observed in the rhyolite when it is in contact with granite. On the other hand at southeast of Juaoshih near the temple Tsingliangshih the granite has been to grade imperceptibly upward into the rhyolite flow. This last observation is very important as it may suggest an areal type[4] of extrusion of the rhyolite. This question can not at present be settled without careful and detailed study.

Although the writer was not able to see any direct contact between granite and red beds, from the general distribution and topographic relationship, it seems without doubt that the intrusion of granite took place before the deposition of the red beds; i. e. at the end of the Cretaceous period.

11. The Chukiang red beds: — In the surveyed area, red beds consisting of red sandstone and occasional intercalations of conglomerate occur near Tungyang and Yiwu, in the latter district some poorly preserved plant fossils have been collected from a yellowish green sandstone bed. On the whole the rock is soft and friable showing in most cases a bright color of purplish red. A thick layer of basal conglomerate is invariably present containing pebbles of older formations.

12. The basalt:—The basalt represents the youngest volcanic rock in Chekiang. It maintains nearly a horizontal position and is unconformable with all the older formations. The rock is dark black in color, vascular in structure, containing abundant olivine, and magnetite, some augite, and a small amount of basic plagioclase.

In the surveyed area the basalt is found near Chenhsien and Sinch'ang, N. W. and S. E. of Tientai and also in the districts of Tungyang and Yiwu. The remarkable hill Pamienshan S. E. of Tungyang, is made up also by basalt but in which a gabbro dike is seen to cut across. This hill may represent perhaps an old volcanic neck.

5. GEOLOGICAL STRUCTURE AND TECTONIC HISTORY

The important geological structure in Eastern Chekiang so far recognized may be enumerated as follows:

1. The Chuchi anticline:—This anticline occurs between Chuchi and Shaohsing with its axis trending from northeast to southwest. The anticlinal core is occupied by Palæozoic strata with Mesozoic volcanics dipping gently on both flanks. The anticlinal axis pitches towards northeast.

4 Daly, R. A.—Igneous rocks and the depth of the earth, 1933, pp. 141.

2. The Chenhsien and Sinch'ang anticline:—Between Chenhsien and Sinchang is another anticline but topographically it forms a narrow depression. Tuff conglomerate and tuffaceous sandstone occurs in the depressed axial region which is bordered on both sides by high hills of rhyolite and rhyolitic tuff. This narrow depression trends from northeast to southwest for about fifty kilometers long and has a maximum width of about ten kilometers.

3. The Tientai anticline:—This anticline forms also a narrow depression which trends in the same direction as the one just described. The depression has a total length of about 40 km. and a maximum width of about 20 km.

4. The Hengshan anticline:—An anticline occurs at Hengshanshih southeast of Chuchi with its axis trending from NNE-SSW. The axial region is occupied by metamorphic rocks while its both flanks by Cretaceous volcanics.

5. Yuanao anticline:—Another anticline occurs at Yuanao north of Chenhsien, where the anticlinal core is also formed of metamorphic rocks and two flanks of Cretaceous volcanics.

Tectonic history:—The tectonic history of Eastern Chekiang may be summarized in the following table:

Geological age	Principal activities	Correlation of Tectonic movement
End of Tertiary	Basalt Eruption	
Middle Tertiary	Tilting & Erosion	Nanling movement
Early Tertiary	Deposition of the Chukiang red beds	
End of Cretaceous	Granite intrusion Tilting & erosion	Phase 3 of Yenshan movement
Upper Cretaceous	Rhyolite eruption	
Cretaceous	Tilting & erosion Eruption of lava of intermediate composition and other pyroclastic material	Phase 2 of Yenshan movement
End of Jurassic	Intense tectonic movement	Phase 1 of Yenshan movement

Thus four periods of tectonic movement may be established in the tectonic history of eastern Chekiang. This conclusion are derived from the observation of unconformities at the following contact:

A distinct and widespread unconformity exists between the Hutoushan conglomerate and its underlying older formations. In the coal field of Wuchao in Yiwu district such an unconformity is especially marked; here the coal series shows a steep dip while its overlying tuff and agglomerate are quite gentle. This unconformity corresponds to phase one of the Yenshan movement.

The next unconformity though of much smaller extent occurs between the tuff formation and the great rhyolite flow. This corresponds to phase 2 of the Yenshan movement.

The third unconformity which is a very marked one occurs between rhyolite and red beds, the latter have filled basins, valleys etc. of a mature topography formed in post-Cretaceous time. Accordingly, the tectonic movement must have taken place at the end of Cretaceous time and corresponds to phase 3 of the Yenshan movement.

The last unconformity of no less intensity exists at the contact between the tilted red beds and the basalt cap, the latter remains practically horizontal. The tilting of the red sandstone may attain to as much as 30°-40°. This may be designated as the Nanling movement.

6. MINERAL DEPOSITS

Mineral deposits are very rare in the surveyed area, the following is some of the most important ones:

Fluorite:—Fluorite veins occurring in rhyolite are found in Yiwu, Sinch'ang, Chenhsien and Chuchi districts. They form usually fillings in contraction cracks which are perpendicular to the bedding planes. Quartz is the principal gangue. The fluorite mined is of two colors, a purple one and a green one. Those pieces showing a brilliant color and free from cracks are used principally as ornamental stones and may cost up to $160 per ton. The ordinary variety is mostly exported and is to be used as flux or for the manufacture of fluoric acid, its price varies from $8-30 per ton. The mining of fluorite is chiefly done by open cut method and requires therefore a very low cost of mining. A chemical analysis made by the Chekiang Reconstruction Bureau on a fluorite sample from Chuntsun, Yiwu district shows the following composition:

CF_2	95.49%
Fe_2O_3 & Al_2O_3	1.00%
SiO_2	0.65%
$CaSO_4$	1.30%
Loss on Combustion	0.60%

Manganese:—A vein of psilomelane occurs on the slope of a hill south of Tantantsun in Loching district. The country rock is a trachytic tuff. The vein of about 60 m long and with a maximum width of five meters is of the fissure filling type; with its strike approximately parallel with that of the tuff beds. The associated minerals are pyrite and galena. Five prospecting pits have been dug by a mining company.

Lead & Zinc:—Several veins containing pyrite, galena and sphalerite are found in the metamorphic rocks near Hengshan east of Chuchi. They have been once prospected by some mining companies but without success. The communication facilities are fairly good, the nearest distance to the railway station being only 20 km.

Pyrite:—Pyrite forming pocket deposit in the Feilaifeng limestone is found near Yitoutsun, N. W. of Chuchi district. The deposit is said to be fairly rich and now being prospected by some mining company. The communication is extremely convenient as it lies only 5-6 km from the railway station. Another pyrite deposit occurring above the contact of rhyolite and granite is found at Tatungshan, between Tientai and Sinch'ang. The communication is, however, extremely difficult.

A MICROSCOPICAL STUDY OF THE BAUXITE DEPOSIT IN THE TZECHUAN-POSHAN DISTRICT, CENTRAL SHANTUNG

By C. Y. Hsieh

1. OCCURRENCE OF THE DEPOSIT

In the Tzechuan-Poshan coal field of central Shantung, there occurs in the Permo-Triassic series a bauxite bed which varies from 2-4 m in thickness. The rock is brown to greenish brown in color, and is hard and compact. It is more resistent to weathering than its associated rocks so it forms usually a steep cliff or scarp on hill slope. One characteristic feature of the deposit is its oolitic structure with each oolite varying from 0.1 mm to 2 mm or more in diameter. The oolites are not uniformly distributed in the bed, certain layers being more rich in oolite while others are either less rich or composed almost entirely of massive material. According to C. C. Wang[1] there are two of such oolite-rich layers in the bauxite bed of Heishan; one is at the top about one foot thick and the other is near the middle with a thickness of about 2 ft.

The general geological condition of the bauxite deposit has been well described by C. C. Wang, so that no repetition is here needed. One fact which deserves special mentioning is its occurrence at the transition between a gray or greenish gray coal bearing series below and a purple, yellow sandstone or shale at the top. The latter series is most probably of Triassic age and represents perhaps a tropical or subtropical climate. The bauxite bed itself is associated with clay, sandstone of yellow or white color. In the section north of Houyou, Poshan district, a layer of white clay much used as porcelain material was seen; it lies about 10 m above the bauxite bed. This clay called Chiaopaotu by the local porcelain maker, is composed of a very pure and amorphous kaolin mineral probably halloysite.

The material for microscopical study was collected by the author in the spring of 1934 while conducting an inspection trip in the Poshan district with the students of the Geological Department, University of Peking.

2. MICROSCOPICAL DESCRIPTION

According to the microscopic examination of C. C. Wang, "the real bauxite is a transparent white to brownish colloidal mass amorphous with some crystalline

1 Wang, C. C., The Bauxite deposit of Poshan and Tzechuan districts, Shantung. Bull. Geol. Surv. No. 18, pp. 23-37, 1932.

acicular particles. Under microscope these particles give anisotropic nature (gibbsite?) distributed in the isotropic mass".

The present study of thin section and polished section has shown that the above description is by no means correct. The material studied (chiefly from Heishan) is quite fresh and compact permitting therefore the preparation of better thin section than that was possible by C. C. Wang; consequently it shows more detailed structure.

According to the present study the bauxite shale of Tzechuan-Poshan district is composed of the following three constituents, namely kaolinite, diaspore and an amorphous mass of brownish yellow in color, the last one forms the bulk of the whole deposit.

The brown amorphous mass is found both in the oolite and in the groundmass; it forms also the chief constituent in the massive variety of the deposit which shows little or no oolitic structure. In the oolite the brown mass shows frequently a concentric growth fairly displayed by difference in color as well as in transparency. Some layers are distinctly red indicating evidently the presence of abundant iron. Closely associated with the brown mass are kaolinite and diaspore which are to be spoken of afterwards. Owing to its amorphous character, the exact mineralogical nature of the brown mass can not be accurately determined. But since chemical analysis has shown a rather high aluminum content (both the picked out oolite and the shale show nearly a same alumina content) up to 59% or more, so it can not be an ordinary shale. Undoubtedly it represents the important constituent of hydrous aluminum oxide in the bauxite. This conclusion agrees with that of Watanbe[2] who considered also the brownish amorphous mineral as the essential part of the deposit.

The other constituents are kaolinite and diaspore, with the former more abundant than the latter. The kaolinite occurs in very minute crystalline aggregate showing a very weak birefringence. Its refringence is also low. (About 1.565 being higher than that of the Canada balsam.) It is soft and insoluble in acid and shows a distinct aluminum reaction before the blowpipe. All these characters indicate that it must be a kaolinite although distinct basal cleavages are not observed. The absence of cleavage can perhaps be explained by its minute size so as to approach a halloysitic type[3]. This kaolinite mineral was called by C. C. Wang as

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2 Kyukichi Watanabe. A note on the occurrence of bauxite shale in Shantung province, Jap. Journ. Geol. & Geogr. Vol. III, Nos. 3-4, p. 87, 1924.

3 According to recent investigation halloysite differs not much from kaolinite in chemical composition and can be considered as a finer grained or amorphous variety of the latter.

the real ~~bauxite[4] which~~ needs however revision in view of this new investigation.

Diaspore occurs usually as detached or aggregated fragments, scales or patches in both the bauxitic mass and kaolinite. It is characterized by high refringence (greater than 1.680 or more) and shows a bright interference color under the crossed nicols. Its optical sign is biaxial positive One direction of cleavage is fairly well shown.

Now it is more interesting to discuss the relationship between these three different constituents. The smaller oolite is usually more homogenous in composition consisting almost entirely of the brown amorphous matter with no or little admixture of the impurities. In the larger oolite, say of one to two mm in diameter the brown mass is frequently replaced by kaolinite and diaspore, the latter one seems to be the last one formed.

In the thin section it is possible to see all stages of replacement between the brown mass and the kaolinite. In fig. 2, Pl. I is shown three oolites of bauxite, fresh and homogenous in composition with one of them showing a small spot in the outer ring replaced by kaolinite. In fig. 1, Pl, II the oolite has been replaced at many spots in the outer ring by kaolinite; in the center of the oolite is shown also several small grains of diaspore, (not well distinguishible in the microphoto). The advanced stage of replacement by kaolinite is shown in fig. 2, Pl, II in which a greater part of the concentric rings of the brown mass has been replaced by kaolinite. In the extreme stage of replacement the entire oolite may be replaced by kaolinite such as is shown in Fig. 1, Pl. III (the white oolite to the left of the photo).

The later origin of kaolinite is further shown by its occurrence as filling of interstices between the oolite aggregate (Fig. 1, Pl. IV). In the massive variety of the bauxite shale, kaolinite may form also as irregular patches or veinlets to cut across the brown, amorphous matter.

Diaspore is less abundant than kaolinite yet in some oolite it may form quite a prominent part. That diaspore is of later origin as compared with kaolinite is clearly shown by its replacing both kaolinite and amorphous mass.

Sometimes a number of small oolite may be grouped together to form a big one attaining 3 mm or more in diameter. Such a texture is shown in fig. 2, Pl. III. These small oolites have been partly replaced by kaolinite and in their interstices are

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4 Most of the authors now agree to consider bauxite as a rock instead of a mineral; moreover bauxite is invariably amorphous so it should never be confused with the weakly but distinctly anisotropic kaolinite.

crystallized small grains of diaspore, thus giving another evidence of the younger formation of the latter mineral.

From the above microscopical description, it may be concluded that the bauxite deposit of Tzechuan-Poshan district is composed chiefly of brownish amorphous matter which has been partly replaced by kaolinite and diaspore. The formation of kaolinite from the aluminous compound is a process of silicification, by which two molecules of SiO_2 are needed. The source of silica is evidently to be sought from the impurities in the brown amorphous matter. Thus by kaolinization the remaining mass will be desilicified or in other words enriched in its aluminum content. As to the formation of diaspore it represents nothing but a process of dehydration and recrystallization of the amorphous aluminum compounds.

3. CHEMICAL ANALYSIS

The chemical analysis of the bauxite shale made by the Huanghai Chemical Laboratory at Tangku and the Geological Survey of China, Peiping are listed in the following table.[5]

Number	Localities	Al_2O_3	Fe_2O_3	Insoluble residue	Loss on ignition	Analyst
1	Upper portion of the bauxite shale at Hei-shan.	46.30	6.13	33.16	14.26	Huanghai Labora-tory.
2	Middle portion.	59.23	5.77	21.04	13.59	"
3	Lower portion.	51.79	5.23	29.08	13.82	"
4	Heishan	39.39	1.57	43.85	14.75	
5	Shihmiaoshan	59.13	2.73	22.74	14.95	"
6	Kingchishan	53.74	2.54	28.16	14.81	"
7	Separated oolite from Shihmiaoshan.	59.61	2.59	22.78	12.88	Geological Survey.

5 Quoted from C. C. Wang's paper.

Another list of chemical analysis[6] made on the samples collected by the member of the Huanghai Chemical Laboratory is given below:

	Al_2O_3	Fe_2O_3	TiO_2	SiO_2	Volatile matter $=H_2O$
Shihmiao-shan, ordinary sample	50.82	12.88	1.50	21.33	13.30
Shihmiao-shan separated oolite.	50.28	14.44	2.00	19.08	14.24
Hualuoshan ordinary sample.	51.64	13.01	1.50	20.22	13.54

From the above two tables it is clear that the alumina content of the separated oolite is not much higher than that of the shale mass proper and so it would be hardly explicable if we assume the oolite represents the pure and high-grade bauxite material. According to the present investigation, however, this would be the natural result, since the amorphous aluminous compounds and the impurities such as kaolinite etc. are almost equally distributed in the oolite as well as in the groundmass. In some cases the oolite may contain even more kaolinite than the groundmass or the massive shale, so that the latter may be more rich in alumina than in the oolite. Owing to lack of systematic sample and complete chemical analysis, this conclusion is still to be proved by future research.

Messrs. Chang and Hsieh[7], chemists of the Huanghai Chemical Laboratory have recently expressed the doubt about the nomenclature and would prefer to call the deposit a high-aluminum shale rather than a bauxite. This seems to be however quite unnecessary. According to the modern definition bauxite is a rock and possesses no definite chemical composition; it is an amorphous material consisting of different proportions of gibbsite and diaspore, which owing to fineness in grain and amorphous in nature, are not easily differentiated. Now in our deposit the highest alumina content may be as much as 59% which is too high to be called a shale. The following is given for comparison chemical composition of the three aluminum minerals (pure material) so commonly found in bauxite:

6 C. L. Chang & K. G. Hsieh (張承隆 謝光遜) 博山鋁石頁岩提煉鋁氧初步試驗研究報告第四號

7 Op. Cit.

	SiO_2	Al_2O_3	H_2O
Kaolinite	46.5	39.5	14.0
Gibbsite		65.4	34.0
Diaspore		85.0	15.0

From the above table we can see that our specimen possesses an alumina content nearly intermediate between kaolinite and the combined amount of gibbsite and diaspore. Although the exact proportion between kaolinite and the amorphous material has not yet been accurately determined, it may be roughly estimated as in the ratio of 3:7, in which the smaller portion is represented by kaolinite. Further complication in the chemical composition is due to the existence of pure and recrystallized diaspore which may only amount to 10% or less of the whole.

4. PRACTICAL SIGNIFICANCE

The result of the present microscopical study has some practical significance and which may be briefly discussed as follows:

a) Taking as granted the oolite layer as the bauxite-rich portion, so C. C. Wang has assumed a 75% deduction out of the total reserve, as the reserve of the rich bauxite. According to my study the richness of the alumina content can not be measured by its oolitic structure, it is quite possible that the entire thickness 2-4 m of the bauxite deposit may yield similar alumina content. This can of course only be tested out by careful sampling and elaborate chemical analysis. Should this supposition come eventually to be correct, then the actual reserve of the bauxite deposit should be considerablly higher than what was estimated by C. C. Wang.

b) The only defect of our deposit is its high content in silica reaching 21-43%. According to the present investigation the silica content is at least partly contained in the kaolinite. Therefore if certain process or means could be devised to separate kaolinite from the main mass, then the silica content of the ore would be considerably decreased. The microscopical structure and occurrence of kaolinite shows that it is not impossible to be separated. On the average the kaolinite aggregates reach a size of about 0.20-0.40 mm or more. Minute intergrowth of kaolinite and amorphous aluminum compound was not observed, therefore they may be well separated by fine crushing and grinding[8]. Now the method of separation is a problem to be soloved. The Huanghai Chemical Laboratory has worked out with

8 The Huanghai Chemical Laboratory has reached a conclusion that in order to concentrate the deposit by the dry roasting method the sample should be ground not less than 80 mesh.

success a dry roasting method with sodium carbonate and lime as flux. The writer wonders if other method such as flotation may be also used to advantage. Mr. C. F. Sze, metallurgical expert is intending to take up this experiment and I hope that before long he will be able to publish some of his experimental result.

5. SUGGESTION AS TO ORIGIN

The characteristic features which are important in the study of the origin of the deposits may be briefly enumerated as follows:

a) The deposit occurs as more or less regular bed between a Permo-Carboniferous coal series and a formation of red shale and sandstone of Triassic age. From the color and lithological character of the beds it may be inferred that the coal series represents most probably a moist and temperate climate, while the Triassic sandstone a dry tropical or subtropical one. The bauxite deposit itself lies just between the two, in other words it may be characterized by a subtropical and moist climate. Under this condition lateritization process could be easily proceeded.

b) According to C. C. Wang the thickness of the bauxite deposit is "almost uniform even in the whole extension of more than 30 miles, and the distribution of oolite is also as persistent as the bed". Basing on this evidence, C. C. Wang supposed that the bauxite deposit has been formed by the ordinary process of sedimentation. My own hasty observation has shown however, that such regular distribution is perhaps not the case. The thickness of the bed shows great variation from the north end to the south end of the entire belt. But even if we accepted C. C. Wang's conclusion as to the regularity and persistency of the deposit there still does not exclude the possibility that the deposit in question may be formed by residual process, since a length of 30 miles is after all not very extensive.

c) The absence of igneous rock either acid or basic prior to the bauxite deposition, excludes the possibility that it might have been formed from an igneous parent rock.

From the facts just stated, some suggestions as origin and mode of formation of the deposit may be given, although definite conclusion must be deferred until further research. It is suggested that the formation of the bauxite deposit in Shantung is essentially a climatic factor; under the favorable condition of moist and hot climate, any kind of rock may be weathered into a laterite, the latter when hardened and consolidated may give rise to a bauxite shale as we see it now. Whether or not the weathered product has been subjected to transportation and redeposited in water such as suggested by C. C. Wang is of course difficult to ascertain. But the formaion could also be easily explained without such an assumption since under surface condition of weathering, colloidal deposition of hydrous aluminum compound in oolitic or pisolitic structure is just as effective and common as under a cover of water. As to the later replacement by kaolinite and diaspore, it must be attributed to the action of ground water which took place perhaps long after the bauxite shale has been formed and consolidated. The older[9] geological age of the deposit seems to have provided sufficient length of time for the replacement and recrystallization of the amorphous material into grains of kaolinite and diaspore.

9 The bauxite deposit of Shantung of Permo-Triassic age seems to be the oldest of the world, as foreign deposits are usually of Cretaceous or Tertiary age.

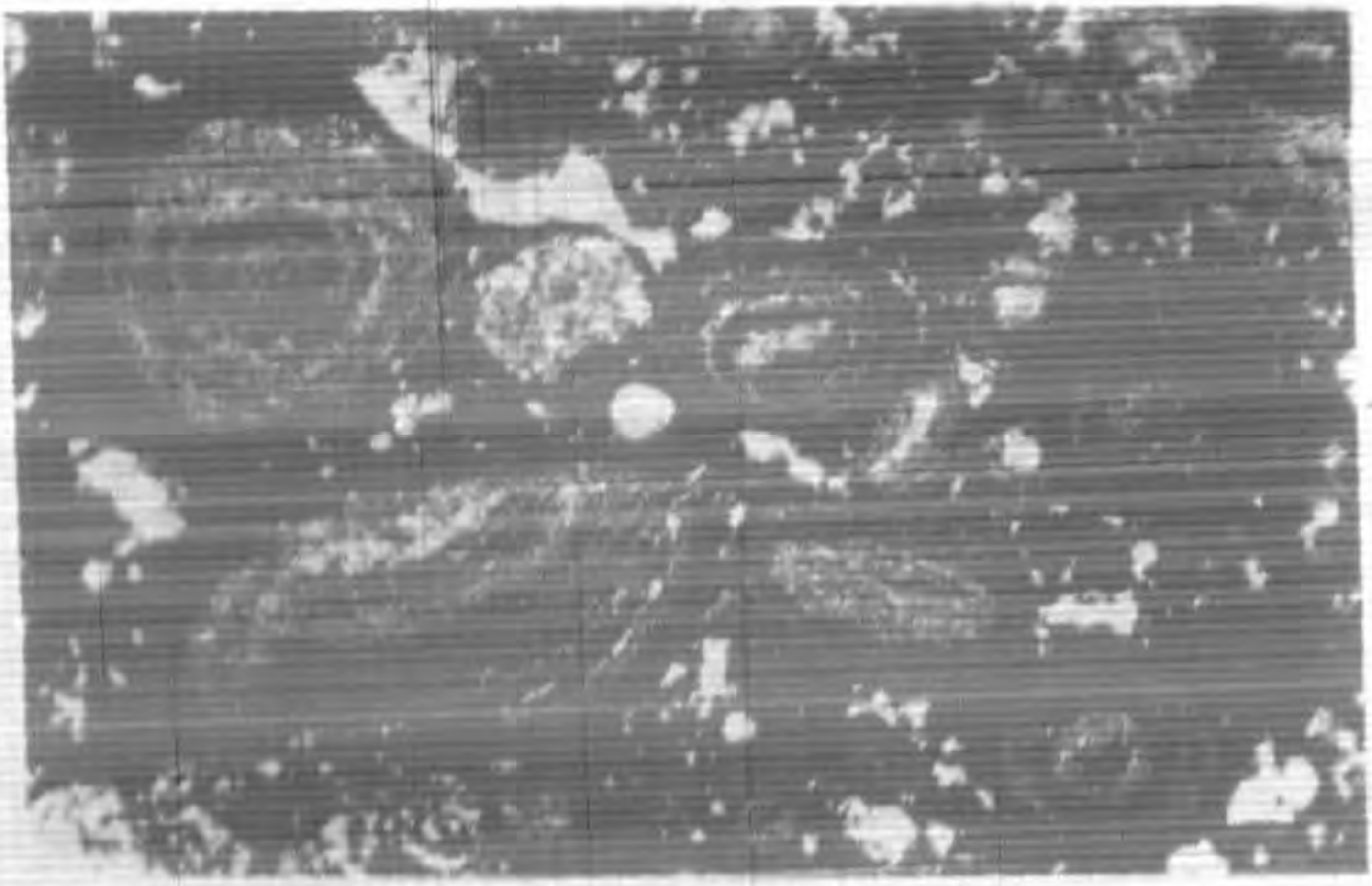

Fig. 1. A group of small oolites of bauxite embedded in a groundmass of the same material, which has been also replaced to some extent by kaolinite white color). × 25 ‖ N.

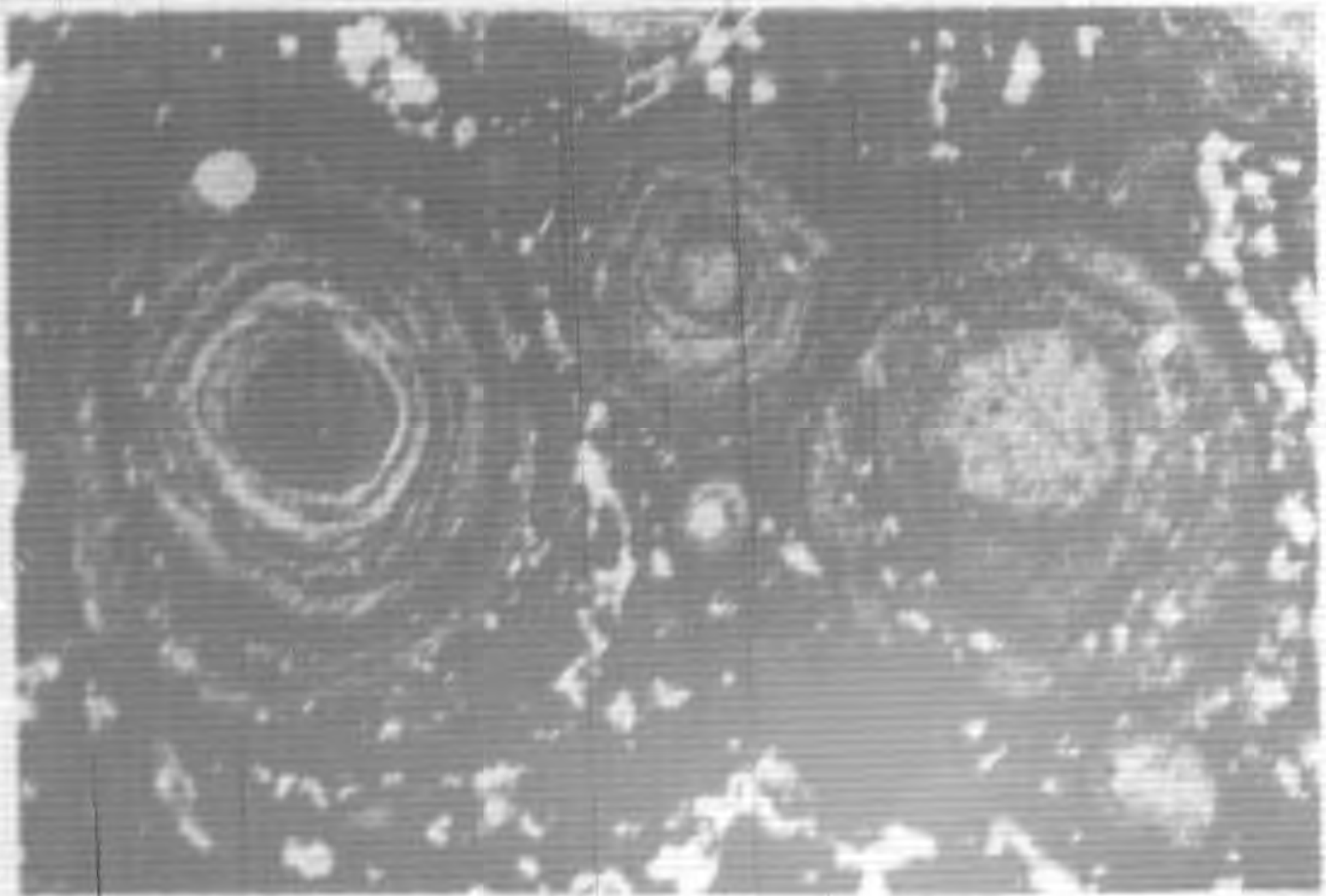

Fig. 2. Three oolites of the bauxite, fresh and homogeneous with only one of them showing a spot in the outer ring being replaced by kaolinite. × 25 ‖ N.

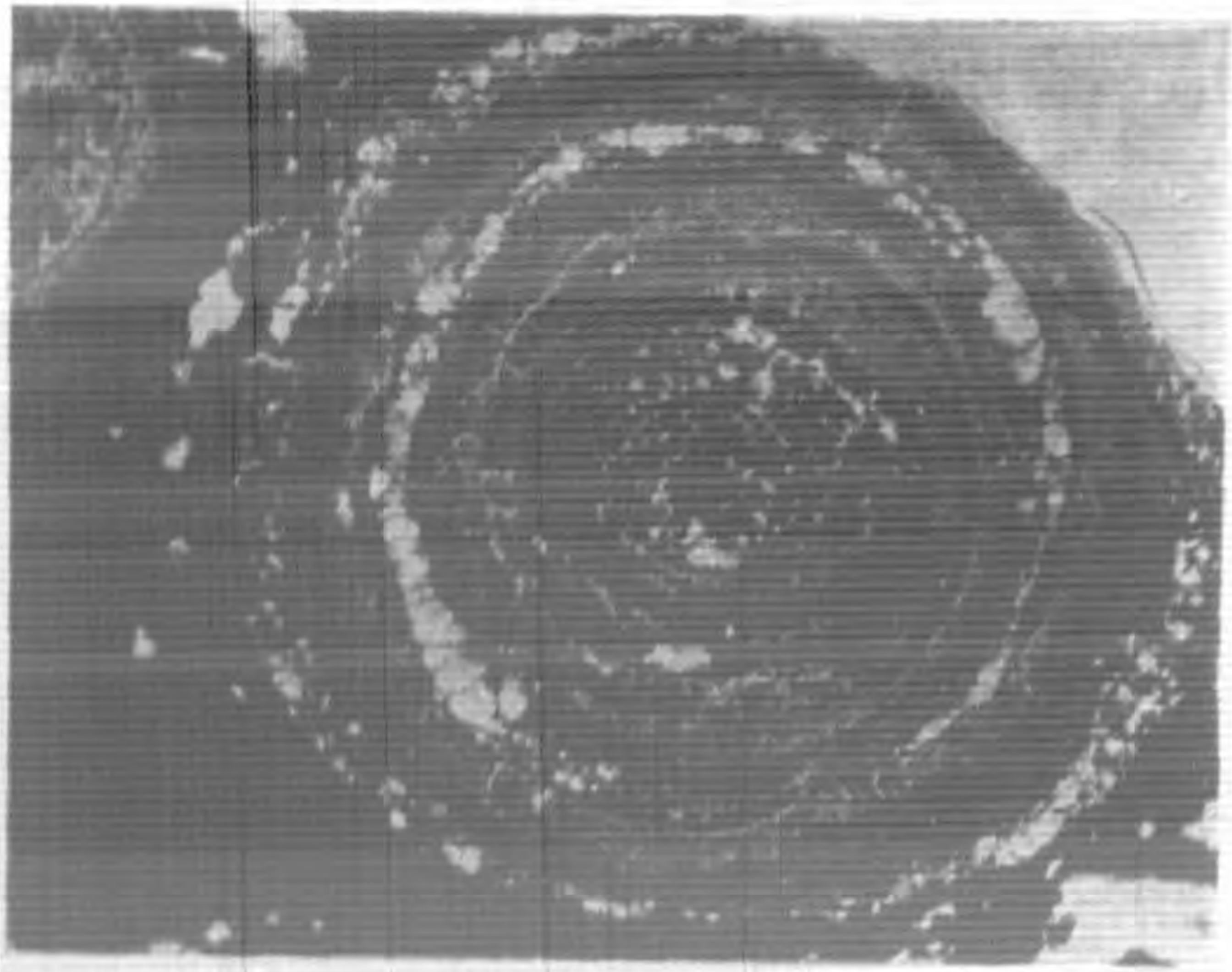

Fig. 1. A big oolite of bauxite with its outer concentric rings partly replaced by kaolinite. In the center of the oolite are small grains of diaspore ×28, ‖ N.

Fig. 2. Same kind of structure as above but the replacement is more advanced with the formation of larger kaolinite. ×43, ‖ N.

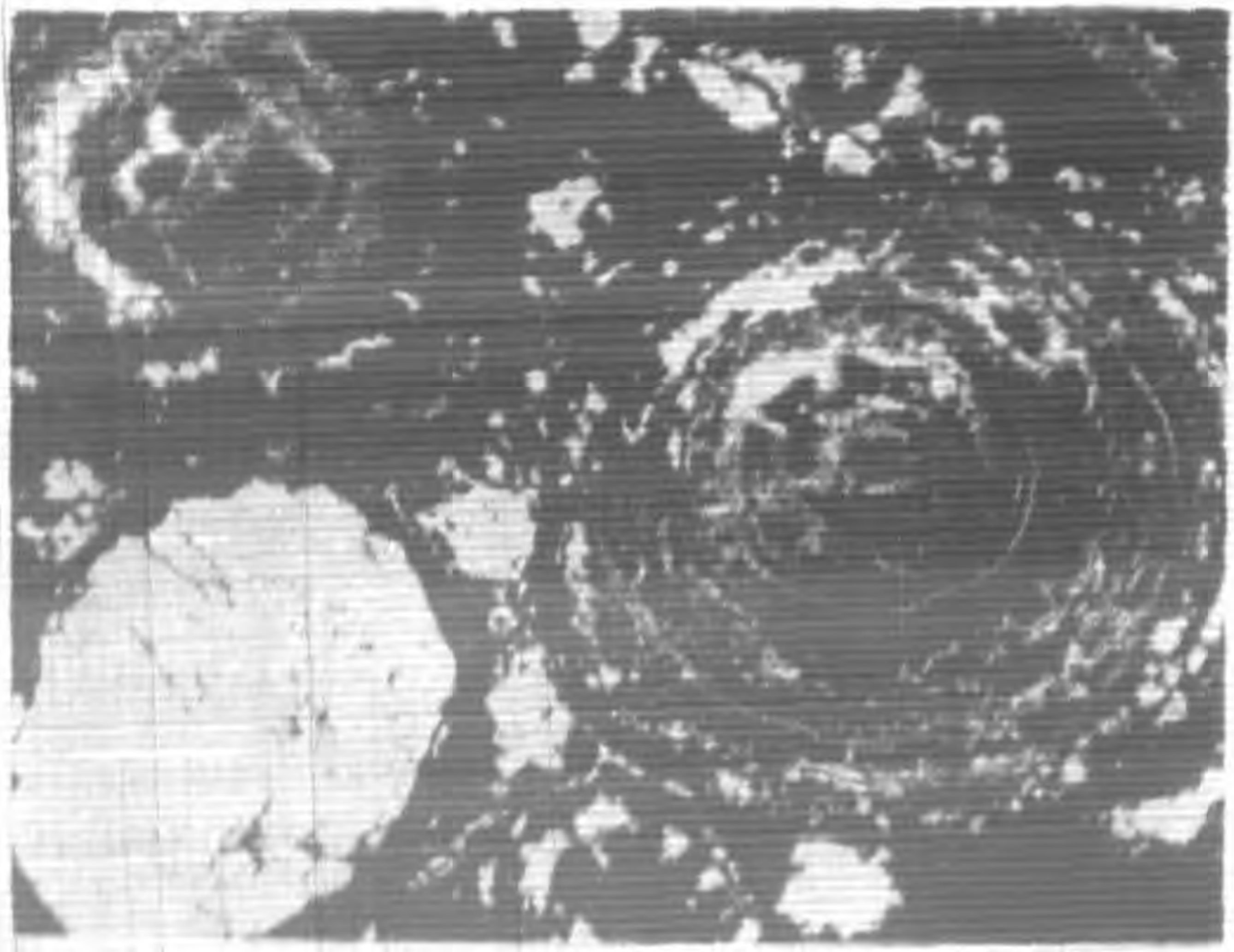

Fig. 1. Microphotograph of a thin section showing three oolites, one of which has been almost entirely replaced by kaolinite (white) while the other two are only slightly attacked on their border by kaolinite formation. ‖ N. × 25.

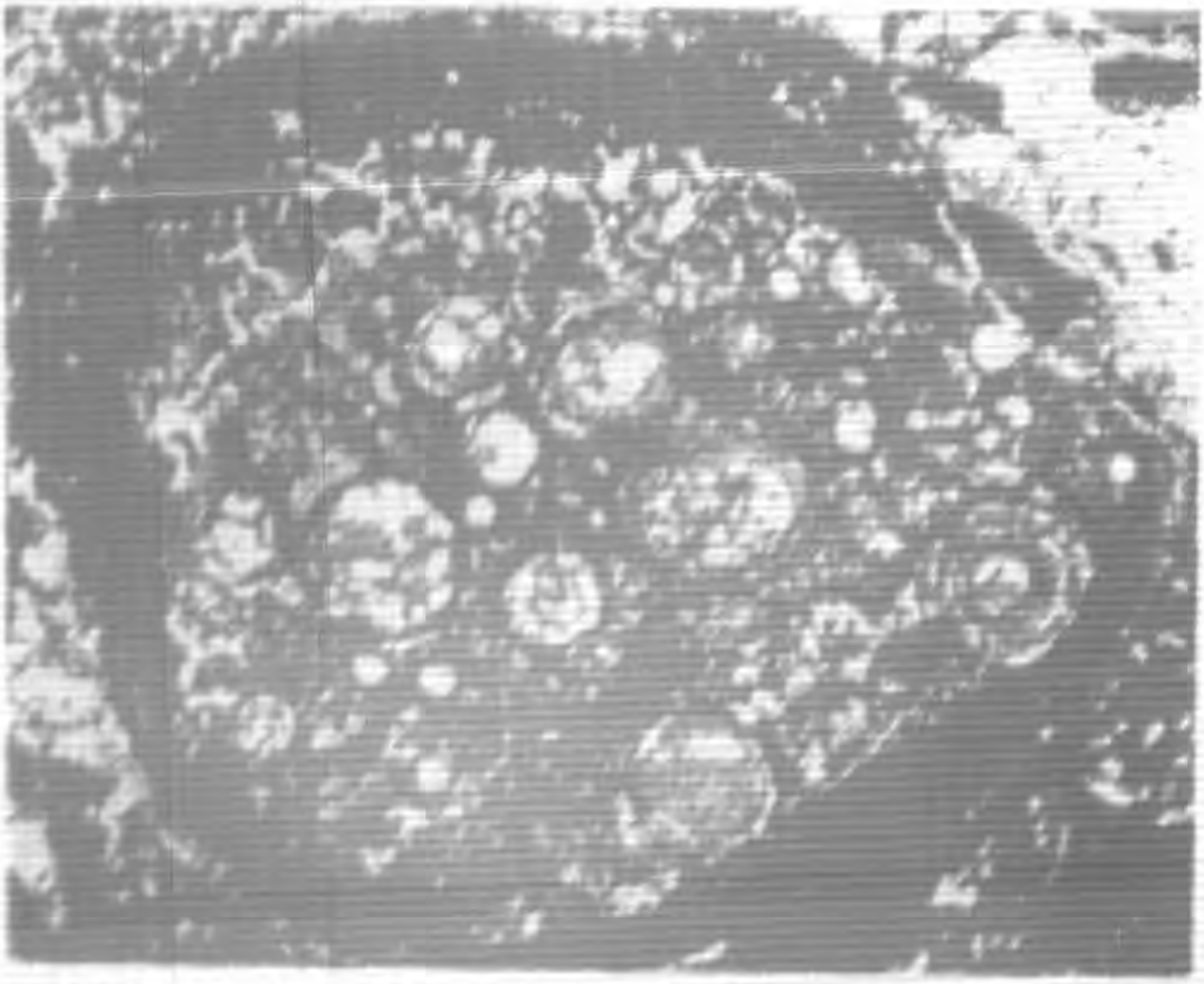

Fig. 2. A big oolite about 3 mm in diameter includes a number of small oolites. These small oolites are also partly replaced by kaolinite; in the interstices of the small oolites are crystallized small grains of diaspore (not well distinguishible in the microphotograph). ‖ N. × 24.