葉良才先生惠存

贈閱

兩廣地質調查所特刊 第七號

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廣州市附近地質

附地質圖一照片二十版插圖十二

民國十九年

兩廣地質調查所印行

廣州市附近地質

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圖版十插圖十二

廣州市附近地質目錄

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緒言

此次野外工作所用二萬五千分一之地圖(十二幅)係廣東陸軍測量局所製。此圖頗精審適用，惟白雲山一隅，地質情形複雜，乃改用一萬分一之地圖，亦廣東陸軍測量局所製。報告附刊之地圖，卽由前二種地圖縮製而成。工作開始，在民國十八年三月，由哈安姆張更李承三等共同進行。旋因戰事發生，未得完成。及至冬季，哈安姆僅能於每週之末，從事工作；而大部份則由承三調查。十九年三月，古力齊亦加入工作，專於研究本區東北部之火成岩。至五月中旬，始得工竣。時川邊調查團，限期出發。故趕編報告，殊多草率。幸得朱庭祜先生代爲整理出版，特誌於此，以表謝忱。

地理

廣州市，居民達百萬，爲中國第三巨埠，地居珠江冲積平原之北部。當第四紀時，海岸線下陷，故江口無三角洲存在。惟自虎門以南，有泥沙堆積。江之下流，向太平洋方面開展，在香港與澳門之間，寬達二五至三〇公里。平原乃由西江北江及東江冲積而成。東江之水，匯於北江，繞出廣州市之東側。試展二萬五千分一之香港廣州地圖視之，或乘飛機下瞰，則見河流交錯，宛成冲積平原，被溺小山，則鰲峙其間。但欲在本市附近之冲積層中，鑽探潛水，殊不可得。因紅色岩層，頗近地面。本市東南各處，往往見紅色岩層，隱約顯

露於冲積層之下。城市亦卽建於此岩層之上。似此當大平原下陷時，適與水平面相齊，僅山之高者，尙聳起於平原中。故紅色岩所佔面積，實較圖中所表示者爲廣。平原之上，又可分地形爲兩級：(一)紅色岩低山，除本區西北之虎頭岡滴水岩等山，高出平地一一七公尺外；其餘諸山，高不過五十公尺。(二)山之成於極耐侵蝕之石英岩及花剛岩者，則更高。本市之南，僅見孤山。本市之北，北江與東江之間，石英岩與花剛岩所成山嶺，高達三五〇至四〇〇公尺。較著者曰白雲山，高三八二公尺。然此種山嶺，關於地質構造上，無特殊地形之表現，主因則在侵蝕過深，流狀花剛岩多成圓丘，惟石英岩猶有削壁焉。山上均乏森林，最近芬次爾氏，曾爲試種，白雲山之北坡，已遍植松苗矣。

地層

據馮技正景蘭張技士會若之廣東粵漢鐵路沿線地質報告，白雲山純由頁岩，砂岩所成。大致向西北傾斜。作者開始調查時。意亦相彷，但經再三履勘，始知前日所認爲含坭質及雲母砂岩者，乃流狀花剛岩也。除石英岩外，白雲山實無他種水成岩存在。故曩日擬稱爲白雲山層者，實難成立。且馮張二君所稱之皇崗嶺系(註一)與本區岩層多不相符。本區中從未發見二疊紀石灰岩(韶關石灰岩)僅在紅岩系礫岩中，尋得石灰岩石礫。本市北北西約三十五公里軍田車站附近，始見二疊紀石灰岩在煤系砂岩之下。可知本區最古岩層，當較韶關石灰岩爲新。又在小坪西南尋得黑色頁岩一層，內含植物化石頗夥。經本所張席禔博士鑒定，屬中生界下部，蓋非二疊紀也。玆分較古之岩層爲二系。卽(一)水口系(二)小坪系。

水口系

水口村附近，此系岩層，甚爲發達，故名。該村在本市西北，約八公里。此岩成山數列，走向自西南至東北。下部爲紅色粘土頁岩，與砂岩灰色石英岩等相間成層，若就小部露頭觀察，頗難與紅色岩層區分。此岩之上，爲淡灰色石英礫岩及角礫岩，獅岡（剖面圖一）背斜層之西北翼最爲發育，造成一百五十一公尺高之展旗岡，向西北傾斜，斜度五十至六十度。展旗岡東北之大布岡，且有曾經紐褶及裂開之角礫岩，內含石英岩小礫與灰白色凝灰岩狀砂岩。此種砂岩於黃埔西西南三至四公里之地，亦曾發現。獅岡背斜層之東南翼，覆於石英礫岩及角礫岩之上者，爲紅，灰，及黃色砂質粘土頁岩等，又夾有一至十公尺之變質灰色砂岩。水口系上部，厚約二千五百至三千公尺。

五雷嶺高出水面二百五十五公尺，在白雲山之西北。流狀花剛岩之上，爲水成岩層所覆，此種水成岩層，卽爲水口系。其下部爲變質砂岩，含有石英粒，上部爲變質青灰色粘土頁岩（剖面圖二）。

水口系之石英岩及紅色頁岩，亦常發現于本區之南部，但在此系中，無化石之跡。

小坪系

小坪系與水口系之分界，以黑色頁岩爲標準。此岩爲本系之主要部分。其下灰色石英岩，雖不重要，但因不易侵蝕，亦常顯露地面。黑色含炭質粘土頁岩與砂質板岩露於小坪站西南二公里處（照片第五幅）褶曲殊烈，厚約五十公尺。新鮮者呈黑色及深灰色，風化後則微紫，棕紅，或諸古力色。植物化石，甚豐富，所

探得者，經張博士席禔鑒定有下列數種。

1. *Tacniopteris* sp. (?)
2. *Podozamites lanceolatus* (L. & H.).
3. *Pterophyllum* sp. (?)
4. *Asplenium Whitbyense* (?) Heer.

以上數種，均為中生界化石，而水口系與小坪系間，無間斷之跡，可知由二疊紀以至中生界為連續的沉積，中生界與古生界間之過渡層並不存在。含炭質頁岩中，常有質劣煤層，較諸二疊紀石灰岩，則為海水下退之表示。岩層以構造關係，變動甚劇，且露頭極小，不能得完善之層次。鐵質結核及黃色結晶之明礬，亦發現於此層中。小坪附近，常有掘煤廢址，然無一處足資開發。小坪系尚有灰色砂岩及石英岩，與紅色粘土頁岩及紅色含雲母砂岩共生。小坪之北，褶皺劇烈之含雲母長石砂岩中（與白雲山曾受侵蝕之流狀花剛岩極難區別）夾有黑色頁岩。砂岩每層厚約二十五公尺。

本市之北，沿公路一帶，直至小坪車站之東南，約二三公里許，岩層構造，更為複雜。侵蝕既久，乃呈灰色及紫色之粘土，露頭甚廣，且有成層之細黃土，極為美觀。作者初誤為紅色岩系，後據其變動劇烈，含有植物化石，故知為小坪系。惟此層與紅色岩系之接觸，尚未能定。

全系厚度，不易測定。下部黑色頁岩厚約數百公尺，上部約在千公尺以上，在白雲山之西首構成向斜層，

褶軸走向爲西南至東北。

小坪系與香港之沱羅水道層(下侏羅紀)(註二)孰先孰後,亦一問題。本區未見沱羅山頂之石英礫岩。沱羅水道南側,亦有黑色頁岩植物化石及煤系而本系之黑色頁岩極似亨利(Heanley)在牟斯灣(Mirs Bay) 之平長島 (Ping-Chan Island) 所發見者。亨利擬爲二疊紀,作者就所採化石而論認爲三疊紀。上部之灰色粘土或可屬侏羅紀。斯皆爲初次之揣論,須俟後證。

紅色岩系

本區紅色岩系不整合的居於較古水成岩或花剛岩之上,走向有時與較古之岩層成直交;但非斷層關係焉。紅色岩系發育於東亞各地,均被認爲第三紀產物,但無化石證明。依哈安姆之經驗,此系極似四川之紅岩系,或爲白堊紀產物,亦須後證。

紅色岩系沉積於較古山嶺間之窪地,其特性爲紅色粘土頁岩,常帶灰質,紅色與灰色砂岩,堅硬泥質礫岩與角礫岩,且有泥質凝結而多孔蓄水之礫岩及細砂;不可得見色紅帶紫四川紅岩系上部之紅磚色岩層(嘉定層,)則未發見(註三)。

紅岩系之下部

本市西北五至十公里許,平原邊界,該系直居於較古岩層之上。瘦狗嶺旁之山谷,露頭最爲明晰 (剖面圖三) 紅色岩系之底部,爲具有淡綠色條帶之淡紅粘土,厚約三公尺,與其下之石英岩爲整合接觸,均

傾向西南，石英岩傾角四十五度。粘土三十五度。此乃表明粘土沉積於傾斜緩和之坡面所致。粘土之上，無顯明接觸，繼續沉積者，爲不規則之石英岩角礫，粘結於紅砂質粘土中。厚約二十公尺，傾向西南，傾角約二十至二十五度。間有一處，角礫岩之上，爲砂岩結核，而無層面。凡此紅色岩系下部地層，均覆有五至十公尺厚之地面角礫岩，概現棕黃色。瘦狗嶺東之鷄籠岡，亦發見此層（剖面圖四）。但無紅色粘土，角礫岩與石英岩直接接觸。角礫岩厚自三十至五十公尺，其底部爲粗大角礫石英岩與少量之粘着物，上部則有數立方公尺大之石塊，此蓋由角礫岩漸變至紅色岩系中之礫岩也。其傾角無從測定。

紅色岩系礫岩

該系礫岩發育之區，分述如下：

廣州市之北

西村之北，粵漢鐵路穿過之馬棚岡，爲紅色岩系中礫岩組成。自南至北。露頭約長百餘公尺。礫岩層厚約半公尺至數公尺，與紫色粘土頁岩，相互而生。礫岩中之石塊，大都爲石英岩及較古之紅砂岩，最大者如頭顱，或帶稜角，或呈圓形。傾向北二十至二十五度東，傾角由五十五度至七十度。

廣州市之西

象岡東之虎頭山，純爲礫岩構成。厚約一百至二百公尺，傾向東南十度至三十度。粗礫岩之間，夾有淡紅礫岩狀砂岩。礫岩多爲玻璃質石英岩，紅，白，灰色石英質砂岩及石英斑岩（？）所成。石塊之大者，徑可半

公尺，虎頭岡西南一千公尺處。曾尋得二疊紀石灰岩片礫。

珠江之南

本市東南七公里處，新村赤砂間之老虎岡，花岡，七星岩等，形成一列，向西北東南延展。東至黃埔，概爲紅色岩系之礫岩。花岡爲堅緻角礫岩或礫岩狀砂岩構成。石礫大部爲圓形石英岩，紅砂岩（中生界至二疊紀）及塊狀花剛岩。據岩層傾向東北二十五至三十度計算，層厚約在五百公尺以上。該礫岩甚堅硬，且全由泥質及砂土凝結而成，似有鑽鑿水井之希望。

黃埔中正公園之小山，由紅岩系礫岩及流狀花剛岩構成。礫岩直接與流狀花剛岩接觸。岩塊除石英岩外，又有塊狀花剛岩，及流狀花剛岩。礫石大可二十至三十公分。此種流狀花剛岩礫石，即與礫岩下之花剛岩（剖面圖五）相當。

紅岩系砂岩

他處之砂岩層，多夾于粘土，泥灰岩，或礫岩中。而本區之西北隅，則砂岩獨著，構成滴水岩，通籠岩，崩口岡，黃慶山等山，風景絕佳。山頂之粗砂岩。色灰白或淡紅，現交錯層 (Cross-bedding) 傾斜幾成水平（照片第九幅圖二）。此岩一部分是長石砂岩其中含有少許石英及石英斑岩之石礫。山頂覆以眞紅土一層，底部爲紅色粘土。

第四紀沉積物及階段地

第四紀沉積物甚少，雖在圖中未着色部分，概屬此物；然沉積甚薄，似不重要。白雲山東麓扇形堆積物，多數爲石英岩塊，大至一立方公尺，且造成十公尺高之階段地，似屬洪積期所成。

沿沙河上下，細砂間有堆積。珠江一帶，則有樓色土舖及田間。北部山間小溪中粘性土多爲淡灰及白色，雜以黃色及棕色砂粒。凡此種種近代沉積物，除遷移未久之紅色土外，餘皆無紅色。

各岩石風化後，顏色各異：流狀花剛岩之邊際現深紅及微紫色。塊狀花剛岩，多爲磚紅及硃紅色。石英岩則爲黃色。而紅岩系則爲微紫。

間有數處，一層棕色土壤，覆於紅色土壤之上。如瘦狗嶺之北，有小路從紅色土壤中開出，在紅色土壤之剖面間，層次清晰，現傾斜角度。凡此皆足表示紅色土壤之沉積已較古矣。

作者對於第四紀沉積物，所知甚少，須加以鑽探，方能得其全豹也。

第四紀前期，除將較古地層侵蝕而留殘形外，作者曾在黃埔中正公園小山，發現階段地有二，(一)高出水平面約二十二至二十三公尺。(二)四十二至四十三公尺。

火成岩

當調查開始時，僅知本區中有塊狀花剛岩一種，迨哈安姆初次偕芬次爾氏至白雲山之北，始見有片麻岩一種，含雲母頗多，且具眼狀之石英及長石晶體。後經詳細勘察，始悉白雲山岩石，除去少量石英岩，概爲流狀花剛岩之侵入體。前所謂含雲母之淡紅色砂岩，夾於石英岩中者，乃受風化後之流狀花剛岩也。

流狀花剛岩

流狀花剛岩分佈甚廣，向東北展延，約在三十公里以外。南北亦不下此數，且不以此為限也。本區北部低山，均為流狀花剛岩所構成。其邊際（剖面圖十二）所受侵蝕，較塊狀花剛岩為甚，變成微紫及紫色之坭質含雲母砂粒。其中之黑雲母，侵蝕日久，變為白雲母。又在邊際，則流狀花剛岩低山，無大塊岩石遺留。然在其內部，則抵禦侵蝕之力，較強於塊狀花剛岩。本區內最高之山大圩嶂（四〇〇・五公尺）鳳凰山（三八二・二公尺），皆為流狀花剛岩所成。石英岩所成之白雲山（三八二公尺）次之，而塊狀花剛岩中之最高峯，如火爐山，僅三百二十四公尺耳。

故流狀花剛岩與塊狀花剛岩之界限，可從天然堦級上見之。二者接觸之處，則其抵禦侵蝕之力，較任何花剛岩為弱。故在山區中部之流狀花剛岩，常成圓潤之斜坡，而在接觸帶則塊狀花剛岩呈多數脈狀。流狀花剛岩，雜夾其間，如烏石山（二四二・一公尺）即其例焉。

片麻岩之視為流狀花剛岩，其理由如下：

（一）片麻岩中，夾雜有石英岩薄層及大小散塊。如白雲山東側路旁，即有此露頭。（剖面圖六）

（二）白雲山中曾有數處發見石英岩被片麻岩侵入。（剖面圖七）

（三）砂岩及石英岩等與片麻岩之接觸帶，常現接觸變質，如結晶砂岩粘板岩等，包含角閃石及赤鐵礦，在五雷嶺見之。

(四)就顯微鏡下研究,此岩結構,與花剛岩相同。黑雲母之分佈,略成平行,初未受若何動力上之變動。

再就化學成分而論,亦屬花剛岩,玆將本所化驗師薛君濟明化驗結果,錄之如下:

	流狀花剛岩	塊狀花剛岩
燃燒損失	一・〇五〇	一・二〇〇
矽養二	六二・二〇〇	六九・四〇〇
鋁二養三	一二・六七五	一三・三五〇
鐵二養三	七・八八五	四・四八二
鐵養	五・〇七一	一・六五二
鈣養	三・八七五	二・八二〇
鎂養	〇・八二五	〇・六三四
鉀二養	三・三九〇	三・二〇〇
鈉二養	三・四一二	三・四九八
總結	一〇〇・三八三	一〇〇・二三六

以上兩分析,適符于照片第三幅之第一圖。

流狀花剛岩又可分為兩類。分述如次:

(一)含有白色及淡紅色之長石(白色正長石及斜長石)石英及多量黑雲母,在龍眼洞東北之瀑布附近,最爲發育。(照片第三十四幅圖一與二)

(二)含有白雲母(漂白黑雲母,) 或無雲母,間有針狀角閃石,此種發見於白雲山之西,侵蝕後與花剛岩質砂岩不易分別。

論此岩之組織,則種類殊多。如白雲山之北側呈塊狀組織,但範圍不大。通常則爲水成或火成片麻岩,含有長石及石英之眼球狀晶體,及白色與黑色條紋,褶皺殊烈,頗現美觀。就肉眼之觀察,酷類片麻岩之在深處受高熱及高壓力所成者。

塊狀花剛岩

塊狀花剛岩常成內侵岩基及多數岩脈。白雲山北側山路之上,老虎膌之下,有一小岩脈露頭,即其例焉(剖面圖八)。岩中晶粒,大一至二公厘,係完全結晶,近接觸處,亦不減小(剖面圖九)。

本區東北塊狀花剛岩體之中部,長石之大,可達數公分,色多白與肉紅,單晶體與雙晶體均備。在花剛岩之中部,雲母甚少,邊際則黑雲母甚多,此或由泥質水成岩中鎔吸而來。塊狀花剛岩之風化物與流狀花剛岩所成者,極易分辨。在本區域內,塊狀花剛岩風化之後,大抵成爲坭質含有石英小粒,且有未經風化之圓塊,半埋半露於此土壤中。廣州及香港之建築石材,多取給於此。火爐山及大嶺之山坡山巔,圓石累累,極爲美觀,此皆侵蝕之結果也。

石牌之北，十字岡附近，爲塊狀花剛岩發育之區。侵蝕甚劇，深溝頗多。

用望遠鏡觀察火成岩諸山，有黑色圓塊者，多爲塊狀花剛岩。有稜角者，乃流狀花剛岩也。

石英斑岩偉晶花剛岩及石英岩脈

石英斑岩　石英斑岩含有石英，長石及白雲母，顆粒適中。大都侵蝕頗劇，無新鮮者可見。其侵蝕後結果，成爲石英及白雲母細粒，雜於綠色泥土中。侵蝕過甚者，僅存石英，且綠色消滅，頗難與其他岩脈相分別。故在地質圖中凡百岩脈，着爲一色。石英斑岩脈，雖有能保持其岩石特性，穿侵甚遠者，如火爐山南之岩脈是。但多數則漸變爲偉晶花剛岩或石英岩脈。

白雲山巔之西北坡，發見一厚約五十至一百公尺之直立岩脈，穿過流狀花剛岩（照片第一幅圖一），此岩係白色石英斑岩逐漸變爲微晶花剛岩，含有紅色正長石及少量黑雲母。

偉晶花剛岩　偉晶花剛岩脈與石英岩脈常互相轉變。偉晶花剛岩，含多量石英，其他礦物甚少，正長石往往爲完美晶體，長可數公寸，白雲母之小晶體（徑約一公寸）結爲巨塊，或大晶體（徑約六公寸）而成小結合。此岩侵蝕之後，則成砂土含石英粒及白雲母片。

石英岩脈　此岩脈幾純爲白色石英所組成。侵蝕之後，大塊石英暴露地面，排列成線，土壤中含石英晶粒。橫頭嶺（六六・五公尺）之石英脈，含有少量磁鐵礦及鉍華，石英內之方孔，多填充以海綿狀之磁鐵礦。

岩脈穿過母岩，甚是繁複（參看地質圖）。識別岩脈於風化土壤中，石英晶體最多之處，卽岩脈所在地。石英不易侵蝕，故造成山嶺或山脊。純粹石英脈，則獨立而為石壁。

流狀花剛岩中多有長英岩內侵體或岩脈，厚可數公分。流狀花剛岩之節理中，曾見有黃鉄鑛。本區之北邊，水聲下瀑布之北，有極薄之過鹽基性岩脈（The Vein of Ultrabasic rock）穿走於長英岩脈中。出水龍附近，尋得同類岩石，暴露地面，當亦為岩脈所在焉。此種暗灰綠色岩石，時含有磁黃鉄鑛。

流紋岩

流紋岩僅見於本市東南三公里許五鳳村旁之陳山及葫蘆岡。此岩從地內流出，斜向東北，傾角約三十度。晶體大小適中，有石英與長石，黑色鑛物，不能以肉眼辨認。此岩色微紫，露頭為二小山，獨立平原中，故其與他種岩石之關係，殊難判定。若依作者等在香港研究之結果，則其噴出期，約在第三紀。

構造

本區地質構造動力發生，可分先後二期。

1. 第一期地質構造，包括水口系，小坪系及花剛岩，但未及于紅色岩系。
2. 第二期則影響及於紅色岩系。紅色岩系之構造，有數處顯然為第一期造山運動所持續。有數處則新舊褶皺不相一致。紅色岩系與古生地層構造一致，曾於廣九路北首見之，紅色岩系之底部居于石英岩之上，向同一方面傾斜，其傾角較小十度至二十度（照片第七幅圖二）。又紅

色岩系與較古地層構造不一致之處，則在市之東北，紅色岩系之走向，與花剛岩石英岩所成山脈相直交，(由白雲山麓向西南直抵城市)市之北亦然。他若廣州市之西北，紅色岩系走向，亦有與水口系相同，者但傾斜方向則相反。

第一期地質構造

此期構造，可分為兩類，(1)有褶皺而無花剛岩侵入者，(2)有褶皺亦有花剛岩侵入者。

(一)有褶皺而無花剛岩侵入者

珠江北支斜切諸山，概屬此類。白雲山西首，寬約十公里之地，似有一大褶皺，造成獅岡背斜層及佛嶺市向斜層(剖面圖一)。

獅岡背斜層　獅岡背斜層之西北翼，傾向西北，傾角五十至六十度，純係石英角礫岩。其中心有紅色粘土頁岩，走向西北，傾角垂直，適與背斜層走向成直交，此為部份斷層及扭曲之所致。獅岡西南隅大橫馬一帶，岩層傾向複雜，斷層甚密。沿獅岡背斜層山脊，或均有斷層，亦未可知。紅色粘土頁岩，在背斜層谷之兩旁見之，但西北翼較薄耳。背斜層之東南翼較為整齊，傾向東南，傾角六十至七十度，角礫岩亦不存在。

佛嶺市向斜層　小坪系所在地，褶皺甚劇。就大構造而論，石井，鶴邊，大圃一帶岩層傾向東南，平均約七十度，白雲山西陳田，蕭岡一帶岩層傾向西北約五十度，造成西南東北走向之佛嶺市向斜層。

本市南三山，大山，大石，員岡一帶，岩層一致傾斜西北，傾角平均由二十至三十度，此或一背斜層之北翼

也。

(二)有褶皺亦有花剛岩侵入者

白雲山爲此種構造之代表，有石英岩與花剛岩兩種。流狀花剛岩經侵蝕之後，頗難與水成地層相辨別。作者再三查勘，疑問仍不能免。始以石英岩成向斜層由雲岩寺起，向北轉折，成一環形（照片第一幅圖二）。但此層之上下，均爲流狀花剛岩，石英岩層不相連續，而包含於流狀花剛岩之中。且自雲岩寺而北，厚約七十公尺之石英岩，計有二層，與流狀花剛岩交互而生（剖面圖十）。白雲山之最高峯曰摩星嶺（三百八十二公尺高）山巔爲石英岩，稍下爲流狀花剛岩，再下爲厚由十至十五公尺之石英岩，更下爲新鮮流狀花剛岩，具眼球狀石英及長石晶體，多黑雲母。流狀花剛岩片理常與石英岩層理相符合，極易誤認爲水成岩（照片第一幅）。摩星嶺北之老虎脯，亦與此現象同，石英岩緩和東傾，流狀花剛岩夾疊其間（照片第一幅）。

據上現象及剖面圖觀察，白雲山係成於流狀花剛岩之侵入當岩漿經過石英岩及他種水成岩時，接觸之處，泥質岩石多熔化於岩漿中。同時而第一期地質變動發生。

第二期地質構造

此期變動地區，即爲紅色岩系與其下岩層之接觸帶，已表明於第二幅地形照片中，紅岩系低山五十公尺之下，石英岩五十公尺之上，乃接觸帶之界限。瘦狗嶺山麓，露頭甚著，（照片第七幅）石英岩傾向西南

或南，傾角四十五度，紅色岩系傾向珠江，紅色岩系向斜層谷，傾角較小十度至廿度，此接觸帶由東（長崗，雞籠崗）向西，至沙河微向北，沿白雲山脚至觀音山及中山紀念堂，成一曲臂形，實爲珠江紅色岩系大向斜層之邊際。海珠公園岩層傾向西南，省黨部處則傾向東北，廣州市實建在紅色岩系次生背斜層之上也。

內侵花剛岩之動力作用

本區東北諸山，均爲花剛岩構成，而此岩基可分爲三帶：

（一）邊際帶　此帶發見於白雲山，直立或平行之內侵流狀花剛岩，夾以石英岩塊，卽爲特徵。塊狀花剛岩及石英斑岩尚少發現，

（二）塊狀花剛岩　白雲山之東北麓，塊狀花剛岩在邊際帶流狀花剛岩之下，二者接觸，多爲直立。近接觸處之塊狀花剛岩含黑雲母頗多，頗類流狀花剛岩。

（三）流狀花剛岩　流狀花剛岩之內部，不夾水成岩及任何岩塊，惟塊狀花剛岩在接觸處，時侵入其中。流狀花剛岩所成之傾角，約由四十至五十度（平面圖十一剖面圖十二）流狀花剛岩有作楔形者，夾於塊狀花剛岩體中。

茲假定塊狀花剛岩岩基侵入於已具褶皺或正在褶皺之二疊紀與三疊紀水成岩中，則岩基之邊際帶與水成岩之泥質起化學作用而熔解（接觸處多黑雲母，或卽因此）熔解冷卻之後，熔液減少，故凝結岩

漿，仍保持其流動狀態。內部較熱岩漿再向邊際侵入，而成兩旁小侵入體（平面圖十一）。在此過程中，塊狀花剛岩漸離邊際帶而爲流狀花剛岩之中樞。因此岩漿分離作用，頂部先凝結者，成爲楔形，浸埋於塊狀花剛岩中。此兩種花剛岩係火成接觸，流狀花剛岩之組織非完全與接觸面一致，其傾斜角常較陡。然二者時期相差不多，故可稱流狀花剛岩，爲塊狀花剛岩之邊區也。

岩脈生成均較花剛岩爲後，而以生於長英岩脈中之過鹽基性岩脈爲最幼。各岩脈之走向，大致爲東西；但若詳細研究，亦不一律，（圖十一）岩脈在山頂常較寬，山麓較狹，此或因岩基自深處擠出，上部膨漲，而爲原生節理之現象焉。又岩脈有橫過二種花剛岩之接觸帶者，是其侵入時期，必在二者凝結以後。

地史鱗爪

本區地質史，以二疊紀爲最古。極厚之水口系岩層，有角礫石英岩，礫岩及紅色粘土頁岩，而無化石。紅色粘土頁岩，爲熱而半乾燥氣候所沉積之物，與後來之紅色岩系相同。

小坪系中，紅色粘土頁岩漸不重要，而易以黑色炭質頁岩。含有植物化石及煤層。上部以柔細粘土爲主。此類沉積，係成於一大陸盆地中。

當小坪系沉積之後，第一期造山運動開始，流狀及塊狀花剛岩內侵亦同時發生。凡此褶皺與內侵似較後於小坪系而早於紅岩系焉。據作者在香港考察之結果，此造山時期，屬於上侏羅紀，與翁文灝先生所說之燕山期相當（註四）。

第一次造山運動之結果，可於紅色岩系底部所含之角礫岩，礫岩，見之。其中礫石均來自較古之石英岩及花剛岩。而紅色岩系與諸較古岩層之不整合，亦一明證也。

香港及廣州紅色岩系之特性極似四川之紅岩系，成於下白堊紀之淡水盆地中，有白堊紀化石。著者比較觀之，本區紅色岩系，似應屬於白堊紀。

紅色岩系沉積於較古向斜谷，得成厚層。當時氣候，似屬暖而半乾燥性。沉積物均由近地取得。例如黃埔之礫岩，含有流狀花剛岩石子，與本地流狀花剛岩相同。在本區東北，紅色岩系之最先沉積物，非石英角礫岩，而爲極細半黏性粘土。

白堊紀之終，或第三紀之始，第二期造山運動發生。廣州香港之紅色岩系，均受其褶皺及掀動，是爲阿爾波斯山期 (Alpine movement)。因注意於阿爾波斯山期與燕山期之比較，作者曾細察各處露頭。如黃埔中正公園小山之紅色岩系礫岩，向北傾斜，傾角爲七十至八十度(剖面圖五)。由此向東北三公里，傾角雖減小，然仍有四十五度(照片第四幅圖一)。粵漢鉄路東側西村之北，紅色岩系礫岩傾向北二十五度東，傾角六十至七十度。此類傾斜，不能視爲斷層所致，乃平行壓力之結果也。紅色岩系之傾角，通常爲二十至三十度。而幾成平台，或未受變動者，則在本區西北部滴水岩，崩口岡，諸山見之。

據各方面觀察所得，及較古岩層侵蝕之狀況，可以推定現在地形，大都由於阿爾波斯山期造山運動所成。紅色岩系與較古地層爲不整合，其褶皺方向甚不規則，使研究廣州地質，欲求一阿爾波斯褶皺軸，幾

不可能。顧其主要走向爲西南至東北耳。廣州市之阿爾波斯山期造山運動如此劇烈，出乎作者意料之外。廣義言之，中國南部諸大山脈，或多屬此時期所造成。海南島之地質構造，適同於此。

當阿爾波斯山期運動發生之際，河流侵蝕亦開始，紅色岩系成爲侵蝕平原。然後中國南部沿海地區，多溺於海；而侵蝕平原下降，幾至海平面。

黃埔中正公園階級地，爲河床之遺痕，此爲暫時的上升，或爲其原生位置，尚難決定。斯則須再加研究者也。

（註一）馮景蘭 張會若 廣東粵漢鐵路沿線地質鑛產 兩廣地質調查所年報第一卷

（註二）哈安姆 香港地質報告 兩廣地質調查所年報第二卷上冊

（註三）哈安姆 四川自流井報告 兩廣地質調查所特刊第六號

（註四）翁文灝 地質學會誌一九二九

Fig. 1

Fig. 2

Plate X.

Fluidal granite at water fall NE of Lung Yen Tung.

Fig. 1.

Showing aplitic and more basic streaks, also fluidal folding (upper left, and lower right corner), as well as flexure in upper part. Phot. K. Krejci, 22 May, 1930.

Fig. 2.

Fluidal folding designed by the biotite scales. See also oblique fault passing through middle part of picture. Size in both figures shown by hammer. Phot. K. Krejci, 22 May, 1930.

Fig. 1

Fig. 2

Plate IX.

Fig. 1.

Red Bed conglomerate of Hu Tou Kang (Tiger Head) 102.3 m, in NW part of map. Compare fig. 1 in text. Dip towards SE, looking NE. In left back ground Lao-Ya-Kang Plateau around 100 meters, of Red Bed sandstone, in NW corner of map. Phot. Arn. Heim, April, 1930.

Fig. 2.

Red Bed sandstone with crossbedding, top of Lao-ya-kang. Phot. Lee-Chêng-San, 1930.

Fig. 1

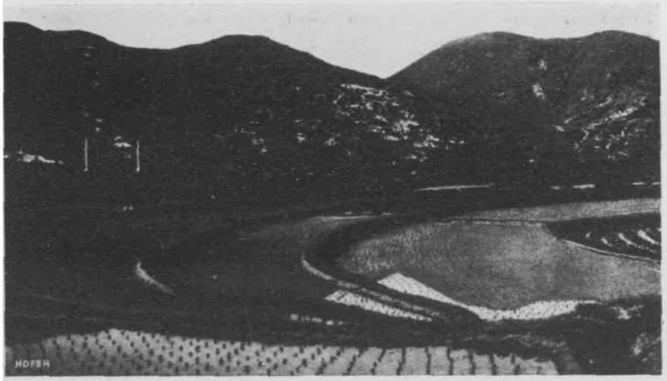


Fig. 2

Plate VIII.

Fig. 1.

Pai Yün Shan (= Peyünshan) seen from water tank tower of Canton-Tungshan, looking north. In foreground artificial terraces with rice and taro, all on Red Beds; in back ground granite with quartzite, deeply weathered. The highest visible point is 364 m. Phot. Arn. Heim, December 1929, late evening.

Fig. 2.

East side of Pai Yün Shan (= Peyünshan) 2 km N of Sha Ho, showing characteristic landscape of deeply weathered fluidal granite, in which are dug the numerous tombs; in foreground rice fields. Looking towards N. Phot. Arn. Heim, April 22, 1929.

Fig. 1

Fig. 2

Plate VII.

Normal contact of quartzite (Permo-Triassic) with Red Beds, S side of Shou Kou Ling.

Fig. 1.

Showing the details, with the ice-axe fixed in the Red Bed clay parallel to its stratification. Dip of Red Bed clay 35°, of underlying quartzite 45—50° to SW. Phot. Arn. Heim, 18 May, 1930.

Fig. 2.

Same place from farther distance, showing the subrecent rust-red surface soil with quartzite fragments on the top of the basal Red Bed clay. Phot. Arn. Heim, 18 May, 1930.

Fig. 1

Fig. 2

Plate VI.

Fig. 1.

Weathering and erosion of massive granite after deforestation. University site, ENE of Canton, looking towards west, in opposite direction as Pl. III, fig. 2. All on this figure down to the deepest crevices is completely decomposed granite. Phot. Arn. Heim, May, 1930.

Fig. 2.

Quartzite breceia of lower Shuikou series, on hill 67,8 m, NW part of map, looking towards N. Much disturbed and faulted region. In middle-back ground the pond which is situated on the fractured anticline of Shih Kang. Phot. Arn. Heim, May 25, 1929.

Heim, Krejci, & Lee — Geology of Canton

Fig. 1

Fig. 2

Plate V.

Fig. 1.

Hsiaoping shale, hill SW of Hsiao Ping station. Best place for collecting lower mesozoic plants in the black sandy slate. Phot. Arn. Heim, 12 April, 1930.

Fig. 2.

Ditto, showing efflorescence of yellowish crystals of alum, with the discoverer of the fossiliferous locality, Mr. Lee Chêng-San. Phot. Arn. Heim, 12 April, 1930.

Fig. 1

Fig. 2

Plate IV.

Fig. 1.

Conglomeratic Red Bed sandstone, 3 km NE of Huang Pu (= Wampoa) N side of Pearl River, showing 45° dip to N 55° W. Geol. excursion with students, phot. Arn. Heim, 2 March, 1930.

Fig. 2.

Lower basin of waterfall of Lin Fo Shü, 5 km ENE of Lung Yen Tung 17 km NE of Canton, showing the best exposures of fluidal granite. Phot. Arn. Heim, May, 1930.

Heim, Krejci, & Lee — Geology of Canton

Fig. 2

Fig. 1

PLATE III.

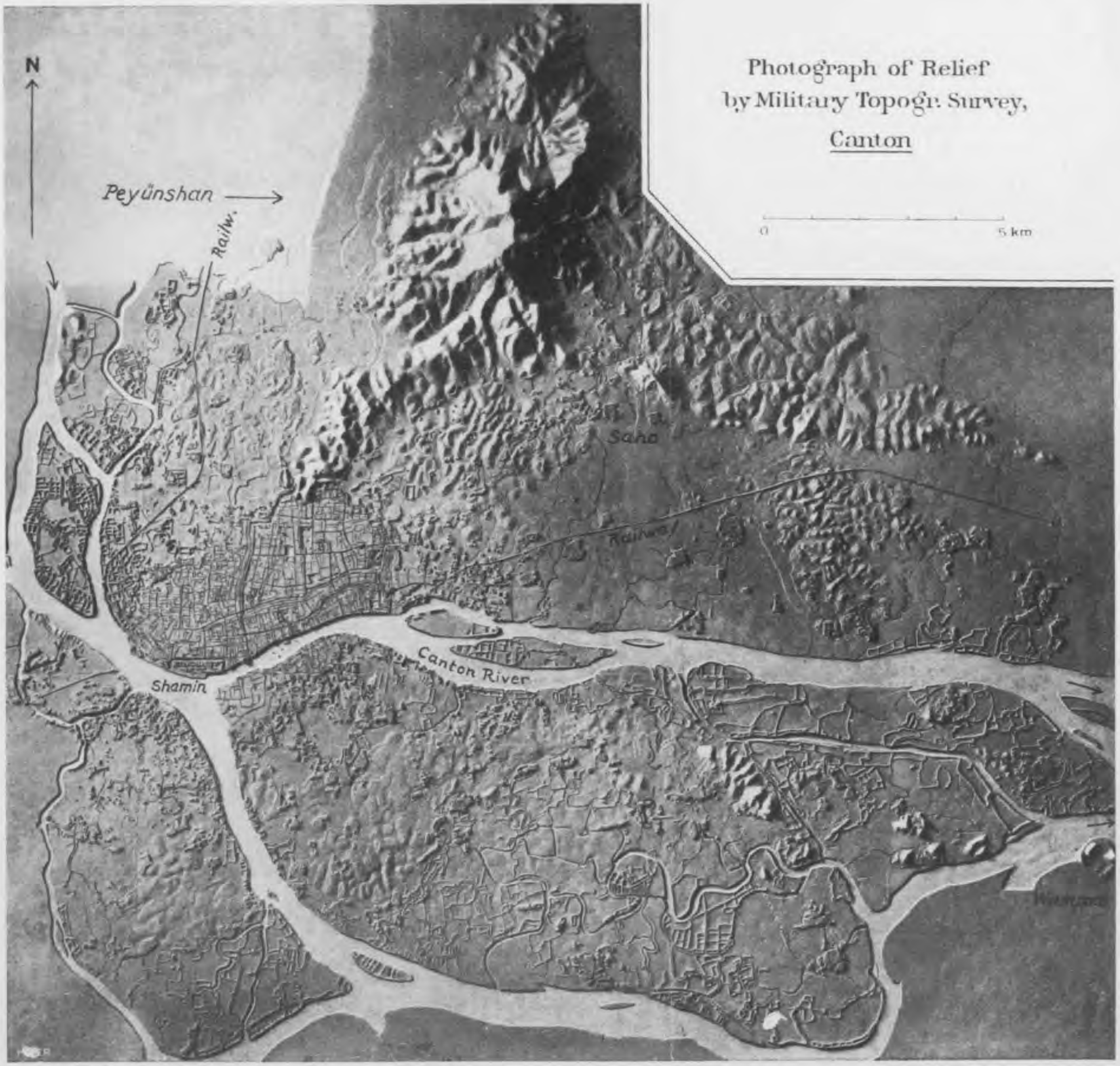
Fig. 1.

Contact of *fluidal granite* rich in biotite, with massive granite. Quarry 3 km S of Hwang Töng, 25 km ENE of Canton. Nearly natural size. The black grains and flakes are biotite. Coll. and Phot. Arn. Heim, 1929.

Fig. 2.

Weathering and erosion of the coarse massive granite after deforestation. University—site, 10 km ENE of Canton. See ravines cut out deeply on hill in back ground. Phot. Arn. Heim, May, 1930.

EXPLANATION OF PLATE III.



Photograph of Relief
by Military Topogr. Survey,
Canton

PLATE II.

Photograph of Relief made by the Military Topographic Survey of Canton, showing the position of Canton, the low hills of peneplained Red Beds E, S and NW of the city, and the higher hills with Pai Yün Shan (Peyünshan) on the N side of Canton Valley. The rivers appear as if their beds were emptied.

EXPLANATION OF PLATE II.

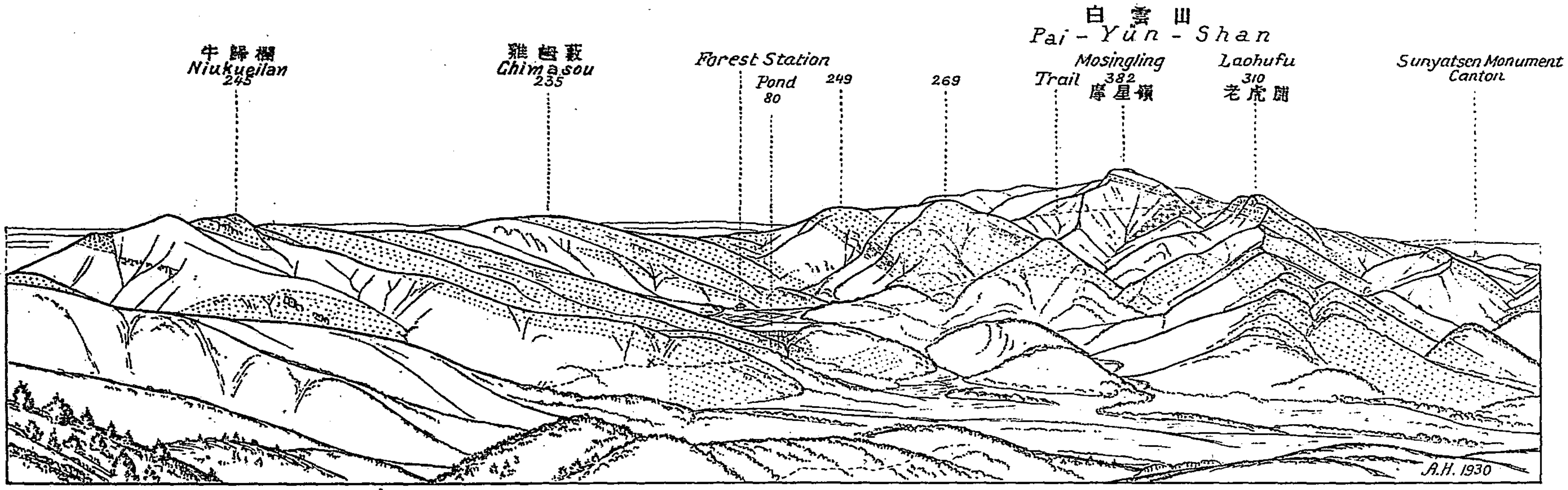
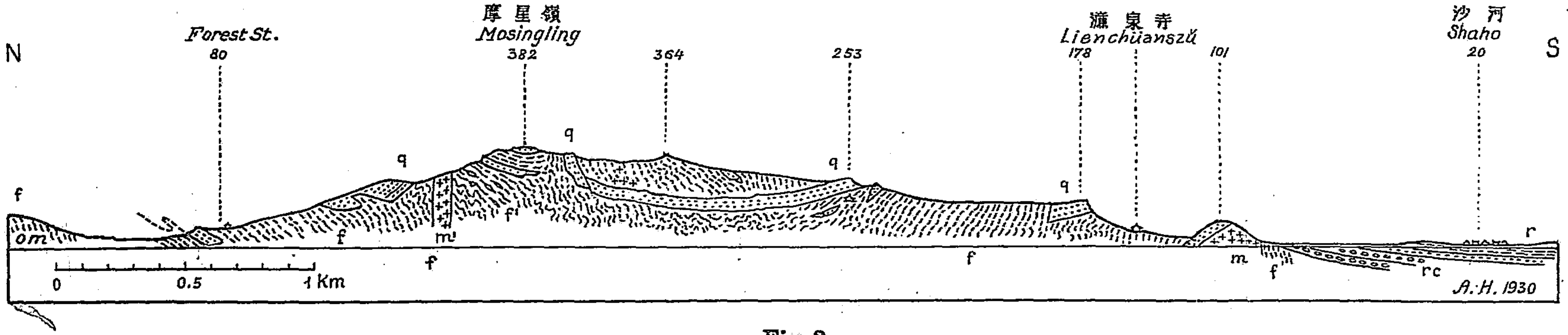

白 雲 山
Pai - Yün - Shan
牛歸欄
Niukueilan
245
雞毡薮
Chimasou
235
Forest Station
Pond
80
249
269
Trail
Mosingling
382
摩星嶺
Laohufu
310
老虎關
Sunyatsen Monument
Canton
A.H. 1930

Fig. 1.


N
S
Forest St.
80
摩星嶺
Mosingling
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364
253
濂泉寺
Lienchüanszü
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101
沙河
Shaho
20
q
f
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f'
m
r
rc
0
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1 Km
A.H. 1930

Fig. 2.

Plate I.

Fig. 1.

Panoramic view of Pai Yün Shan (= Peyünshan) seen from North. (Standpoint near top of Wu Lai Ling, 210 m).

Points = quartzite (Permo-Triassic), +++ = dyke of quartz-porphyry to granite, all the rest without signature is fluidal granite. The reader is advised to paint the empty spaces with a purple pencil, in order to obtain an easier reading. - - - - - - = trails of forestry service. Elevations in meters above sea level.

Fig. 2.

Section through Pai Yün Shan (= Peyünshan), at a right angle to Fig. 1, f = fluidal granite, m = massive granite, m′ = granite to quartz-porphyry, q = quartzite, rc = Red Bed conglomerate, r = Red bed clay shale and sandstone.

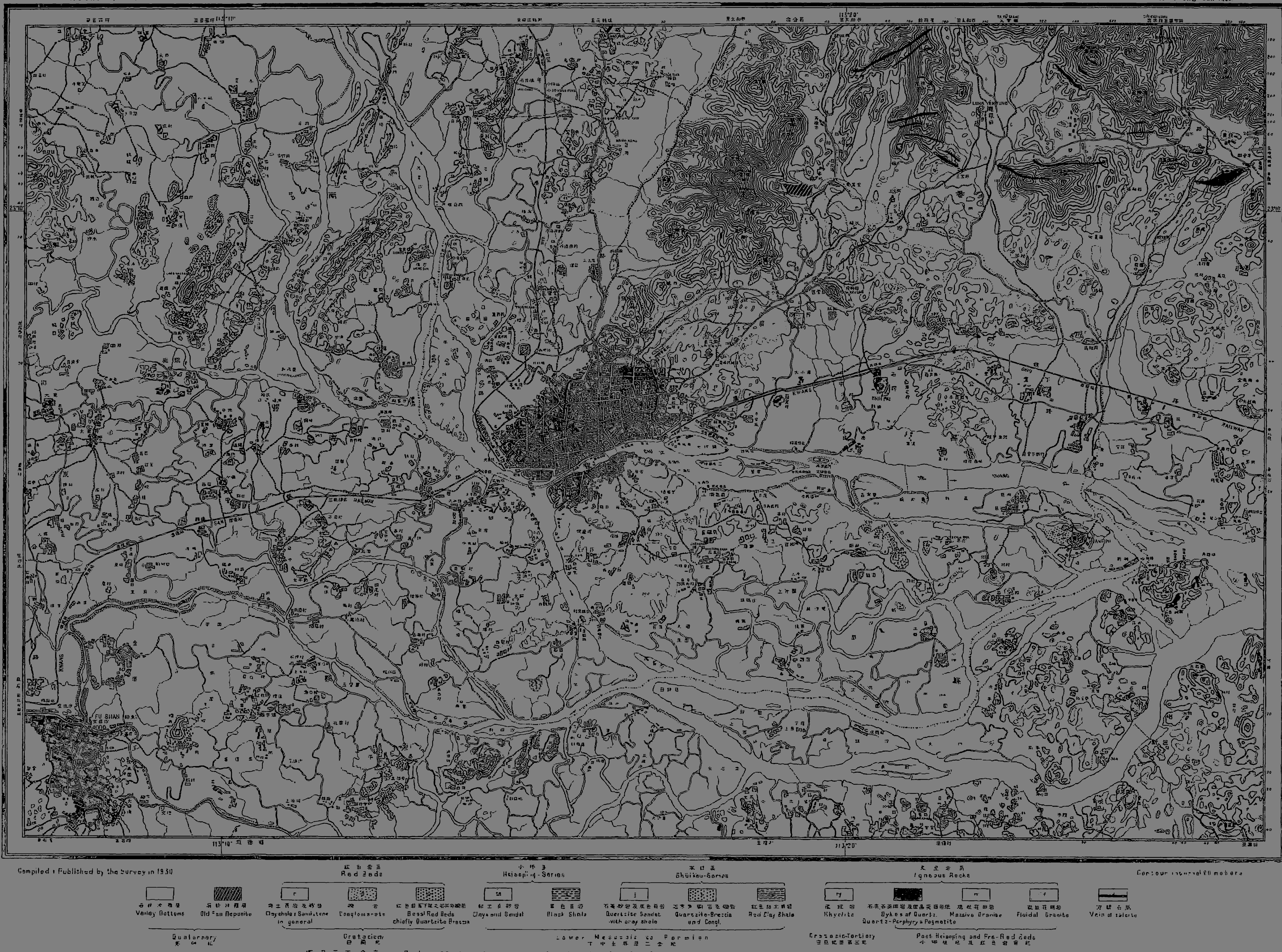
EXPLANATION OF PLATE I.

廣州市地質圖

GEOLOGICAL MAP OF CANTON

Geological Survey of Kwangtung and Kwangsi
Chu Chia Hua, Director

Geology by Arnold Heim, K. Krejci-Graf and Lee Ch'êng San 1930.



trace a special trend of Alpine Folds. Probably, the main trend is SW-NE as in older time.

The Alpine Movement of Canton of such intensity was a surprise to the writers. For ever the idea of exclusively old mountain making in South China is to be abandoned.

Exactly the same principles of tectonical structure we have encountered again on the Island of Hainan.

By the Alpine Movement, a new phase of erosion was initiated. The Red Beds were peneplained by extensive river erosion. Then, the entire coastal region of South China was subsided, and the peneplain was lowered nearly to sea level.

The terraces of Huang Pu district seem to be relics of general higher valley bottoms. But whether they have been caused by temporary rising, or if they are simply relics of valley bottoms formed at their actual height, we could not determine. An extensive special study would be necessary to clear up the latest phases of the geological history of Canton.

In a great thickness, the Red Beds have filled up the old, partly synclinal valleys. They seem to be a continental deposit of a warm semi-arid climate similar to that of sub-recent time. The coarse clastic elements in some places derived directly from the surroundings, as is seen for instance at Huang Pu, where the Red Bed conglomerate at the contact with the fluidal granite is especially rich in pebbles of this same fluidal granite.

It is a peculiar fact however that NE of Canton, the very first deposit of the Red Beds is not the quartzite-breccia, but a very fine semiplastic clay.

At the end of Cretacic or in early Tertiary time occurred the *second orogenic movement,* by which the Red Beds throughout Canton and Hong Kong have been tilted and folded. This is the *Alpine Movement.*

In regard to the importance of the Alpine Movement compared with the Yenshan Movement, we have carefully measured all good outcrops.

As shown in Fig. 5, the dip of the basal Red Bed conglomerate of Huang Pu is as much as 70-80° towards N. Three kilometers further NE, the dip has diminished, but is still 45° (Pl. IV, Fig. 1).

On the railway N of Canton we have found a dip of 60-70° towards N 25° E over abut 100 meters across the strata. Such dips cannot be explained by local movement along supposed faults. They are simply the result of *horizontal compression.*

Dips of 20-30° are common all over the Red Beds. Nearly flat and undisturbed Red Beds may be represented by the valley hills south of the Hong Kong Railway, and are also found in the form of a plateau in the NW corner of our map of Canton.

From these observations and in regard to the deep weathering of the older formations we may conclude that the actual relief is chiefly caused by the Alpine Movement. The directions of the Red Bed folds on account of the great unconformity with the older formations are so irregular and diversed, that the study of Canton does not allow to

Fragments of Geological History

The geological history of Canton begins with the Permian.

The great thickness of the Shüikou Series with quartzite breccias, conglomerates and a great amount of red clay shales without traces of fossils, suggests a warm and semi-arid climate similar to that of the younger Red Beds.

The Hsiaoping Series gives a clearer evidence. The red clay shales are rapidly diminishing in importance, while a big series follows with black carbonaceous shales containing older mesozoic land plants and unimportant coal seams. Instead of conglomerates and sandstones, the upper part of the thick Hsiaoping series seems to be made chiefly of soft clays. The accumulation must have occurred in a quiet *continental basin.*

After the deposition of the Hsiaoping Series followed the *first orogenic removement,* accompanied and followed by fluidal and massive granitic intrusions. Both, this folding and the intrusion, seem to be younger than Hsiaoping and are certainly older than Red Beds.

According to our results at Hong Kong[1] the most probable time is the younger Jurassic, which corresponds about to Yenshan Movement A of W. H. Wong.[2]

The result of this first orogenic movement is seen in the deposition of the Red Beds with their basal breccias and their conglomerates which contain all kinds of pebbles from the older formations, especially of quartzite and granite. It is further demonstrated by the general unconformity of the Red Beds with the older formations.

The whole character of the Red Beds of Canton and Hong Kong is so similar to that of the famous Red Beds of Szechuan with their lower Cretacic fresh water fauna at the basis, that until contrary proves the writers regard the Red Beds of Canton also as Cretacic.

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[1] Heim, Arnold, Hongkong, Annual Report Geological Survey of Kwangtung and Kwangsi, 1929.

[2] Wong, W. H., The Mosozoic orogenic Movement of E. China, B. G. S. China, 1929.

part (Figs. 11 and 12) wedges of fluidal granite are found; other parts are swimming within the massive granite.

We suppose that a big granitic batholith, of which the massive granite is the true representative, intruded into the folding or folded Permotriassic sediments. The argillaceous parts of the latter became dissolved, making a chemical change (shown in the forming of much biotite) of the marginal and roof zones of the batholith. By this dissolution and cooling these zones lost much of their liquidity, so that the signs of fluidal movement were preserved in the solidifying magma. The hotter and more liquid magma of the interior found the easiest means of intrusion near to the marginal zone, and formed the belt shown in Fig. 11 with small intrusions on both sides of it. By this process, the massive granite separated the marginal zone from the roof, which now forms the interior zone of fluidal granite. By this magmatic movement, the roof became wedged into the massive granite. The contact between the two granites is an igneous contact, as shown by the many intrusions along the contacts, and by the fact that the texture of the fluidal granite is not quite conform to the contact: it seems that the laminae usually are dipping steeper. Nevertheless, both granites seem to be of little difference in age. Thus the fluidal granite is regarded as a marginal facies of the massive granite.

The *veins* and *dykes* are *younger* than the granites. The youngest are the *ultrabasic* veins found in the middle of some aplites near to the northern margin of the map and outside of it. The main strike of the dykes is in general roughly WE, but in the detail the strikes may differ from this direction (Fig. 11). There is certainly no geometric joint system represented by these dykes. Very often it seems that the dykes, or dyke zones, are broader on the top of the hills than on the foot, or that they even completely pinch out downwards. This would point to the conclusion that an upheaval of the batholith, with extension on the top, was the cause of the original joints.

The dykes in many places are crossing the limit between the fluidal and massive granite. Both rocks, therefore, must already at this time have formed a solid body.

Mechanism of Igneous Intrusion.

The big granite complex in the eastern part of the map has the shape of a Batholith. It probably is only superficially divided into a northern and southern part, by a syncline of Red Beds. Within the batholith we distinguish three zones (Fig. 11).

1. *Marginal Zone.*—This zone is beautifully exposed on Pai Yün Shan. Vertical and horizontal intrusions of fluidal granite, with fragments of quartzite characterize this zone. Intrusions of massive granite or quartz porphyry are found locally only.

2. *Massive Granite.*—The next zone is the massive granite which NE of Pai Yün Shan underlies the fluidal granite of the marginal zone. Elsewhere the contact seems to be steep. Near the contact with the fluidal granite, the massive granite often contains biotite in large quantities, and takes up the petrological and perhaps even the textural character of the fluidal granite.

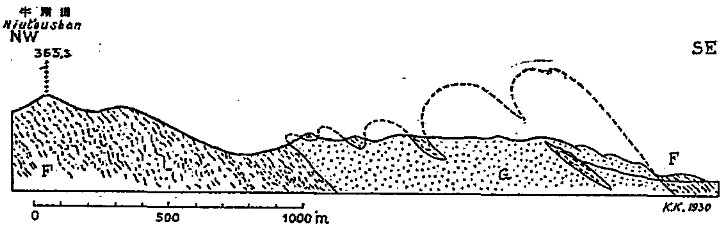

Fig. 12. Contact of fluidal and massive granite of Niu Tou Shan, NE border of map.

3. *The Fluidal Granite* of the interior contains, within the map and its immediately adjoining regions, no inclusions of sediments or other fragments of foreign rocks, except intrusions of massive granite near the contact. This limit in some parts is intensely curved (Fig. 11, eastern part) and shows a fluidal arrangement. The contacts are usually not vertical. The angle of dip, determined after the outcrop of the contact as observed on different points, is around 40-50 degrees. On the top of the small intruding body of massive granite in the eastern

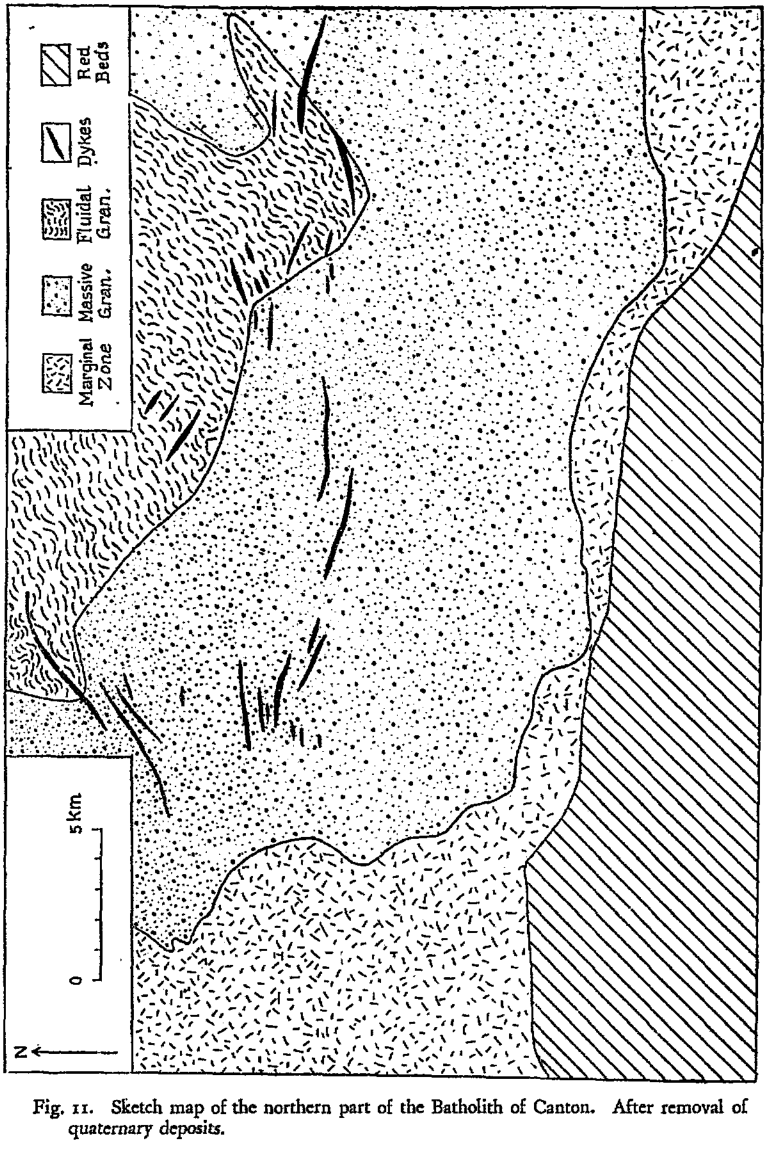

Fig. 11. Sketch map of the northern part of the Batholith of Canton. After removal of quaternary deposits.

In looking at the sections and views, it might be thought that these repetitions are caused by thrust sheets of gneiss. This view however is in disregard with the numerous places of intrusion and contact metamorphism.

We thus must consider Pai Yün Shan as formed by an *intrusion of fluidal granite which passed between the quartzites and digested most of the argillaceous beds of the stratigraphic series, which at the same time the first tectonical movement was initiated.*

YOUNGER TECTONICAL STRUCTURES.

The Border of the Plain NE of Canton.

This is the only region where the normal contact of the Red Beds on their substratum is found for a long distance. This contact is already indicated by the topography (see photo of relief, Pl. II). It is the limit between the lower hills of the Red Beds (below 50 meters) with those of the quartzite (above 50 meters).

Only on Shou Kou Ling at Sha Ho the exact contact is opened (Pl. VII). The quartzite dips 45° towards SW and S, while the Red Beds dip 10-20° less towards the wide Synclinal Red Bed Valley of Canton River.

This zone of normal contact follows a line from E to W, then makes a beach at Sha Ho and towards N, and follows the foot hills of Pai Yün Shan towards the Five-story Pagoda and the Sunyatsen Monument in the shape of a wide arch.

This arch is the border of the Red Bed Syncline, to which corresponds the great valley of the Canton River below Canton, while the city itself from SE to NW seems to be traversed by a secondary *Red Bed anticline* (see dips on map).

2. *Folds with granitic intrusions.*

The main region of this type is Pai Yün Shan. Lithologically and tectonically it is the most extraordinary mountain, and one which presented the greatest difficulty for mapping, especially on account of the difficulty in distinguishing the weathered fluidal granite from sedimentary rocks. Although Pai Yün Shan has been worked by us over and over again, some places still are left doubtful.

The first appearance of Pai Yün Shan is that of a gentle syncline, the main quartzite of the rock-temple Yün Yên Szŭ (雲岩寺) going around the culminating region in the shape of a collar. (Pl. I, Fig. 2). But the "strata" above and below have been recognized as fluidal granite. The quartzites are disconnected, and swimming in fluidal granite.

A closer study showed that even the apparently uniform and flat lying quartzite of the Yün Yên Szŭ and N of it, of about 70 m thickness is twice interbedded with fluidal granite (Fig. 10). In the scale of 1:50,000 these different layers cannot be separated.

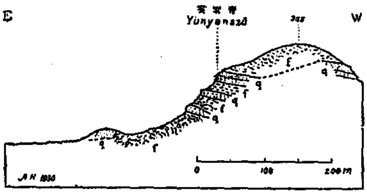

Fig. 10. Detail of Yün Yên Ssŭ, E side of Pai Yün Shan. f=fluidal granite; q=quartzite (Permo-Triassic).

The highest point of Pai Yün Shan, called Mo Sing Ling, 382 m, is made of quartzite, which is underlain by fluidal granite, below which immediately follows a second quartzite of 10-15 meters thickness, resting on relatively fresh fluidal granite, rich in biotite and with eyes of quartz and feldspar. The laminae of these intermediate fluidal granites correspond frequently with the stratification of the quartzites, deceiving us of a normal stratigraphic succession. (Pl. I).

The same phenomenon is repeated in a larger scale on the ridge of Chi Ma Sou and Niu Kuei Lan on the N side of Mo Sing Ling, where gently eastward dipping sedimentary quartzite sheets are interbedded with fluidal granite (Pl. I).

Older Structures.

We can distinguish:

1. *Folds without granitic intrusions.*

To these belong the ranges of hills which are cut obliquely by the northern branches of the Canton River.

Although only local folds have been directly observed, it seems that this region west of Pai Yün Shan, of 10 km width, is formed of a large fold, with an anticline and a syncline (Fig. 1).

The anticline passes near Shih Kang and will be called Shihkang Anticline. The NW wing dips 50-60° towards NW and is chiefly formed of quartzitic breccia. In the center is found a pond, on the SE side of which, peculiarly, vertical red clay shale is found with a NW strike, thus perpendicular to the strike of the fold. This seems to be caused by local faults with contortion. Great detail complication with faulting also occurs at the SW end of Shihkang anticline at the village Ta Hung Ma (大橫馬).

Possibly, the apex of the anticline is *faulted* all along. Red clay shales are found on both sides of the anticlinal valley, but of much less thickness on the NW limb. The SE limb is more regular, and shows dips of 60-70° towards SE. The breccias are missing.

With Hsiaoping Series, local disturbances again prevail and make it impossible to determine the major structure. At the town of Hsiao Ping, the strata are much contorted.

Judging from the dips of strata and from the outcrops of black clay shale which are found in two main zones, it seems that the Hsiaoping Series forms a big syncline from SW to NE, passing at Fo Ling Shih, with the clays in the central part. (Fig. 1).

Another region which for about 17 km seems to be undisturbed by granitic intrusion is found on the south of the map. It seems to belong to the northern limb of an anticline, with an average dip of 20-30°.

It is a medium-grained rock containing small phenocrysts of quartz and feldspar (orthoclase and a small quantity of plagioclase), but the dark minerals cannot be determined by naked eye. Its colour is light violet. The two small hills stand alone in the rice field. Therefore, the relation to the Red Beds and older formations, as well as to the granites cannot be determined. In regard to our experience in Hong Kong this eruptive rock might be of tertiary age.

Tectonical Structure.

General Features.

Two tectonical disturbances are sharply divided:—

1. An older, concerning the Shüikou and Hsiaoping Series including the granites, which has not affected the Red Beds.

2. A younger, which has affected even the Red Beds.

The tectonical structure of the Red Beds in some regions is distinctly the effect of continuation of the earlier tectonical movement. In other regions, the tilting of the Red Beds appears to be entirely different, and the older and younger folds are in disharmony.

Harmonial structures are found chiefly on the north side of Hong Kong Railway, where the basal Red Beds, as a whole, dip in the same direction as the underlying old quartzites, although with a 10-20° more gentle angle. (Pl. VII, Figs. 1 and 2).

NE of Canton City, the strike of the Red Beds is at a right angle to the hills of granite and quartzite, which project from Pai Yün Shan towards SW until the new Sunyatsen Monument. A similar disharmony is found again N of the city.

In the NW of the map 1:50,000, the strike of the Red Beds approximately coincides again with that of the Shüikou Ranges, although the dip does not correspond with the older nucleus.

Pegmatite veins and quartz veins frequently pass into each other. The pegmatite consists to a great deal of quartz, while the other minerals always are in minor quantity. The orthoclase sometimes forms beautiful crystals up to some centimeters in length. The muscovite occurs in big pure aggregates of small crystals (up to 1 cm. in diameter) or in small aggregates of big crystals (up to 6 cm. in diameter). In weathering, a sandy soil with much quartz, and always some muscovite, is formed. The *quartz veins* are nearly exclusively formed by white quartz. Big boulders, arranged in lines, mark the outcrop. The weathered soil consists of quartz crystals. In some places, as especially on Hung Tou Ling (横頭嶺) 66.5 m., poor *magnetite ore* and traces of *bismuth-ochre* are found in such a quartz vein. Cubic holes in the quartz are partly filled by spongy magnetite.

The dykes figured in the map are mostly composite; a large body of the country rock is crossed by numerous veins. In the weathered soil this zone always is recognisable by its richness in quartz crystals. The resistency of the quartz causes the formation of crests and ridges, while pure quartz veins often stand out in the form of walls or reefs.

In the fluidal granite often *aplitic* intrusions or veins, of a thickness up to some centimeters, are observed. On joints in the fluidal granite, *pyrite* is found. Near the northern margin of the map, N of the waterfall near Shui Sheng Hsia (水聲下) in the mid of aplite veins, very thin veins of an *ultrabasic* rock occur. In the creek and on the path, big boulders of the same rock are found, which suggest an outcrop in the vicinity. Prof. W. Credner showed us an accumulation of such blocks in the creek N of Ch'u Shui Lung (出水龍), which suggests an outcrop there. The outcrop itself, however, could not be observed. This dark gray green rock often contains some inclusions of *pyrrhotite*.

Rhyolite.

In Canton the rhyolite is only found near the village of Wu Fung Tsun (五鳳村), 3 km SE of Canton city. The hills of Chên Shan (陳山) and Hu Lu Kang (葫蘆崗) are formed by rhyolite. It was poured out from the underground, and dips about 30° towards NE.

Throughout the world, the massive granite weathers to an argillaceous quartz-sand in which remain round blocks of fresh rock. From these, the granite is blasted out for building constructions (Canton and Hong Kong).

Beautiful groups of such boulders are found on the Huo Lu Shan (火爐山) about 700 m W of point 324.1 m (the "tottering stone" or "Wackelstein," which however, is safely supported on two places and therefore not moving); and on the Ta Ling (大嶺) 297.1 m., just east of the map. At the University-site, 10 km ENE of Canton, the weathered granite is washed out in deep furrows.

The massive granite usually can be distinguished already at long distance with the telescope. Where black round blocks are found, they must belong to the massive granite. If the blocks are angular, they belong to the fluid granite.

Dykes of Quartz, Quartz Porphyry and Pegmatite.

The *quartz porphyry* is a medium grained rock, containing quartz, feldspar and muscovite. No absolutely fresh rock has been found in the dykes. The weathered rock contains mostly grains of quartz and muscovite in a green argillaceous groundmass. Often only the quartz is left, and, if weathering is more complete, the green colour disappears. Then it is impossible to distinguish the quartz porphyry from the other veins. Therefore all veins in the map are reproduced by the same sign. It is however certain that some of the quartz porphyry veins retain their petrologic character over long distances, as for example the southern vein on Huo Lu Shan; while others seem to pass into pegmatite or quartz.

On the NW slope of Pai Yün Shan summit, a dyke of 50-100 meters thickness cuts nearly vertically across the fluidal granite (Plate I, + in Fig. 1). It is made of white quartz porphyry passing into fine-grained granite with reddish orthoclase and some biotite. It is traversed by two superposed trails of the forestry service.

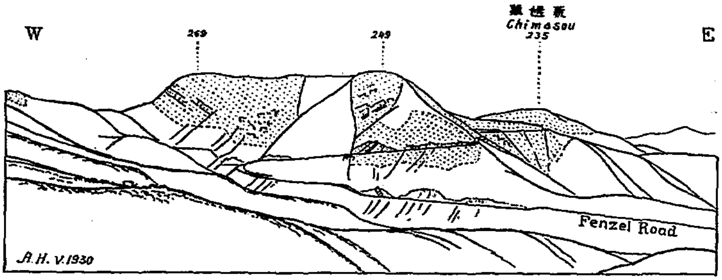

Fig. 8. Quartzite (small points) swimming in fluidal granite. North side of Pai Yün Shan.

Massive Granite.

Massive granite is found in a great Batholithic mass of intrusion, as well as in the form of dykes.

A pretty small vein is exposed at the upper end of Fenzel Road on the N side of Pai Yün Shan, just below Chi Ma Sou of Fig. 8.

This granite is of medium grain 1-2 mm) and holocrystalline without showing finer grain at the contacts (Fig. 9).

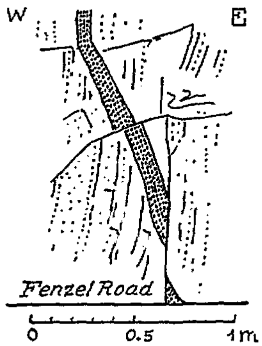

Fig. 9. Granite dyke in quartzite, Pai Yün Shan—N.

In the central part of the big body of massive granite NE of Canton, the feldspars reach the size of several centimeters. They are chiefly white to pink, in single crystals or in twins of orthoclase of the Karlsbad law.

Little mica is present in the interior of the granite complex, while at the boundaries, it is frequently rich in biotite, probably from digestion of argillaceous sediments.

Fortunately, the weathering of the massive granite usually is distinctly different from the fluidal granite.

Also the chemical composition is of the type of a granite. The following analyses have been made by Mr. C. M. Hsüeh, Chemist of the Geological Survey of Kwangtung and Kwangsi, from samples gathered in a quarry at Hwang Tong, 25 km ENE of Canton.

	"Gneiss"	Massive granite
Loss on ignition	1.050	1.200
Silica SiO_2	62.200	62.400
Alumina, Al_2O_3	12.675	13.350
Ferric oxide Fe_2O_3	7.885	4.482
Ferrous oxide, FeO	5.071	1.652
Lime, CaO	3.875	2.820
Magnesia MgO	0.825	0.634
Potassium oxide K_2O	3.390	3.200
Sodium oxide Na_2O	3.412	3.498
	100.383	100.236

These two analyses correspond to the photograph Pl. III, Fig. 1.

The following varieties of fluidal granite have been encountered.

(*a*) Fluidal granite of white to pink feldspar (white orthoclase with plagioclase), quartz, and much biotite. The best place to study this normal type is the waterfall NE of Lung Yên Tung (Pl. III, Fig. 1; IV, Fig. 2; X, Fig. 1, 2).

(*b*) Fluidal granite with muscovite (bleached biotite?) or without mica, sometimes with fine needles of hornblende. This type was especially found on the west of Pai Yün Shan. In the weathered condition it is almost indistinguishable from an arkose sandstone.

In regard to texture, there is a great variety. In some places, the texture is massive for a short distance (north side of Pai Yün Shan). Usually, the texture is that of an ortho- or paragneiss, frequently with eyes of feldspar and quartz, and with white and dark bands. Beautiful fluidal folding and flexuring are frequent. They are of the same macroscopic appearance as the mechanical deformations of true gneiss made in great depths, where high temperature and enormous pressure are causing a plasticity similar to a semi-fluid magma.

forms. On the contact with the massive granite, veins of the latter often form a network, in which pieces of fluidal granite are swimming, as for example on Wu Shih Shan (烏石山) 242.1 m.

The reasons for regarding the gneiss-like rock as an intrusive granite are the following[1]:—

(1) Small and big sheets and blocks of quartzite are swimming in "gneiss" or are "interbedded" with it. (Fig. 6).

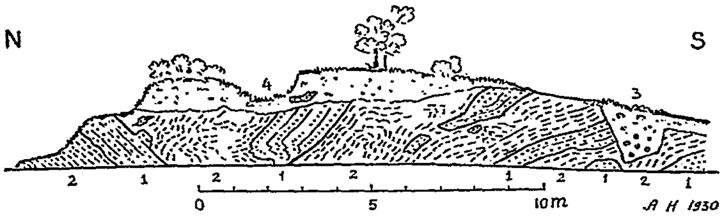

Fig. 6. Blocks of quartzitic sandstone (1) swimming in fluidal granite (2) Deeply weathered outcrop on road, east of Pai Yün Shan.

(2) Sedimentary quartzite in some places (Pai Yün Shan) was found intruded by this " gneiss. " (Fig. 7).

(3) The Sandstones and quartzites on contact with the " gneiss " usually show distinct *contact metamorphism* (recrystallized sandstone, clayslate impregnated with hornblende and haematite at Wu Lai Ling).

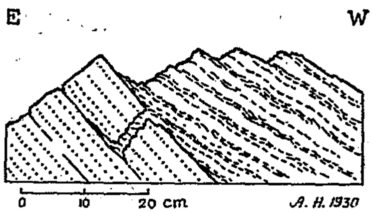

Fig. 7. Detail of "gneiss" penetrating in fine vein into quartzite. North side of Pai Yün Shan, at × of Pl. I.

(4) The microscopic structure is the same as that of a granite. The biotite is distributed in more or less parallel flakes without showing mechanical deformation.

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[1] Arnold Heim, Three textural types of granite in Southern China, National Research Institute of Geology, Shanghai, Contributions, No. 1, and
Arnold Heim, The Structure of sacred Omeishan, Szechuan, Bull. Geol. Soc. China, Vol. IX, No. 1.

. The tectonical position, several hundred meters above and between the quartzite, however, pointed to the question, if this "gneiss" might be an intrusive body of fluidal granite.

Further observations have decidedly proved this conception, and even all of the former "pinkish sandstone with mica," which is interbedded with the quartzites of Pai Yün Shan, had to be changed into weathered fluidal granite.

Fluidal Granite.

The fluidal granite is the most interesting rock of Canton. It is found in wide extension, at least 30 km to NE and as much from S to N. But neither the southern nor the northern limit have been determined.

In the northern region, several low mountain ranges are exclusively formed of fluidal granite.

The fluidal granite of the "marginal zone" (Fig. 12) is more deeply weathered than the massive granite, and is transformed into a purple to violet argillaceous mica sand, which only after long experience can be distinguished from weathered sediments. The biotite seems to be bleached out by weathering, and appears with the aspect of muscovite. In the marginal region of the granitic mass, the fluidal granite forms the lowest hills without leaving any bigger blocks at the surface. In the interior, however, the fluidal granite seems to be more resistant against weathering than the massive granite. The highest hills, Ta Hsü Chang (大圩嶂) 400.5 m, and Fung Huang Shan (鳳凰山) 382.2 m, are in this region. Nearest comes Pai Yün Shan, 382.0 m, with its resistent quartzite on the top. The highest hill in the massive granite is the Huo Lu Shan (火爐山) with only 324.1 m. The limit between the internal fluidal granite and the massive granite, therefore, is often shown by an orographic step or even by a pass or valley; it also seems that the contact zone is weathering more easily than either the massive or the fluidal granite by themselves. In the interior mountain region the fluidal granite often forms large smooth into the rice fields. In some bends of the creeks in the northern mountainous region recent deposits are found of light-grey to whitish plastic clays, interbedded with yellow to brown sands. In all recent deposits, except such, where red sediments are redeposited without longer transport, the lack of red colour is remarkable.

Lateritic or laterite-like red soils are scattered throughout the region. Especially the fluidal granite of the "marginal zone" shows rich red to violet colours in its weathering products, while the weathering of the massive granite furnishes more brick-to cinnabar-red soils, and the quartzite decays into more yellowish soils. The Red Beds, on the other hand, usually retain their purple.

In many places a brown surface soil overlies the lateritic or red-coloured soil. Where a trail is cut out in red soil, as north of the hill of Shou Kou Ling, bands of different shades within the red soil are observed which are more steeply inclined than the surface, and thus crop out at an angle to the surface. All these observations seem to suggest that the red soils have been formed in past time and that to-day no more red soils are formed.

Our knowledge of quaternary deposits is extremely poor, and only could be furthered by drilling.

Rests of older quaternary time, besides the deep rock residues from weathering, are left in the shape of erosion terraces. Such we found SW of Huang Pu. Two terraces could be followed, a lower one of 22-23 meters, and a higher one of 42-43 meters elevation above sea-level.

Igneous Rocks.

At the beginning of our field work, only the common massive granite was known. The writer (A. H.), on his first excursion guided by Professor Fenzel on Pai Yün Shan was much surprised to find a "Gneiss," first in blocks and then also in situ. Indeed, on the north side of the summit, the rock appeared to be a true biotite gneiss. Even "gneiss" with eyes of quartz and feldspar was encountered.

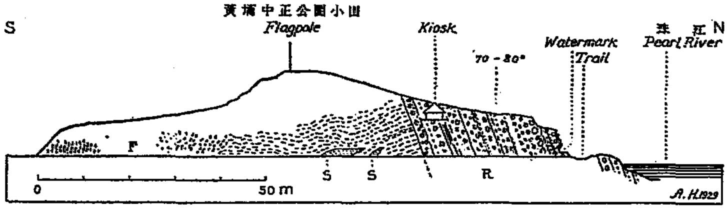

Fig. 5. *Contact of Red Bed Conglomerate with fluidal granite at Huang Pu,* 14 km ESE of Canton City. F=Fluidal Granite, deeply weathered; s=inclusions of reddish sandstone; R=Red Bed Conglomerate.

Red Bed Sandstone.

Besides the sandstone which everywhere is interbedded with the clays, marls, and conglomerates, a region is to be mentioned where sandstones are dominating in the landscape. This is the plateau in the NW corner of our map, formed of about 50 meters of gray, white and pink coarse sandstone with crossbedding, but of nearly horizontal stratification (Pl. IX). Partly it is an arkose. It also contains few pebbles of quartz and quartz porphyry. The top of the sandstone is covered with true laterite (W. Credner). At the base is exposed red clay.

Quaternary Deposits and Terraces.

Remarkably little has been deposited or is left from quaternary time. Although the uncoloured "Valley Bottoms" cover the largest area of the map, the volume seems to be unimportant on account of the little thickness.

On the map, the fan deposits on the east-side of Pai Yün Shan are specially indicated. They are made of an accumulation of angular rocks from the adjoining slope, especially of quartzite, up to one cubic meter, and form a terrace about 10 meters above the adjoining ravines. They seem to be of younger diluvial age.

On the creek of Sha Ho, in some places sand has been accumulated. Along the Canton river, brown recent mud only is found, which extends reach the size of a head, and are angular, with rounded edges, or completely rounded. The dip is 55-70° towards N 20-25° E.

Region West of Canton.

The most prominent outcrop is presented by the Tiger Head (= Hu Tou Kang) 102.3 m at the village Hsiang Kang. This whole rock is formed of conglomerate, of 100-200 meters thickness. The dip is from 10 to 30° to SE. With the coarse conglomerate is interbedded conglomeratic pinkish sandstone. The pebbles up to the size of a head are formed of hard glassy quartzite, reddish to white and gray quartzitic sandstone and quartz porphyry (?). One kilometer SW of the Tiger Head, also rare pebbles of Permian limestone were gathered.

Region South of Canton River.

Already from long distance a row of black hills (highest 62 meters) of a NW-SW extension are visible, covered with pine trees (Hua Kang). They are situated 7 km SE of Canton city. The whole Red Bed region therefrom to Huang Pu is conglomeratic.

The pine tree hills are formed of hard compact breccious conglomerate or conglomeratic sandstone with partly rounded inclusions of chiefly quartzite, with red sandstone (Permo-Mesozoic) and massive granite. The thickness, according to the dip of 25-30° towards NE, is at least 500 meters.

This conglomerate seems to be hardened and so completely cemented with argillaceous sand and clay that there is little chance to obtain from it large quantities of water by deep boring.

In the eastern prolongation is found the Red Bed Conglomerate of Huang Pu, which is on direct contact with fluidal granite and contains not only quartzite, but also inclusions of massive and fluidal granite, of up to 20 and 30 centimeters. These pebbles of fluidal granite are exactly corresponding with the fluidal granite, upon which they have been deposited (Fig. 5). One pebble even showed pretty fluidal folding.

of the basal clay. The breccia (b) seems to come in direct contact with the quartzite (q).

This breccia (b) is of great thickness, apparently 30-50 meters, and at the base is composed of coarse angular fragments of quartzite with little matrix. Even in the upper part blocks of several cubic meters are enclosed. It seems that the basal breccia passes into the Red Bed conglomerate, the dip of which could not be measured.

Red Bed Conglomerates.

Three regions of conglomeratic facies can be distinguished.

Region North of Canton.

On the railway north of the city, a hill of Red Bed Conglomerates has been cut out, showing continuous exposures over about 100 meters. There, the coarse conglomerate layers have a thickness of ½ to several meters each, and are bedded with numerous repetitions in purple clay shale. The inclusions, chiefly of quartzite and red sandstone of the older series

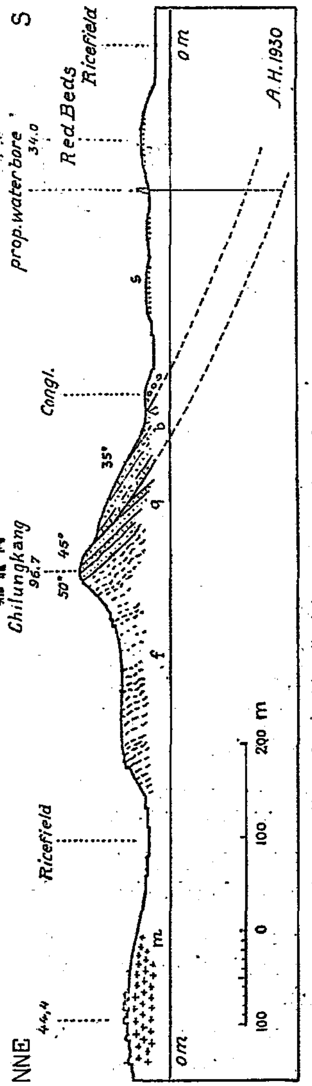

Fig. 4. Section across Chi Lung Kang, the Signal Hill of the University-Site, 8 km ENE of Canton. q=Quartzite (Permo-Triassic); b=basal breccia of Red Beds; s=surface gravel; relics from weathering of Red Bed Conglomerate. f=fluidal granite; m=massive granite.

NE of the city. The best outcrops are found in the deep ravine on the SW side of Shou Kou Ling (elevation 141.2 m) east of Sha Ho. (Fig. 3).

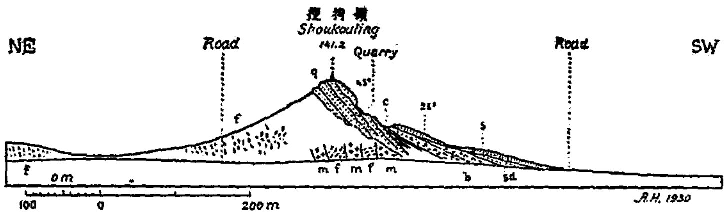

Fig. 3. Section across Shou Kou Ling, 5 km NE of Canton. q=quartzite (Permo-Triassic); c=Red clay, basis of Red Beds; b=Breccia with quartzite fragments; sd=gray to reddish sandstone; s=Surface debris; f=fluidal granite; m=massive granite.

The lowest strata of Red Beds are made of pink clay beds with greenish white bands, of which about 3 meters are exposed. The basal quartzite dips 45° to SW, while the red clay dips 10° less. At the very base, however, the clay is conformable to the quartzite. (Pl. VII). This shows that the clay has been deposited on a slightly inclined bottom of 10-15°, while the erection after the deposition of the Red Beds was 35°.

Above the basal clay, without an exposure of the contact, follows an irregular breccia formed chiefly of angular fragments of quartzite, cemented with sandy red clay. The thickness may be about 20 meters, and the dip is 20-25° towards SW.

In one place, above the breccia, is seen a concretionary sandstone, without visible stratification.

All these basal subdivisions of Red Beds are covered with a rusty brown crust of surface breccia of 5-10 meters. (Pl. VII).

Another place to study the basis of the Red Beds is Chi Lung Kang 96.7 meters, in the eastern prolongation of the same tectonical zone. (Fig. 4).

At this hill (upon which is considered to be built the future observatory of Astronomy of Sunyatsen University), no outcrop is seen that on the S side of Tolo Channel, in which also traces of land plants and coal have been found. But more likely, the Hsiaoping shales are related to the black shales found by Dr. Heanley on Ping-Chan Island of Mirs Bay. They have been thought to be Permian, but now would seem rather to be Triassic. The gray clay division of Hsiaoping then might reach into the Jurassic.

These are only preliminary considerations.

Red Beds.

Throughout the region, the true Red Beds lie *unconformably* upon the older strata or upon the granites. The strike may be even at a right angle to the older formations although no fault is present.

The Red Beds are known throughout Eastern Asia from Mongolia to Siam and are frequently considered as Tertiary, although usually without fossil evidence. In regard to the similarity with the Red Basin of Szechuan, the author (A.H.) considers the Red Beds as Cretacic, until the contrary can be proved.

No trace of fossils was found in the region of the map of Canton.

The Red Beds are deposited in big depressions between the older mountain ranges. The characteristic rocks are red clay shales, frequently calcareous (marls), red to grey sandstones, hard conglomerates and breccias with an argillaceous matrix. No porous, water storing conglomerates with sandy matrix have been found. The red colour is distinctly purple; no brick-red beds similar to the uppermost subdivision in Szechuan (Kiating Series)[1] have been encountered.

Basal Red Beds.

The basal Red Beds with normal position upon the older formation only occur on the northern border of the plain, 5-10 km

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[1] Arnold Heim, Tseliutsin, Special Publication of the Geological Survey of Kwangtung and Kwangsi No. VI, 1930, and Arnold Heim, the structure of sacred Omeishan, Bulletin of the Geological Society of China, Vol. IX, No. 1, 1930.

ironstone ("Toneisenstein") occur within the carbonaceous shales. Also efflorescences of yellow crystals of Alum are found. Frequently diggings on coal have been encountered in the region of Hsiao Ping, but none of the brilliant black coal streaks seem to be worth exploitation. Associated with gray sandstones and quartzites of Hsiao Ping are also red clay shales and red micaceous sandstones.

On the trail on the N side of the town of Hsiao Ping, a much contorted, folded and fractured succession is exposed of micaceous arkose sandstone (almost undistinguishable from the weathered fluidal granite of Pai Yün Shan), manyfold inter-bedded with black shale. The sandstones have a thickness up to 25 meters each, but are intimately related to the carbonaceous shales by lithological passages.

Another and probably again higher complex is exposed in a weathered condition along the motor road N of Canton, where chiefly gray to violet more or less plastic clays are exposed over a long distance. (Kao Ling 2-3 km SE of Hsiao Ping station). Also layers of bright ochre have been noted.

We first considered the question if these clays belong to the Red Bed Formation. In mapping, it was found that they are tectonically independent from the true Red Beds, and seem to pass into the Hsiao Ping Series. Also traces of plants have been found. The exact limit towards the Red Beds, on the N side of Canton, could not be determined on account of lack of outcrops.

The thickness of the Hsiaoping Series cannot be determined. It apparently forms a syncline on the W side of Pai Yün Shan, with the axis directed from SW to NE. The lower part with black shales around Hsiaoping is at least several hundred meters thick, and the upper part may be over 1000 meters.

The question arises if the Hsiaoping series is younger or older than the Tolo Channel Formation (Liassic) of Hong Kong. At Canton, the characteristic quartzite-conglomerate of Tolo Crest[1] has not been found. The black shale, it is true, reminds to some extent

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[1] Arnold Heim, Hongkong, Annual Report of Geological Survey of K. and K., 1929.

Hsiaoping Series.

The limit with the Shüikou series has been taken below the black shales which are the characteristic sediments of the Hsiaoping Series. In the lower part are found gray quartzites like those of the underlying series. Although of minor importance, they are usually the only rocks which, on account of their resistance to weathering, are exposed at the surface.

The best exposure of the black carbonaceous clay-shales and sandy slates is found on the hill 2 km SW of Hsiaoping station. (Phot. Pl. V). There, the lower black shales are much contorted and folded, but form a homogeneous body of at least 50 meters thickness. While dark gray to black inside, the colour of weathering is bleached to purplish, brown-madder or chocolate.

Plant fossils are abundant and can be easily collected in the debris of the slopes. We thank Professor Dr. Chang Hsichih for the preliminary determination of the following genera:

1. *Taeniopteris* sp. (?)
2. *Podozamites lanceolatus* (L. & H.)
3. *Pterophyllum* sp. (?)
4. *Asplenium whitbyense* (?) Heer.

These are distinctly *mesozoic* types. Being apparently no break from the Shüikou to the Hsiaoping Series, it seems that the sedimentation has been continuous from the Permian into the Mesozoic. The favoured transgression of the Mesozoic upon the Paleozoic thus is to be cancelled for Canton. The carbonaceous shales, in which also frequently are found unimportant coal seams, compared with the marine Permian limestone, would point to a regression.

The stratification on account of tectonical disturbance, is so irregular and the outcrops are so isolated, that unfortunately no complete succession can be established. Frequently layers and concretions of breccias again with fantastic rocks (Pl. VI, Fig. 2) but also contorted and fractured layers of conglomerates containing quartzite pebbles and white tuff-like sandstone.

Such tuff-like strata also were encountered at Lön Tan, 3-4 km WSW of Huang Pu.

The SE limb of the anticline of Shih Kang presents a more regular stratification of the series which apparently overlies the breccias and conglomerates. It is made to 80% of red, grey and yellow, more or less sandy clay shales, interbedded with layers of 1-10 m each of more or less quartzitic gray sandstone. The thickness of this upper part of Shüikou Series is estimated to about 2500-3000 meters.

On Wu Lai Ling, the pyramid 255 m, north of Pai Yün Shan, a sedimentary series overlies the fluidal granite; these sediments may also belong to the Shüikou Series. They begin with quartzitic sandstone which contains minute quartzite pebbles, and are further characterized by bluish gray, slightly metamorphic clay shales. (Fig. 2).

The typical Shüikou Series is represented again in the southern part of our map, with quartzites and red shales.

No traces of fossils are known.

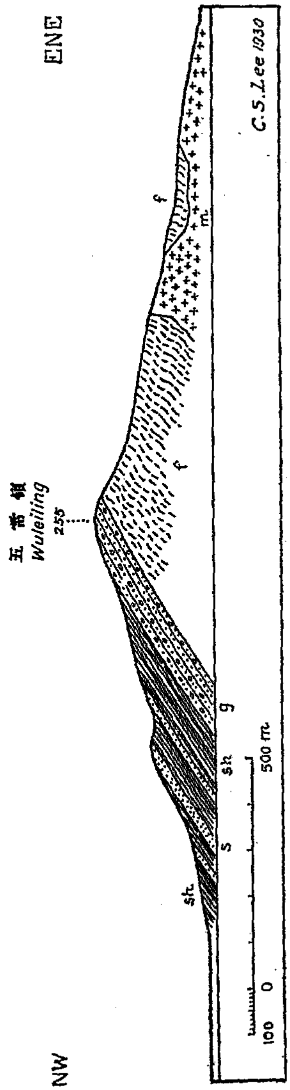

Fig. 2. Section of Wu Lai Ling, N. of Pai Yün Shan. f=fluidal granite, m=massive granite, g=gravel sandstone, sh=gray shale, s=quartzitic sandstone.

(*a*) Shüikou Series, after the type locality of Shüi Kou (水 口) on the River branch 8 km NW of Canton.

(*b*) Hsiaoping Series, after the type locality of Hsiao Ping (小 坪) the railway station 10 km N of Canton. (Fig. 1).

Shüikou Series.

This series is best developed NW of Canton, where it forms several rows of hills of a SW-NE strike.

In the lower part, red clay shales are found, interbedded with sandstone and gray quartzite. In small outcrops, these red clay shales cannot be distinguished from those of the younger Red Beds.

On the NW limb of the fractured anticline of Shih Kang follow thick bodies of light gray quartzite-breccia. They form the highest hill of the region, Chan Chih Kang 151 meters, with a dip of 50-60° towards NW.

The lower hill to the south bordering the river at Ta Pu Kang not only shows these

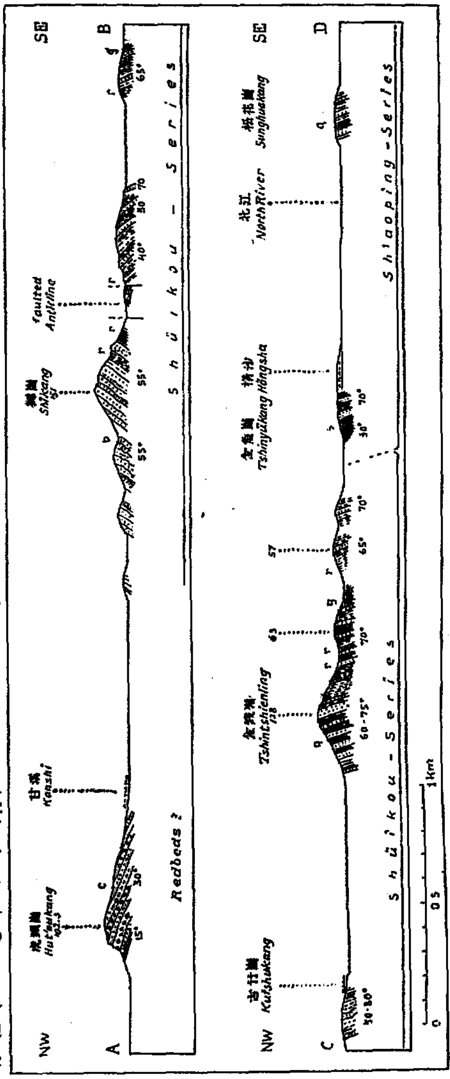

Fig. 1. Sections across anticline of Shih Kang, showing Shüikou and Shiaoping series. CD=continuation of same section of AB towards SE.

c=coarse conglomerate; q=gray quartzite and sandstone; b=quartzite breccia; r=red clay shales, more or less sandy, also gray shales; g=yellow and gray shales with sandstone; s=black shale with sandstone and quartzite.

STRATIGRAPHY

The Old Formations in General.

According to Fong Kin Lan and Chang Hui Je[1] "the whole range of Pai Yün Shan is made of shales and sandstones dipping generally toward the north-west."

We also, at the beginning of our field work, considered Pai Yün Shan as formed of a thick series of quartzites and argillaceous sandstones with mica, of probably Upper Permian age.

More and more, we found out that the pinkish to violet "sandstone" is nothing else than deeply weathered fluidal granite. Thus, there is not much more left of sediments on Pai Yün Shan than the quartzite, and our former name of Pai Yün Shan Formation must be abandoned.

On the other hand, the description of the "Huangkangling" Coal-bearing series as described by Fong and Chang from the Shaokuan Region on the North River does not sufficiently correspond with the older formations of Canton.

No trace of the Permian Limestone (Shaokuan-Limestone) has been found in the mapped area, except in pebbles of the Red Bed Conglomerate. It first appears below the coal bearing sandstone series at Chün T'ien station and Tshek Nai, some 35 km NNW of Canton. We thus consider the older formations of Canton to be younger than the Shaokuan Limestone.

On the other hand, the plants discovered in the black shale of Hsiao Ping by Mr. Lee Chêng San, as determined by Professor Dr. Chang Hsichih, prove that the older formations are not confined to the Permian, but also comprise the lower Mesozoic.

We have tried to subdivide the older formations of Canton. Although with hesitation of introducing further new names we propose the following terms:—

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[1] First Annual Report, Geological Survey of K. and K., p. 66, 1928.

however, we have sought in vain alluvial deposits with gravels good for boring on water. Everywhere, the Red Beds seem to come close to the surface. In numerous places in the plain south and east of the city, these Red Beds are found immediately below the surface soil or mud. The whole city of Canton is erected on levelled Red Beds. It seems that the quaternary or tertiary peneplain has subsided just to about sea-level, with the higher hills of the Red Beds only overtopping the plain. Thus, the Red Beds cover a much larger surface than coloured on the Geological map.

Above the plain with its irrigated rice fields two morphological steps can be distinguished from the far distance, especially in looking down from a hill (Huang Pu) or from an aeroplane (Pl. II).

1. The low hills formed of Red Beds, which rarely rise as high as 50 meters above the plain except in the NW corner of our map, where they reach as much as 117 meters.

2. The hills and mountains formed of the older formations with quartzite as the most resisting element to weathering, and of granite.

South of Canton and of the Canton River branch (= Pearl River) only isolated hills are found, while north of it, in the corner between the North- and the East-River, the mountains of granite with quartzite rise 350-400 meters above the plain.

The best known of them is the Pai Yün Shan or White Cloud Mountain (= Pakwanshan in Cantonese), which rises on the north side of the city of Canton to 382 meters. None of these mountains show very characteristic forms in relation to the tectonical structure. The chief cause is the deep weathering, especially of the Fluidal granite, which caused rounded forms. Only the quartzites in some places are forming sharp contours. All these mountains are deforested, and it is only a few years ago that, organized by Professor M. Fenzel, systematic reforestation has been commenced. About 10 square kilometers on the northern side of Pai Yün Shan are planted now with the native pine (*Pinus massoni*).

GEOLOGY OF CANTON.

WITH GEOLOGICAL MAP 1:50,000,
10 PLATES, AND 12 FIGURES IN THE TEXT.

BY ARNOLD HEIM, K. KREJCI-GRAF, AND LEE CHENG-SAN.

GEOGRAPHICAL POSITION.

Canton, with about 1 million inhabitants, the third largest city of China, is situated in the northern part of the great flood plain of Chu Chiang. On account of the general subsidence of the coastal region in quaternary time, no delta projecting towards the sea has been formed. Notwithstanding the actual growth of the sand and mud deposits south of Boca Tigris, the rivers are opened towards the Pacific Ocean in the form of an estuary, with a width, between Hong Kong and Macao, of 25-30 kilometers.

The great plain is flooded by three rivers: the Hsi Chiang (West River), the third largest river of China; the Pei Chiang (North River) and the Tung Chiang (East River), the waters of which join the Pei Chiang arms E. of Canton.

Looking on a modern map as for instance the beautiful map of "Hong Kong and Canton" 1:250,000, issued by the Geographical Section, General Staff, London, 1927, or looking down from an aeroplane, the network of the river arms connected by thousands of canals appears to form an alluvial plain, from which are rising the drowned hills and mountains.[1] For the nearer surroundings of Canton,

[1] Arnold Heim, Fragmentary Observations in the Region of Hongkong, compared with Canton, Annual Report of the Geological Survey of Kwangtung and Kwangsi. Vol. 2. Part 1, 1929.

PREFACE.

The original mapping in the field was chiefly based on the map 1:25,000 with 10 m contour lines (12 sheets), issued by the Military Topographic Survey of Kwangtung, Canton. This map, some mountainous regions excepted, has proved to be of excellent service and of remarkable accuracy. For the difficult region of Pai Yün Shan (White Cloud Mountain) N. of Canton, the recent map 1:10,000 of the Military Topographic Survey was used as a basis. The present map is a reduction from these two larger originals.

The field work was commenced by the undersigned in March 1929. On account of civil war, it soon became interrupted, and in the winter 1929–30 it again had to be stopped. The undersigned having had only the week end free from lecturing, the greatest part of the field work had to be done by Mr. Lee Chêng-San, the excellent geologist of the Geological Survey of Kwangtung and Kwangsi. Since March 1930, Dr. K. Krejci, Professor of Paleontology, Sunyatsen University, has joined us as a collaborator. We owe him specially the geology of the north-eastern part of the map, with the great igneous complex.

The text, written in a hurry before the departure of our Szechuan-Tibet Expedition, is our mutual work. We thank Mr. Chutingoo, vice-director of the Geological Survey of Kwangtung and Kwangsi, for the supervision of the printing of the map and of the text during our absence.

Arnold Heim

Canton, May 1930

CONTENTS.

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CANTON, CHINA.
1930